Physico-chemical attributes of Nguni chevon prepared and preserved using indigenous methods

By

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Declaration

I, Kagiso Mowa declare that this dissertation hereby submitted for the degree of Masters in Animal Science at the University of KwaZulu-Natal, is my own original work under the supervision of Professor Michael Chimonyo. This dissertation has not previously been submitted for any other purposes to any other institution. All the information sourced from other authors have been cited and acknowledged accordingly.

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General abstract

The broad objective of the study was to determine the influence of indigenous preparation and preservation methods on sensory and physico-chemical attributes of Nguni chevon. Thirty clinically healthy castrated Nguni goats aged 1.5 years, with an average body weight of 18 ± 1.32 kg were slaughtered using the suprasternal notch piercing method. The carcasses were chilled for 24 hours. Both right and left thighs were dissected and diced into fragments of about 3 × 3 cm and boiled for 20, 35, 50, 65 and 80 minutes at 100ºC. Aroma, tenderness, juiciness, flavour, residue and off-flavour were assessed using five-point hedonic scale in the vernacular isiZulu. There was a positive correlation amongst all sensory attributes tested, except for an aroma that was negatively correlated to all sensory attributes tested. A quadratic decrease in tenderness (P<0.05) with an increase boiling time of chevon was observed. Juiciness decreased linearly (P<0.01) with an increased boiling time of chevon. There was a quadratic decrease in residue with the increased boiling time (P<0.001). The off-flavour decreased linearly (P<0.0001) with an increased boiling time. There was no relationship observed between increased boiling time with the aroma and flavour (P>0.05). It was concluded that boiling time up to 35 minutes increases sensory attributes than those boiled for 20, 50 65 and 80 minutes.

The brisket samples were preserved with river salt (Treatment A), table salt (Treatment B), river and table salt combined (Treatment C) and without salt (Treatment D) for five days in the traditional house (rondavel) where the fire was prepared every day. The visible fat and connective tissue of the brisket was trimmed, then freeze-dried at -54°C for three days and ground. Moisture content, ether extract (EE), crude protein (CP), ash, pH and colour were analysed. Moisture, CP, EE, ash and colour were different among the treatments (*P*<0.001), except pH which was similar (*P*>0.05). Treatment D showed higher moisture than Treatments A, B and C. The CP content was high in Treatment B compared to Treatments A, C and D.

Treatments A and B had similar EE content. Ash content was higher in Treatment B than Treatments A, C and D. Chevon lightness, redness and brightness were also influenced by preservation methods ($P<0.001$). In conclusion, using river salt when preserving chevon prevents deterioration of physico-chemical attributes and produces acceptable chevon.

Key words: Aroma, ash, colour, flavour, food security, indigenous knowledge system, juiciness, pH, tenderness

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Dedications

To

‘Almighty God’

The entire Mowa family: Frans, Alphina, Delina, Tebatso, Kholofelo, Kamogelo, Isaac, Gabriel, Mogau, Phuthanang, Poncho, Hlokomelo, Katlego, Thato and Tshegofatso

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List of Abbreviations

a* : Redness

AOAC : Association of Official Analytical Chemists

b* : Yellowness

BCS : Body condition score

C13:0 : Tridecanoic acid

C14:0 : Myristic acid

C15:0 : Pentadecanoic acid

C16:0 : Palmitic acid

C16:1 : Palmitoleic acid

C17:0 : Margaric acid

C18:0 : Stearic acid

C18:1 : Oleic acid

C18:3 : Linoleic acid

C20:1 : Eicosanoid acid

Ca : Calcium

CP : Crude protein

Cu : Copper

DM : Dry matter

EE : Ether extract

FAO : Food and Agriculture Organization of the United Nations

Fe : Iron

g : Grams

GLM : General linear model

IK : Indigenous knowledge

IKS	: Indigenous knowledge system
IMF	: Intramuscular fat
K	: Potassium
kg	: Kilograms
KZN	: KwaZulu-Natal
L*	: Lightness
MC	: Moisture content
Mg	: Magnesium
Mn	: Manganese
MT	: Metric tons
Na	: Sodium
NaCl	: Sodium chloride
NRF	: National Research Foundation
NS	: Not significant
OBCFA	: Odd- and branched- chain fatty acids
P	: Probability value
SA	: South Africa
SAS	: Statistical analysis systems
SASAS	: South African Society for Animal Science
SEM	: Standard error of the mean
SFA	: Saturated fatty acids
SSA	: Sub-Saharan Africa
UKZN	: University of KwaZulu-Natal
Zn	: Zinc

CHAPTER 1: General Introduction

1.1 Background

Most resource-limited farmers do not own modern instruments such as grillers, refrigerators, and chemical additives to prepare and preserve meat (Zhou *et al*., 2010). Over many generations, Nguni communal farmers have been able to reduce the risk of food wastage and loss of nutrients through boiling and salting. As a result, meat spoilage was not a huge challenge in communal households (Webb *et al*., 2005; Faisal *et al*., 2009). It is important to ensure that meat is prepared and preserved in a way that satisfies the consumer's needs. Prolonged boiling decreases sensory attributes such as juiciness, tenderness and flavour of the meat (Xazela *et al*., 2011). Salting at the high concentration result in high lipid oxidation and protein degradation (Lawrie and Ledward, 2006). These indigenous methods need to be documented, evaluated and when appropriate to meet nutritional needs of consumers.

Indigenous knowledge system (IKS) is a community-based knowledge, including beliefs, innovations, skills, experiences, ideas and insights about the survival of the people within their local environments (Kaya and Masoga, 2005). In practical terms, IKS is transferred orally from one generation to the other. It is used in agriculture, education, social welfare, natural-resource management, medicine and food technology (Okorafor, 2010). The knowledge tends to adapt too slowly because of the adoption of conventional modern knowledge and techniques that promise short-term solutions to challenges, urban migration and changes to the population structure, rapid changes in natural environments, economic, political and cultural activities (Kamwendo and Kamwendo, 2014; Kaya and Chinsamy, 2016).

Primarily goats are owned by resource-limited farmers for food and nutrition security, religions and traditional functions (Peacock, 2005). Goats in Greece, Italy, France and Spain are mainly kept for chevon consumption during the celebrations of Easter and Christmas festivities (Stanisz *et al*., 2009). In communal production systems of South Africa, chevon consumption is also ranked as the most important function of goats (Bester *et al*., 2009; Mpendulo, 2015). Indigenous goats of South Africa, are of the Nguni breed with adult males weighing up to 40 kg and females 30 kg (Rumosa Gwaze *et al*., 2009). Nguni goats have a small body frame and short-hair coat composed of white, brown, black to a variegated combination of these colours. The Nguni goat is prolific and thrives under stressful environmental conditions, including high disease and parasite prevalence, poor nutrition and high ambient temperatures (Campbell, 2003; Durawo *et al*., 2017).

The majority of Nguni resource-limited households in communal production systems depend on boiling and river salt treatment to prepare and preserve chevon. These indigenous preparation and preservation methods need to be improved to better and cleaner methods without prejudice or nostalgia as these can lead to better nutrition and health. During cultural purposes such as ancestral worship, goats are slaughtered for consumption (Simela and Merkel, 2008). All the chevon cannot be consumed and finished at once, therefore the surplus is preserved by drying using river salt and farmers who do not have access to river salt uses table salt. River salt is found in most rivers, such as the Tugela River in KwaZulu-Natal, South Africa. Boiling is the commonest method of chevon preparation during traditional ceremonies (Webb, 2014). It improves chevon palatability and digestibility. Salt treatment improves colour, enhance essential vitamins, minerals, protein and prolong shelf-life for up to 24 days

(Dave and Ghaly, 2011). Preserving chevon helps to meet dietary shortfalls during times of crop failure and food scarcity. It is also valued during the peak agricultural labour period when less time is available for cooking. By around 2050, there is likely to be a fierce competition for food due to the expected increase in population to nine billion (Van Marle-Kőster *et al*., 2015). Preserved chevon becomes essential to reduce food insecurity. Indigenous preparation and preservation methods are commonly used. However, there is no information available of these methods on the sensory and physico-chemical attributes of Nguni chevon.

1.2 Justification

Lack of balanced diets challenges are likely to impact the low and middle-income countries, vulnerable with poor nutrition, especially women and children, leading to increased food and nutrition insecurity (Govender *et al*., 2016). Chevon can be the potential meat alternative since goats are cheap to keep, nutritious than other meat source and abundant in resource-limited communal production systems (Rumosa Gwaze *et al*., 2009; Madruga and Bressan, 2011). Goats thrive in marginalised environments and require minimal, if any, external inputs. Indigenous preparation and preservation methods can help increase the acceptability of chevon, thus ensuring food security for communal households.

Determination of boiling time on sensory attributes can identify the relationship between boiling time and sensory attributes of chevon. The knowledge of boiling times can be used in restaurants and fast food suppliers to produce desirable sensory attributes preferred by consumers, thus increases the acceptability of chevon. In addition, chevon can easily be commercialised to provide employment opportunities for a large percentage of the population.

Goats can easily be owned and kept by women and children who can, therefore, benefit immensely from their commercialisation.

Determining physico-chemical attributes of Nguni chevon preserved using indigenous methods helps to develop appropriate preservative strategies to reduce food and nutrition losses. There is a need to determine the available preservatives that are available for resource-limited farmers and the commonly used to prevent deterioration of nutrients of chevon. This assist in evaluating the effect of river salt, table salt and combination of these on physico-chemical attributes of chevon. Identifying their effect will help observe how they affect acceptable physico-chemical attributes. Furthermore, knowledge of indigenous methods of meat preservation can complement modern knowledge and technologies. When households have access to both knowledge systems, they can adopt sustainable and appropriate methods that suit their socio-economic circumstances and locations. Complementing indigenous knowledge with modern knowledge and technologies improves the chance of documenting and protecting the dying indigenous knowledge. Indigenous knowledge (IK) is community-based, participatory and, hence, sustainable.

1.3 Objectives

The broad objective of the study was to determine the influence of indigenous preparation and preservation methods on sensory and physico-chemical attributes of Nguni chevon. The specific objectives were to:

1. Determine the relationship between boiling time and sensory attributes of chevon; and
2. Assess the influence of indigenous preservation methods on physico-chemical attributes of chevon.

1.4 Hypothesis

The specific hypotheses were that:

1. Boiling time has a linear relationship with sensory attributes of chevon; and
2. Indigenous preservation methods influence physico-chemical attributes of chevon.

1.5 References

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CHAPTER 2: Literature Review

2.1 Introduction

Indigenous knowledge system is the social capital for communal farmers and their main asset to invest in for survival to produce and provide food (Kaya and Chinsamy, 2016). The knowledge risks getting extinct because of the attention that scientific knowledge systems of modern preparation and preservation of meat are receiving. This has led to indigenous preparation and preservation practices being perceived as backward, outdated and old fashioned. Incorporation of modern technology into the indigenous practices can improve preparation and preservation of chevon in communal areas. This can subsequently lead to improved access, distribution and stability of food.

Webb *et al*. (2005) argued that chevon is a healthy protein rich flesh utilized as food. It is, however, less consumed in comparison with beef, mutton, pork and chicken because of its aroma caused by odd- and branched- chain fatty acids (OBCFA), mainly four methylnanoic acid (Wong *et al*., 1975; Louca *et al*., 1977; Madruga and Bressan, 2011), low intramuscular fat (Schönfeldt *et al*., 1993) which results in less juiciness, late maturity which results in tough meat (Madruga and Bressan, 2011). It plays a major role in ensuring food security in communal production systems. With the role of chevon on food security being less understood or appreciated, this chapter presents an overview on goat production, indigenous preparation and preservation methods to improve food security, indigenous slaughter of goats, impact of indigenous preparation on sensory attributes of chevon, impact of indigenous preservation on physico-chemical attributes and limitations of using indigenous preparation and preservation methods.

2.2 Goat production in communal production systems

Communal farmers use extensive production systems to raise goats for improving their livelihoods (Masika and Mafu, 2004). Indigenous Nguni goats are preferred because they are not capital intensive and reproduce quickly as compared to cattle (Peacock, 2005). Communal farmers are usually smallholders and individuals owning less land who rear these goats because of their adaptability and compatibility with the environment, survive on little inputs and adjust to fluctuations in feed availability (Alexandre and Mandonnet, 2005; Durawo *et al*., 2017). The common breeds used are Nguni, Tswana, Pedi, Matebele, Mashona, Malawi, and Landim (Rumosa Gwaze *et al*., 2009).

Goats play a critical role in the social and economic livelihoods of communal farmers. In times of crop failures and during currency fluctuations communal farmers resort to goats as the main source of food and income (Lebbie, 2004; Sebei *et al*., 2004). As a result, traditional attires, drums, mats, and tents made of goat skins are sold locally among communal households (Peacock, 2005). Therefore, goat products have a huge potential create employment amongst the communities. Goats are mostly used for cultural purposes such as ancestral worship and other traditional functions (Masika and Mafu, 2004; Simela and Merkel, 2008). A person owning goats is regarded as richer than the one without goats. Goats also fulfill several functions such as biological control for bush encroachment and provision of animal draught power (Saico and Abul, 2007). Goats produce rich manure for maintaining or improving agricultural production since small livestock have high Nitrogen economy compared with cattle (Lebbie, 2004). Goats can be used for transport to plough and move possessions around.

Although keeping goats is advantageous in communal production systems, the productivity is low because of challenges associated with production system communal farmers use which lowers their food and nutrition security (Table 2.1).

Table 2.1: Challenges to goat production in communal areas which causes food insecurity

Challenges	Explanation	Sources
High prevalence of diseases	Common diseases in communal areas are Gastrointestinal nematodes (especially *H. conrtotus*), Bacterial: *Clostridium tetani*, *Brucellosis militensis*, and *Bacillus anthracis*; Viral diseases: *Dermatophilus congolensis*, and Protozoal: *Cowdria ruminantium*, *Clamydia psiattaci*, *and Eimeria spp* which results in reduced goat productivity. These diseases cause 33.3% of kid's mortality and 44.6 % in pre-weaning mortality.	Masika and Mafu (2004); Aganga *et al*. (2005); Rumosa Gwaze *et al*. (2009)
Low level of management	Communal farmers have no breeding system hence there is mixing of both sexes which results in uncontrolled mating and inbreeding which causes recessive genes to dominate the flock. Since communal farmers use extensive system pregnant does are not taken care of this results in less colostrum for weanling's and results in poor immunity and high mortality rate leading to low productivity. Goats are not marked hence get lost and tracing them becomes difficult.	Rumosa Gwaze *et al*. (2009); Mohlatlole *et al*. (2015)
Limited forage availability	Poor management of pasture by communal farmers causes overgrazing subsequently quality becomes poor. This causes the nutrients requirements of goats not met, this lowers productivity. In the tropics goats walk long distances for fresh pasture and protein content drops by 8% in dry seasons. In most communal areas school children are responsible for herding goats, implying that grazing is dependent on the school time table which affects the productivity of goats.	Mahanjana and Cronje (2000); Peacock (2005); Saico and Abul (2007); Rumosa Gwaze *et al.* (2009)
Poor marketing management	Communal farmers use informal ways of marketing their goats, even the price is based on visual assessment resulting in low income and these transactions are not on official records for statistical purposes on importance of chevon on food security.	Simela and Merkel (2008); Rumosa Gwaze *et al.* (2009)
Predators	Communal farmers have insecure enclosures for their goats such as kraal hence predators have easy access to their goats thus this endangers food security. Moreover, the extensive system they use predisposes goats to wild dogs and snakes because no one herds them when the kids are at school.	Masika and Mafu (2004)

2.3 Characteristics of Nguni goats

Nguni goats are predominantly found in South Africa (SA), Swaziland and Lesotho (Epstein, 1971). These goats are distinguished from other indigenous breeds by appearance and productivity characteristics. Nguni goats show a variable coat colours composed of white, brown, and black, horned and medium-sized ears within the same herd (Epstein, 1971). They have small body frame that make them to have low maintenance and growth nutrient requirements. The adult males weigh up to 40 kg and females 30 kg (Rumosa Gwaze *et al*., 2009). Their lower requirement for nutrients is advantageous in communal production system since resources are limited.

The Nguni goat have good mothering ability, high reproductive efficiency, thrive under stressful environmental conditions, including high disease and parasite prevalence, poor nutrition and high ambient temperatures (Campbell, 2003; Durawo *et al*., 2017). Du Toit (2008) reported that these goats are less susceptible to gastro-intestinal nematodes. Gastro-intestinal nematodes was found to be the major factors that reduce productivity in goats, especially kids (Masika and Mafu, 2004; Sebei, 2004).

2.4 Consumption patterns of chevon

In 2008 about 4.9 million metric tons (MT) of chevon was produced, approximately 97 % of this meat was produced in developing countries (Aziz, 2010). Consumption of chevon is influenced by culture, traditions, and socio-economics of the community. This plays a role in making it inferior to other meat types such as beef, mutton and chicken. Other limitations are its repelling smell caused by odd- and branched- chain fatty acids (OBCFA), mainly four methylnanoic acid (Wong *et al*., 1975; Louca *et al*., 1977; Madruga and Bressan, 2011), low intramuscular fat (Schönfeldt *et al*., 1993) which results in less juiciness, late maturity which results in tough meat since meat toughness increases with age (Madruga and Bressan, 2011). Tshabalala *et al*. (2003) reported that chevon is not as demanded as other meat types because it provides less economic returns due to its low popularity. The good preparation and preservation could reduce all negative factors and enhance chevon consumption.

Casey and Webb (2010) reported that low chevon consumption is due to preference of beef, mutton and chicken by most urbanised households. Conversely, Mpendulo (2015) found that communal households of KwaZulu-Natal (KZN) province in SA ranked keeping goats for chevon consumption as most important (Figure 2.1). However, in another study conducted in communal households of Eastern Cape province of SA, it was reported that communal famers keep goats mainly for traditional ceremonies (35 %) followed cash sales (23 %), and for meat consumption (15 %) (Mahanjana and Cronje, 2000). It was also interesting to note that Zulu and Xhosa tribes keep goats for different priorities and reasons.

Simela *et al*. (2008) argued that chevon is acceptable to South African consumers and may be as acceptable as mutton if the meat is from goats of about two years old or younger. Moreover, for chevon to be consumed equally as other meat types more research is vital on identifying attractive meat parts and sensory attributes that consumers prefer so that can be used and improved to market chevon. More surveys like that done by Mpendulo (2015); Mahanjana and Cronje (2000) on communal farmers should be conducted, so that accurate official records for statistical purposes on importance of chevon on food security can be obtained. Perhaps more effort should be put in marketing chevon as much as beef, mutton and chicken. Hence, consumers would accept chevon equally as other meat types since it is healthier and cheaper. Goats are slaughtered informally in communal production systems, which may influence chevon quality hence reduce acceptability. It is, therefore important to erect and maintain abattoirs that can improve slaughter and chevon quality since abattoirs are governed by the Meat Safety Act and various quality certifications and regulations.

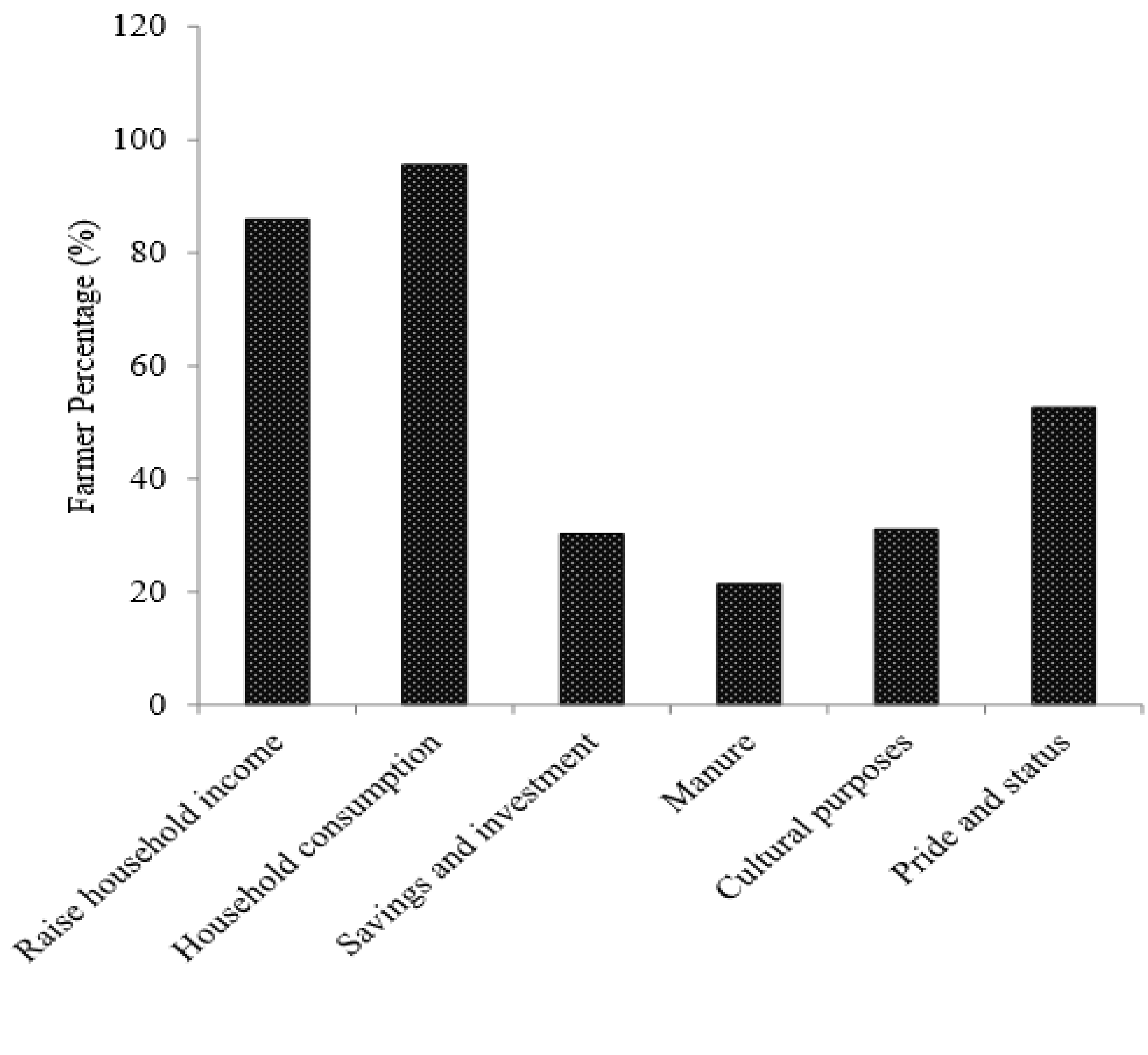

Figure 2.1: Reasons for keeping goats in communal areas adapted from Mpendulo (2015)

2.5 Chemical composition of chevon

In recent years, consumers are highly cautious of what they eat hence want meat that will not be detrimental to their health. Chevon is lean meat because has less fat and cholesterol and rich in proteins thus ideal choice for health-conscious consumers (Kannan *et al*., 2001). The consumption of chevon as protein source of meat come with health benefits such as reducing the risk for cardiovascular disease and other chronic conditions, whereas unsaturated fats improve blood cholesterol levels, ease inflammation and stabilize heart rhythms cancer (Harvard School of Public Health, 2008).

Lipids are a source of energy and essential fatty acids, also increase palatability. Chevon contains less intramuscular fat compared to its closest meat competitor lamb (Shija *et al*., 2013). This is because chevon seems to contain oleic acid (C18:1), palmitic acid (C16:0) and stearic acid (C18:0) in large amounts compared to sheep (Casey, 1992). This characteristic is independent of nutrition the animal is browsing (Casey, 1992). The odour from fatty acids, especially four-methyloctanoic seems to influence the flavour of the chevon (Wong *et al*., 1975). In lambs, C18 and C18:3 fatty acids influence the flavour by causing odour (Casey, 1992). Minerals from chevon are very bioavailable since meat does not contain inhibitors found in some vegetables (Casey, 1992). Webb *et al*. (2005) reported that red meat is an excellent source of iron, the haem iron being 5–10% more available than non-haem iron. Chevon is reported to have more moisture compared to lamb (Shija *et al*., 2013). Table 2.2 compares the nutrient values of chevon and lamb, Table 2.3 lists the mineral concentrations of chevon and Table 2.4 gives the fatty acid proportions of chevon and lamb.

Table 2.2: Chemical composition of chevon and lamb (g/kg)

Nutrient	**Meat type**	**Mean**	**MSE**
Moisture	Chevon	750.4	0.517
	Lamb	741.2	0.403
Proteins	Chevon	208	1.15
	Lamb	212	1.08
Fat	Chevon	28	0.5
	Lamb	35	0.84
Ash	Chevon	12.3	0.1
	Lamb	12.4	0.09

MSE: Mean standard error, **Source:** Babiker *et al*. (1990)

Table 2.3: Mineral concentrations of chevon (g/kg)

Mineral	Mean
Calcium	11.00
Phosphorus	155.5
Magnesium	19.7
Potassium	350
Sodium	64.48
Copper	0.30
Zinc	3.51
Iron	4.37
Manganese	0.087

Source: Webb *et al*. (2005)

Table 2.4: Fatty acid proportions of chevon and lamb

Fatty acid	Meat type	Mean	MSE
C13:0	Chevon	5.0	0.47
	Lamb	2.7	0.47
C14:0	Chevon	6.0	3.08
	Lamb	7.4	2.09
C15:0	Chevon	0.8	0.19
	Lamb	0.6	0.13
C16:0	Chevon	19.5	1.42
	Lamb	22.5	1.85
C16:1	Chevon	3.1	0.26
	Lamb	3.4	0.70
C17:0	Chevon	2.4	0.10
	Lamb	2.1	0.13
C18:0	Chevon	20.0	1.69
	Lamb	16.4	2.50
C18:1	Chevon	37.7	2.54
	Lamb	38.9	1.93
C18:3	Chevon	3.9	0.20
	Lamb	3.9	0.62
C20:1	Chevon	1.6	0.37
	Lamb	2.0	2.26

MSE: Mean standard error, **Source:** Tshabalala *et al*. (2003)

2.6 Physical and sensory characteristics of chevon

Consumers mostly judge chevon based on physical and sensory attributes such colour, pH, tenderness, juiciness, and flavour. These attributes are mostly affected by sex, age, feed, and breed (Ngambu *et al*., 2011). Other factors could be preparation and preservation such as cooking methods, time, end-point temperature, live weight, pre-slaughter handling, post-mortem handling, slaughtering techniques, chilling and freezing of the carcass (Simela *et al*., 2004b; Casey and Webb, 2010).

2.6.1 Colour

Colour of the meat is a physical attribute parameter that catches the eye of the consumer to purchase meat (Muchenje *et al*., 2008). Meat colour observed is due to myoglobin content. Myoglobin is a hydrophilic protein that contains oxygen used by muscle during aerobic metabolism (Boles and Pegg, 2010). This protein could lose or gain electrons. When it loses electrons, the meat colour changes to brown as metmyoglobin is formed. However, when it gains electrons the meat colour changes to red. When meat is being boiled the proteins are broken down. Hence, boiled meat is brown in colour because boiling yields metmyoglobin.

Simela *et al*. (2004) reported that both sex and age have no effect on colour of meat. Conversely, Gordon and Charles (2002) found that slow-growing birds have a redder meat colour than fast growing birds' due to age effect. Chilling time after slaughter seems to influence carcass colour. Hence, carcasses that chill quickly with low glycolysis activity show dark colour (Onyango *et al*., 1998). There is a negative relationship between myoglobin content of meat and its lightness.

Chevon has been reported to have lower lightness and higher redness than lamb, due to the lower intramuscular fat (Kannan *et al*., 2001).

2.6.2 pH

Carcasses with low pH have bright colour which is attractive to the consumer. While carcasses with high pH tend to have dark colour, which is not attractive to the consumer (Simela *et al*.,2004b). Low pH is desirable because it enhances the breakdown of lysosomal membrane to expel cathepsins, which target myofibrils proteins thus more tenderness (Hopkins and Thompson, 2002). During post-mortem, the pH drops from 7.0 to 5.7 in 24 hours (Boles and Pegg, 2010). Chevon with high pH needs to be cooked at higher temperature to yield the same colour as the meat with normal pH (Boles and Pegg, 2010).

2.6.3 Tenderness

Meat tenderness refers to the ease of chewing and amount of residue remaining after chewing. Carcasses with slow chilling after slaughter show a quick drop in pH and thus are more tender (Simela *et al*., 2004a). Toughness may also be due to inability of collagen to solubilise under the boiling temperature and time, which can be due to age and sex of the animal (Adam *et al*., 2010). Meat tenderness is also affected by weight of goat. Light weight goat produces more tender meat compared to heavy weight goats (Dhanda *et al*., 2003). Chevon was reported to be less desirable in tenderness compared to mutton (Schönfeldt *et al*., 1993; Tshabalala *et al*., 2003). In contrast, Sheridan *et al*. (2003) found no difference between tenderness of chevon and mutton. These results may be due to experience of the trained sensory panellists used. Factors such as the aging of the muscle and the intramuscular fat (IMF) are reported to enhance meat tenderness (Muchenje *et al*., 2008; Muchenje *et al*., 2009).

2.6.4 Juiciness

Chevon juiciness is dependent on boiling time and temperature. Cooking losses in chevon are worsened by low fat content within it in comparison to other meat types. This results in chevon with low juiciness (Adam *et al*., 2010). As a result, the lower the cooking loss the higher the juiciness of the meat (Lijalem *et al*., 2015). Influence of age on chevon juiciness is not fully understood, Smith *et al*. (1978) found that carcasses from older animals is more juicy and palatable. Whereas, Gaili *et al*. (1972) reported that young goats are more juicer than older goats. This may be due to less collagen in younger goats compared to older ones. Weight of the goat seems to play a role in juiciness, Schönfeldt *et al*. (1993) reported that kid meat from 10 to 25 kg carcasses were juicier than meat from 15 to 30 kg carcases. Similarly, Marichal *et al*. (2003) reported a linear relationship between live weight of goats at slaughter and IMF content.

2.6.5 Flavour

Flavour is determined by the sense of taste and smell. Breed, nutrition, age and type of tissue seems to influence the flavour of chevon (Moyo *et al*., 2014). Ngambu *et al*. (2011) reported that Nguni goats had highest frequency of off-flavour (23.86) compared to Xhosa and Boer cross goats. Casey (1992) said Angora chevon has a better flavour compared to Boer goat. The author said this might be attributed to high subitizable collagen in Angora goats. Chevon is characterised by a strong odour caused by OBCFA, mainly four-methyloctanoic and four-methylnanoic acids (Louca *et al*., 1977; Madruga and Bressan, 2011). This branched chain fatty acids are responsible for a strong goat odour which also affects taste. A taint in chevon of intact males can be detected from age of 8 months and older. However, castrated male goat's meat has no off flavour. Hence, off flavour in chevon can be alleviated by castrating males (Dhanda *et al*., 2003). Most communal areas use indigenous methods to prepare and preserve chevon to improve food security.

2.7 Role of indigenous preparation and preservation methods in food security

About 53 million tonnes of meat produced every year become wasted through spoilage (FAO, 2012). Indigenous preparation and preservation methods remain vital. These methods provide an economic means of preserving food thus making it available during the period of scarcity. In addition, the methods enhance and maintain nutritious food desirable to consumers since they are health cautious about what they consume. Thus, is important to ensure that foods are prepared in a way that meets the needs of a changing environment characterized by good tastes and preferences. Therefore, chevon could be more acceptable and commercialised thus contributing to food security. Food security is whereby all members of household have access to adequate amounts of nutritious, safe and culturally appropriate food all the time to lead a healthy life (Pinstrup-Andersen, 2009). It encompasses the availability, accessibility and utilization of food by households.

Resource-limited households rely on indigenous methods to prepare and preserve food. Some methods are well documented, for example is that of cassava preparation which reduces cyanogen substantially and ensures that food, is safe to consume; sweet potatoes preserved as chips, the use of banana leaves to preserve meat, soaking and/or sprouting of grains are well documented to reduce the content of antinutrients (FAO, 2013). Insects, such as locusts and worms (*mopani worms*) are seasonal and therefore are also preserved in communal production systems by means of drying for later use and scarcity. All these methods of preparation and preservation play a vital role in improving and achieving food security in communal production systems.

The other indigenous methods are reported to result in loss of nutrients for example prolong boiling could reduce the nutritional value of the food. Cabbage, for example, is normally recommended to be consumed raw to ensure the preservation of all its nutritional benefits. However, in most rural homes, this vegetable is boiled causing it to lose much of its nutritional value. The same is true for a traditional method of grinding the leaves followed by boiling for at least 30 min removes all the cyanogen's from the leaves, but unfortunately also removes many of the vitamins and some amino acids from the protein rich leaves. The common method of cooking chevon also does not need too much boiling as results in lipids oxidation and proteins degradation. Efforts promoting certain food, which are based on successful indigenous preparation methods need to be accompanied by development activities that help ensure that consumers are aware of the ways to prepare their food in a way that maintains their nutritional properties.

Since most communal households rely on indigenous preparation and preservation methods for their nutritional needs. Indigenous preservation methods should be surveyed so that they can be improved, adopted and documented. This is because preservation and preparation methods can impact the nutritional content and sensory attributes of chevon.

2.8 Chevon preparation and preservation

Fresh chevon is highly perishable and therefore need to be prepared and preserved to ensure good quality for latter consumption. The surpluses of chevon can be preserved and prolonged by using various indigenous and modern preparation and preservation methods. Indigenous methods require less energy, little and inexpensive equipment hence contributing to household's food security. The modern preparation and preservation are known as excellent methods, however, are expensive, uses much energy and large investments are needed whereby most resource-limited communities cannot afford.

2.8.1 Indigenous slaughter of goats

In communal production systems goats are slaughtered mostly to honour ancestors, celebrate weddings and birthdays, perform ritual during funerals, welcome visitors and for meat consumption (Masika and Mafu, 2004; Simela and Merkel, 2008). The goats are slaughtered with different indigenous methods based on the purpose of slaughter. Most of these slaughter methods involve the killing by exsanguination. A preliminary study reported three common methods used to slaughter goats in communal areas of KwaZulu-Natal province in South Africa, namely: transverse cut of the neck, suprasternal notch piercing and side piercing. The transverse cut of the neck, goats are pinned down and allow to lay on their back. The throat silted with a sharp knife and allowing to face down for blood to come inside the dish. It was believed to bath with the blood to chase away the bad luck. Goats slaughtered using this method was reported to die within ten minutes.

The suprasternal notch and side piercing involves holding the goat with its forelegs spread apart, allowing it to stand on its hind legs. The notch is poked with a sharp spear deep to the heart. The goat make noise twice or more before the spear can be removed and is believed that the ancestors were honoured. Once the spear is removed, blood sparingly spraying out of the wound and to ensure maximum exsanguination the animal hung upside down. Goats slaughtered with this method was reported to die after ten minutes. Qekwana (2012) reported that signs of death were described by visual assessment of the goat, when breathing stopped, when the eyes were no longer moving, when the goat stopped kicking, when the goat was no longer making a noise, if the goat urinated after the throat was slit, when there was no movement and the tongue hung out, and when blood stopped pumping out.

All the indigenous methods do not involve stunning before slaughter and does not require abattoir (Qekwana *et al*., 2017). This is because the slaughter that has classified well yet failed to meet the purpose of religious commandments during the slaughter process, would be considered spiritually worthless. In addition, goats slaughtered for "spiritual quality" serve an important role in communal areas worldwide, similar for Hindu, Jewish and Muslims (Clottey, 1985).

2.8.2 Impact of indigenous preparation on sensory attributes of chevon

Widely chevon is prepared by either boiling, roasting, grilling, and frying and the methods are used by resource-limited households, commercial farmers and foodservices (Xazela *et al*., 2011). Boiling is the most common used indigenous method as compared to others because it is simple. It makes tough meat to be digestible and palatable. The sensory attributes of boiled chevon are reported to be less acceptable as compared to other methods of cooking (Xazela *et al*., 2011).

Boiling time could be controlled when cooking chevon to improve the sensory attributes that are preferred by consumers. Hence chevon could be accepted as other meat types and be on market.

Factors such as cooking temperature, salt addition, amount of water used to boil, and type of equipment used to boil also play a role in decreased sensory attributes of boiled chevon. Furthermore, cutting chevon into big chunk size could prolong the boiling time thus decreases sensory attributes. Chevon has less intramuscular fat content (Schönfeldt *et al*., 1993), if it can be overcooked would result in decreased juiciness thus decrease tenderness and flavour. Tshabalala *et al*. (2003) reported chevon to be less juicy and tender as compared mutton. In contrary, Sheridan *et al*. (2003) reported chevon and mutton to produce the same juiciness and tenderness.

Since resource-limited households rely on boiling to prepare chevon, all the factors influencing sensory attribute should be investigated to make sure that the consumers are given knowledge on how they can control them to maintain desirable sensory attributes contributing to their food and nutrition security. Thus, chevon could be commercialised and used as the animal protein source during the competition of food that is expected in 2050 due to overpopulation to nine billion (van Marle-Kőster *et al*., 2015).

2.8.3 Impact of indigenous preservation on physico-chemical attributes

Preservation of chevon has been reported to influence moisture, crude proteins, fats, ash and pH. In communal areas chevon is preserved by either drying, curing with salt or smoking (Faisal *et al*., 2009). Drying involves exposure of meat to air to reduces the availability of water that is stored in such a level where microbes cannot live. Curing of meat is adding common salt and sugar to improve the flavour and reduce the growth of microorganisms. Meat is cured by sodium nitrate to prevent spoilage, enhance colour which may be due to some impurities in sodium nitrate which happens when nitrate undergoes reduction (Lawrie and Ledward, 2006). Drying is the most common method used by communal households to preserve chevon. It requires no energy, less materials, and cheap. In terms of curing method salting is the most commonly used method, it comes with an advantage such as ability to kill microorganisms such as *E. coli* which can cause health scares to consumers (Faisal *et al*., 2009).

The cuts chosen for preservation must have small amounts of fats such as the brisket and rump (McLaughlin, 2013). Fats limit the efficacy of salt drying thus prevent rancidity of the meat. The ash contents increase with the addition of salt compared to that dried without salt (Ferreira *et al*., 2013). Lightness and red colour decreased with increase in preservation. Salt decreased moisture content. An increase in salt levels in meat makes the meat darker due to development of metmyoglobin (Ferreira *et al*., 2013; Teixeira *et al*., 2011). Tables 2.5 and 2.6 show the effects of salt drying on colour parameters of chevon.

Table 2.5: Effect of salting chevon on colour parameters

Colour parameter	Days of preservation	Mean	MSE
L*	3	33.8	0.17
	5	34.2	0.17
a*	3	10.9	0.17
	5	9.3	0.15
b*	3	6.6	0.09
	5	6.6	0.09
H*	3	35.2	0.52
	5	39.2	0.52
C*	3	76.9	1.60
	5	64.6	1.60

MSE: Mean standard error**, Source:** Teixeira *et al*. (2011)

Table 2.6: Effects of drying chevon on colour parameters

Colour parameter	Days of preservation	Mean	MSE
L*	3	32.2	0.25
	5	32.2	0.25
a*	3	4.5	0.12
	5	4.3	0.12
b*	3	6.5	0.16
	5	5.9	0.16
H*	3	54.8	0.67
	5	53.5	0.67
C*	3	30.7	1.40
	5	26.7	1.40

MSE: Mean standard error**, Source:** Teixeira *et al*. (2011)

2.9 Limitations of using indigenous preparation and preservation methods

Indigenous preparation and preservation methods are important for communal households to improve food security and their livelihoods; hence the utilization of these methods is constrained by lack of documentation and presence of modern technologies.

2.9.1 Lack of knowledge and documentation

Indigenous knowledge system (IKS) is undocumented skills, experiences, ideas, information and understanding about survival and livelihood developed over generations (Kaya and Masoga, 2005). It is passed from one generation to the other using word of mouth. The knowledge might be altered or lost through transfer. Furthermore, it is a secretive knowledge known by few who could mostly die with it. For this reason, this knowledge system needs to be documented for protection and sustainability thus utilization for food security.

Indigenous preparation and preservation methods are predominantly used by women to deliver income and employment. For instance, vegetable, cereals and legumes play an important role in the diet of most of the population and in issues related to their production, storage, marketing, and processing are very important. The aim is to provide communal areas with adequate and nutritionally balanced diets at affordable prices, both now and in the future. Asongwa *et al*. (2017) reported the cereals grown in Ghana that could use in many various foods using indigenous knowledge and technology. The foods from maize include fried cakes (akpiti), steamed or baked dumplings (abolo), boiled maize porridge, corn-wine (nmeda), or just corn on the cob. Legumes are used in various forms in Ghana, such as boiled beans, cakes (akara), bean stews, bambara porridge (aboboe), roasted or boiled groundnuts, ground-nut paste, groundnut soup, and groundnut cakes. These indigenous methods are affordable, acceptable, economically and socially feasible as well as a sustainable for reduction of food insecurity and hunger. However, there are some constraints to utilize these preparation and preservation methods (Oniang *et al*., 2004). Figure 2.2 present the major constraints of documenting IKS.

2.9.2 Presence of modern technologies

A significant number of indigenous methods of food preparation and preservation have extinct mainly because of the forces of urbanization, the emergence of technologically advanced food processing system which has accompanied in fast foods. The adoption of modern technologies result in indigenous knowledge system considered as backward, outdated and old fashioned. The westernisation is decreasing popularity of indigenous knowledge because it is often thought to be associated with being uncivilised.

For example, in modern way of living meat is preserved using refrigerators that requires energy source such as electricity and chemical additive which are expensive that resource-limited households cannot afford. Refrigeration involve above or below the freezing point to extends shelf-life of meat by slowing growth of microorganisms and action of enzymes (Zhou *et al*., 2010). The method has been used and reported to be successful. The chemical preservation is done by applying chemicals such as saline solutions to the meat to extend freshness after slaughter and to improve shelf-life (Zhou *et al*., 2010). The use of these techniques is believed in maintaining good nutrition quality of food and for food to stay long. However, the use of chemical to preserve their meat could be detrimental to their health.

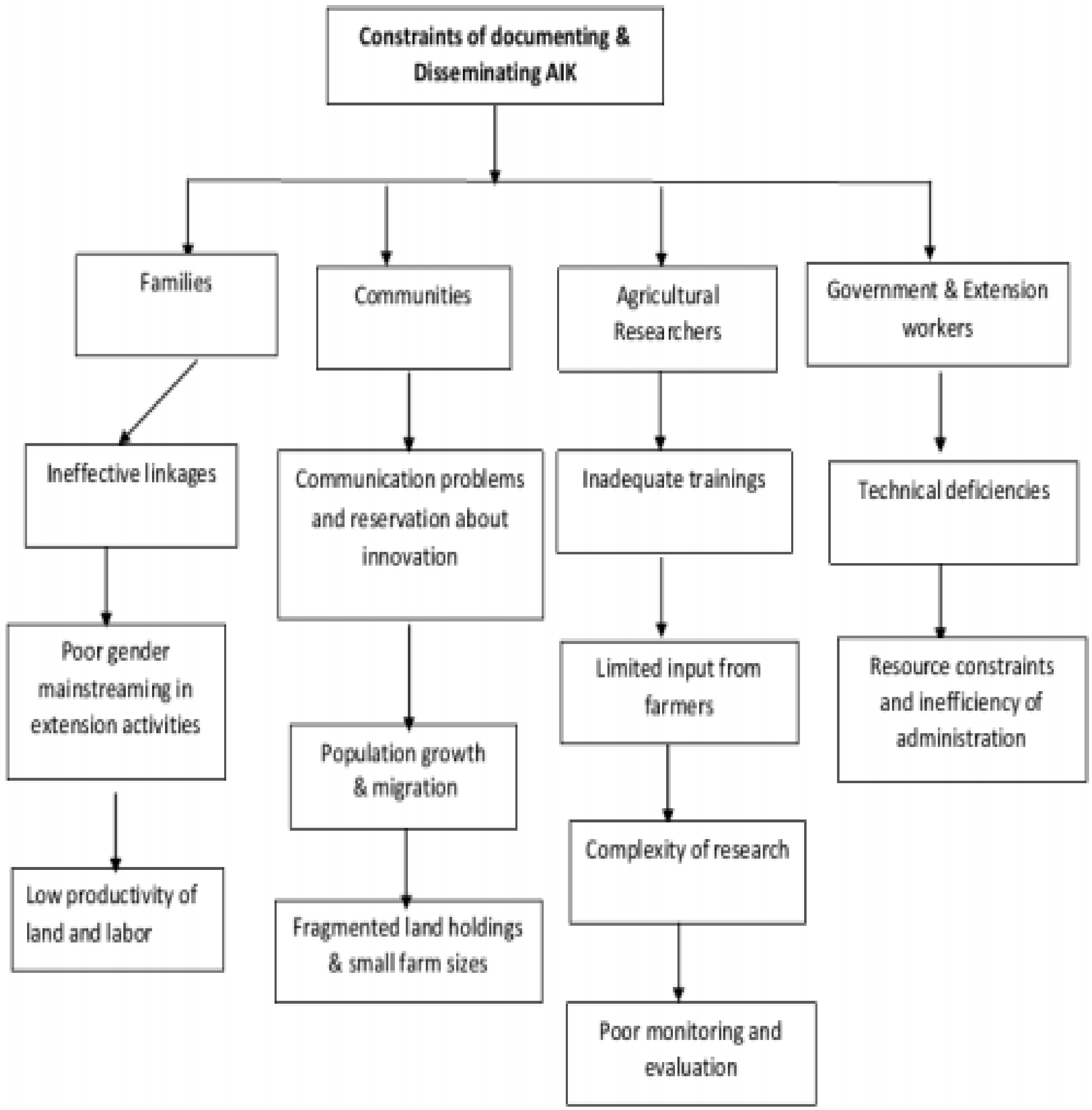

Figure 2.2: Constraints of documenting and broadcasting indigenous knowledge system (Asogwa *et al*., 2017)

2.10 Consumer acceptability and preference of chevon

Negative consumer response about chevon is influenced by negative misconception attached to "goat" which has imageries of low quality, odour and unpalatable meat (Degner and Lin, 1993). Hence, new names to refer to goat meat should be used such as chevon and cabrito. Pig meat also previously received negative comments until it was referred to as "pork" and consumers started preferring it.

Marketing-related aspect such as brand name of product play a role in consumers preference of a product. Goat meat name causes the consumers to misjudge chevon regardless of sensory attributes and its quality, as a results goat meat needs to be marketed under chevon or cabrito (Degner and Lin, 1993). Degner and Lin (1993) gave respondents unidentified beef and goat meat, results showed that respondents equally prefer any of the test meat products. Consumers prefer products with higher social ranking, goat meat is associated with lower social community standing while chevon and cabrito are associated with upper class consumers (Degner and Lin, 1993).

Simela *et al*. (2008) showed that chevon is acceptable to South African consumers and may be as acceptable as mutton if the meat is from goats of about two years old or younger. Moreover, for chevon to be preferred equally as other meat types more research is vital on identifying attractive meat parts that consumers prefer in goat meat so that goat meat can be marketed using them. In addition, cooking time and preservation methods which result in sensory attributes and nutritional value that consumers prefer must be thoroughly studied.

2.11 Summary

Goat productivity is low in communal production systems because of challenges associated with extensive production system communal farmers use, thus, contributing to food insecurity. Chevon was found to produce low fat content that reduces juiciness hence lower the acceptability by consumers. Therefore, it is important to develop research and development programs to improve the sensory characteristics of chevon and to understand the acceptance of chevon among consumers. An attempt was made to indicate the relationship between indigenous knowledge systems of chevon preparation and preservation, household food and nutrition security and agricultural extension. The objective of this study was, therefore, to determine the indigenous preparation and preservation methods on sensory and physico-chemical attributes of Nguni chevon.

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CHAPTER 3: Relationship between boiling time and sensory attributes of chevon

Abstract

The objective of the current study was to determine the relationship between boiling time and sensory attributes of chevon. Thirty clinically healthy castrated Nguni goats aged 1.5 years, with an average body weight of 18 ± 1.32 kg were slaughtered using the suprasternal notch piercing method. The carcasses were chilled for 24 hours before both right and left thighs were dissected and diced into fragments of about 3 × 3 cm. Five pots each with 3 litres of water and 50 diced fragments added inside were used to boil chevon for 20, 35, 50, 65 and 80 minutes at 100ºC. Aroma, tenderness, juiciness, flavour, residue and off-flavour were assessed using five-point hedonic scale in isiZulu. There was a positive correlation amongst all sensory attributes tested, except for aroma which was negatively correlated to all sensory attributes tested. A quadratic decrease in tenderness ($P<0.05$) with increase boiling time of chevon was observed. Juiciness decreased linearly ($P<0.0001$) with increased boiling time of chevon. There was a quadratic decrease in residue with increased boiling time ($P<0.0001$). The off-flavour decreased linearly ($P<0.0001$) with increased boiling time. There was no relationship observed between increased boiling time with aroma and flavour ($P>0.05$). Sensory attributes of chevon are influenced by prolonged boiling by causing a negative linear relationship. Boiling time of 35 minutes was found optimum in assessment of better sensory attributes of the chevon than 20, 50, 65 and 80 minutes.

Key words: Aroma, food security, flavour, IKS, juiciness, linear, quadratic, tenderness

3.1 Introduction

In most regions of Sub-Saharan Africa indigenous goats occur abundantly in communal areas (Rumosa Gwaze *et al*., 2009). In South Africa, resource-limited households use different ways to prepare chevon. Some boil and add salt, others boil and then fry with fat from any animals, and others merely roast over fire, while some eat it raw and find it excellent. Frying and roasting chevon mostly was done occasionally, during weddings and birthday celebrations. Raw chevon was eaten mostly during the ancestral worship such as chasing away bad luck. Boiling chevon is the most common method used in all functions, restaurants and fast food supply because it is simple (Webb, 2014). It involves heating cold water in a pot until it reaches the boiling point which is 100°C (Vasanthi *et al*., 2007). Although chevon formed part of the diet in most communal areas, but their importance in the diet and nutrition were never recognized.

Chevon has relatively low fat and cholesterol contents and high proteins; it is recognized as a healthier meat compared to beef, mutton, pork and chicken (Madruga *et al*., 2009). Consumption of chevon is constrained by consumers perception that chevon is tough and smell bad (Simela, 2005). These perceptions can be rectified by improving sensory attributes of chevon using varying boiling times. Prolong boiling is the main cause of toughness in chevon because of high oxidation of lipids (Webb *et al*., 2005). The use of low to medium time when boiling chevon can decrease denaturation of fats which are responsible for juiciness of the chevon that consumers would prefer. When evaluating the sensory attributes of chevon, consumers or sensory panellists, respond based on their perceptions through the senses of sight, smell, touch, and taste (Amerine *et al*., 1965). By using local villagers in tasting chevon could identify and respond to consumer preferences more efficiently, thus increasing their nutrition security and segmenting their specific market.

Boiling time starts when the water reaches maximum boiling point. Helmenstine (2017) describe the boiling point as the temperature at which the vapor pressure of a liquid equals the external pressure surrounding the liquid. For every boiling time used to prepare chevon, produces certain sensory attributes. The low to medium boiling of chevon may increase the sensory attribute in which may improve acceptability in market. An increase in boiling of chevon decreases the sensory attributes in which limits the acceptability of chevon by consumers. Knowledge about boiling time of chevon is not documented. A preliminary study revealed that boiling times for chevon preparations varies from 20 minutes up to 80 minutes. It is not clear for how long chevon can be boiled to maximise sensory attributes. Therefore, the objective of the current study was to determine the relationship between boiling time and aroma, tenderness, juiciness, flavour, residue and off-flavour of chevon. It was hypothesised that increasing boiling time has a linear relationship with sensory attributes of chevon.

3.2 Materials and Methods

3.2.1 Study site

This study was conducted at Jozini local municipality which is situated in uMkhanyakude district in extreme north of the Kwazulu-Natal province, South Africa (27^o 41'S and 31^o 58'E). The study site is 900m above sea level and classified under sub-humid climate characterised by hot-dry and cool-wet seasons. The average annual rainfall is 600 mm, while the maximum rainfall is received between January and March with the months of June and July being dry and cool. Jozini is mountainous areas with a topography that varies from deep ravines and high cliffs. The vegetation was mainly characterised of bush veld and foothill wooded grasslands (Morgenthal *et al*., 2006). The area is dominated by the Zulu tribe who largely rely on goat farming.

3.2.2 Goats and their slaughter

The care and use of goats was done according to the ethical guidelines given by the UKZN Animal Ethics Committee: (Reference Number: HSS/1071/016D). Thirty clinically healthy castrated Nguni goats were used. These goats were 1.5 years, with an average body weight of 18 ± 1.32 kg. Clinically healthy goats were purchased from communal farmers of Jozini with a body condition score (BCS) of 3. The BCS was assigned by assessing the physical appearance of the goat. For BCS of 3, the backbone is not prominent, ribs are barely discernible, an even layer of fat covers them, and intercostal spaces are felt using pressure (Wildman *et al*., 1982). The goats were raised on communal pastures which allowed them to move freely graze during the day, collected and penned at night. They were provided with water *ad libitum* but were not provided with feed.

The goats were randomly chosen and slaughtered using the suprasternal notch piercing. The method involves the killing by exsanguination without stunning. The goats were held with its forelegs spread apart, allowing it to stand on its hind legs and holds the head on the other hand holding a spear that is specifically designed to slaughter goats. The slaughter man vertically inserts the spear deep into the suprasternal notch and directed it downwards to the heart. Once the spear is removed, blood sparingly spraying out of the wound and to ensure maximum exsanguination the animal hung upside down. The goats took more than ten minutes to die. The goats were skinned and eviscerated as per the standard of indigenous knowledge procedure. Goats were hanged with their hind legs allowing it to face down to avoid contamination. As such, the skin was removed from hind legs moving down to the head thereafter the head, hooves and offal (intestine and tripe) were removed and the carcasses were chilled for 24 hours.

3.2.3 Preparation of chevon

A preliminary interview indicated that thighs are preferred organs for meat tasting as it contains less bones than other organs. Meat from both left and right thighs were dissected and diced into fragments of about 3 × 3 cm and prepared by one person using indigenous way of cooking. Five pots, each with 3 litres of water and 50 diced fragments added inside were used to boil chevon for 20, 35, 50, 65 and 80 minutes at 100ºC with about 125 g of salt to taste. After boiling, each meat sample was allowed to cool for 10 minutes. Five plates were used to put the meat samples and wrapped in aluminium foil until allocated to participants.

3.2.4 Sensory evaluation

The sensory characteristics were assessed by tasting the meat by local villagers of Jozini municipality. The participants were composed of 40 individuals (20 males and 20 females) from the same tribe (Zulu) of different ages. It was explained to the participants how to record scores for each characteristic tested. The waiting period between meat samples tasting was 10 minutes and after tasting, the participants were drinking water that contained piece of lemon to rinse their mouths before tasting the next sample to reduce crossover effects (Ngambu *et al*., 2011). Each participant completed an evaluation form rating the acceptability of aroma (*Izinga lephunga*), juiciness (*Ubusobho kwenyama*), tenderness (*Ukuthamba kwenyama*), flavour (*Ubumnandi benyama*), residue (*Ukuzwakala kwemisipha*) and off-flavour (*Ukunuka kabi kwenyama*) using five-point descriptive scale for aroma (1-extremely bland, to 5=very intense); juiciness (1=extremely dry, to 5= very juicy); tenderness (1= extremely tough, to 5= very tender); flavour (1= extremely intense, to 5= very bland); residue (1= extremely abundant, to 5=none); and off-flavour (1=none, to 5=extremely bland) (Babiker *et al*., 1990).

Table 3.1: Sensory characteristics of chevon tested

Characteristic	Description
Aroma	Odour sense of certain volatile substances
Tenderness	Ease of chewing with little force needed between molars
Juiciness	The moisture felt in the mouth after the first two chews
Flavour	Combination of taste and smell while chewing
Residue	Amount of tissues perceived in the mouth after swallowing
Off-flavour	Sour and unpleasant taste like livery/bloody

3.2.5 Statistical analyses

All the data were analysed using the Statistical Analysis Software (SAS) Version 9.1 (SAS, 2008). The Pearson correlation was performed amongst chevon sensory attributes. A polynomial regression was used to determine the relationship between boiling time and aroma, tenderness, juiciness, flavour, residue and off-flavour attributes.

The regression model used was:

$Y = \beta_0 + \beta_1 L + \beta_2 L^2 + E$

Where: Y is the response variable (aroma, tenderness, juiciness, flavour, residue and off-flavour)

β_0 = the intercept

$\beta_1 L$ = linear regression component

$\beta_2 L^2$ = quadratic regression component

E = the residual error

3.3 Results

3.3.1 Correlation coefficients amongst chevon sensory attributes

Correlation coefficients of aroma, tenderness, juiciness, flavour, residue and off-flavour attributes of chevon are shown in Table 3.2. Aroma had weak negative correlation with juiciness, tenderness, and residues (P<0.05). There was an insignificant relationship between aroma, flavour and off-flavour (P>0.05). Juiciness showed highly significant positive strong relationship with tenderness and residue (R^2= 0.91 and 0.74 respectively) and moderate positive relationship with flavour (R^2= 0.55), whereas there was no relationship with off-flavour (P<0.05). There was significant strong relationship observed between tenderness with flavour and residue (R^2= 0.57 and 0.67 respectively), then there was no relationship between tenderness and off-flavour. Flavour showed positive but weak relationship with residue and off-flavour (R^2= 0.38 and 0.31 respectively). Then a positive weak correlation was observed between residue and off-flavour (R=0.27).

3.3.2 Influence of incremental boiling time on chevon sensory attributes

Chevon at different times of boiling differed significantly (P<0.05) for tenderness, juiciness, residue and off-flavour. However, boiling time did not influence the aroma and flavour response of chevon (P>0.05). Figure 3.1 shows the response in tenderness, juiciness, residue and off-flavour to boiling time. A negative quadratic relationship between tenderness and boiling time was observed ($y= -0.000733x^2 + 0.003615x + 0.6913$). The increase in boiling time initially decreased with tenderness (Figure 3.1a). There was a negative relationship between juiciness and boiling time ($y=-0.038911x+0.8534$). As the boiling time increased, the juiciness decreased linearly (Figure 3.1b). The residue output decreased quadratically with boiling time ($y= -0.001103x^2 + 0.082625x + 0.6329$), residue decreased with increased boiling time (Figure 3.1c). The off-flavour responded linearly to boiling time ($y= -0.035158x + 0.6042$). The off-flavour decreased with the increased boiling time (Figure 3.1d).

Table 3.2: Pearson correlation coefficients amongst chevon sensory attributes

	Juiciness	Tenderness	Flavour	Residue	Off-flavour
Aroma	-0.43**	-0.28*	-0.25^{NS}	-0.30*	-0.12^{NS}
Juiciness		0.91**	0.55**	0.74**	0.07^{NS}
Tenderness			0.57**	0.67**	0.07^{NS}
Flavour				0.38*	0.31*
Residue					0.27*

** *P*< 0.001* *P* <0.05; NS: not significant (*P* >0.05)

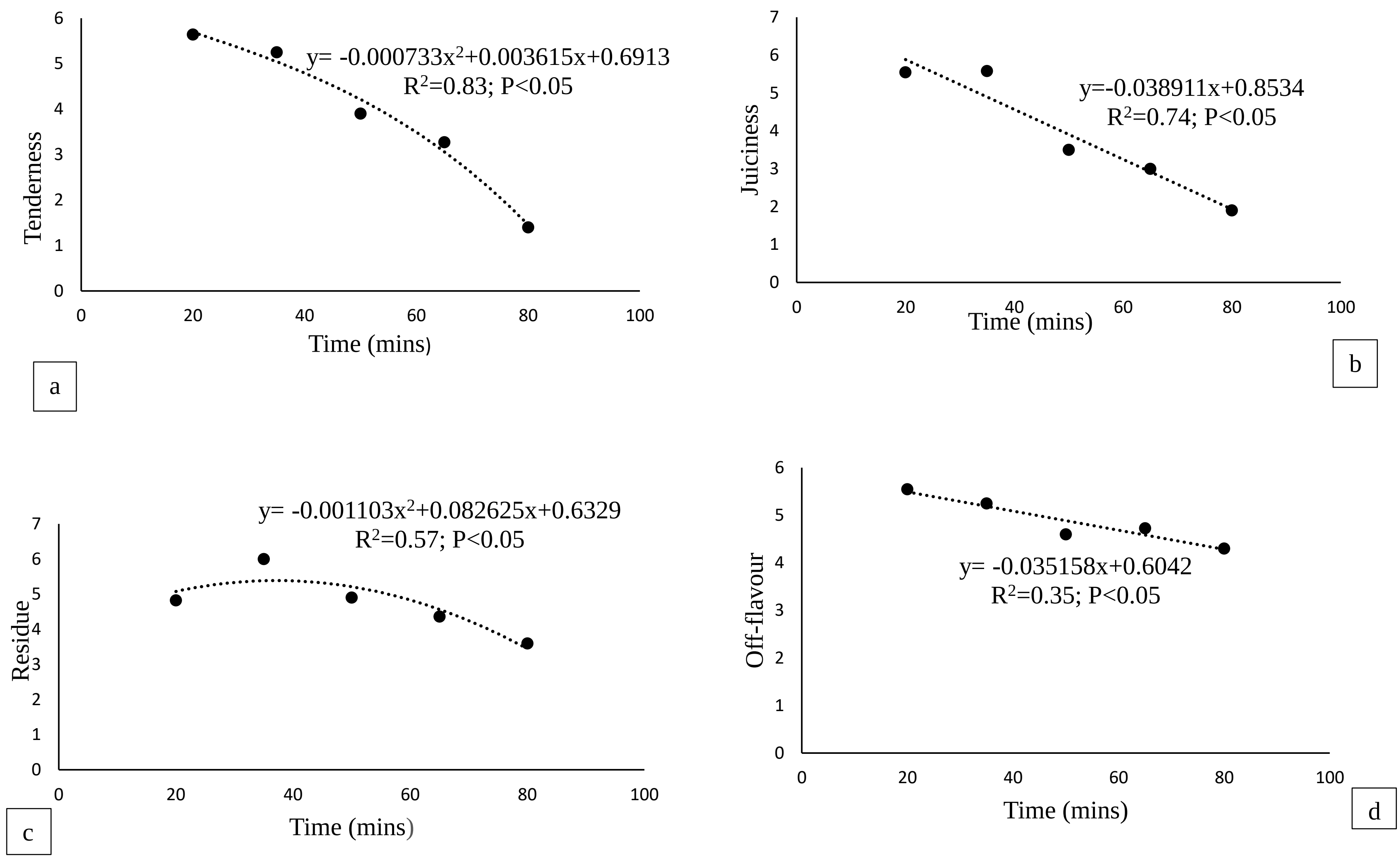

Figure 3.1: Relationship between a) Tenderness; b) Juiciness; c) Residue; and d) Off-flavour and boiling time

3.4 Discussion

Boiling is the common indigenous method that is commonly used by communal households to prepare chevon (Webb, 2014). To commercialise chevon, boiling time needs to be understood. In the current study, incremental boiling time was used to determine the relationship between boiling time and chevon sensory attributes, aroma, juiciness, tenderness, flavour, residues and off-flavour. The observed weak negative correlation of aroma with juiciness, tenderness, and residue could be attributed to the strong odour that is common in chevon. Consumers use the odour to predict the juiciness, tenderness, flavour and residues because consumers usually assume that meat with an unpleasant smell has lower juiciness, tenderness, flavour and residue compared to that which has an appetizing smell (Reed and Knaapila, 2010).

The juiciness showed a strong positive correlation with tenderness and residue. When chevon releases moisture during chewing juiciness increase, increase in juiciness increases tenderness and thus residue decreases (Sebsibe, 2008). The observed moderate positive correlation between juiciness and flavour could be attributed to the increased in juiciness and tenderness of chevon that contribute to the taste of chevon during chewing. The moderate positive correlation between tenderness with flavour and residue could be explained by the little force that is needed during chewing thus make chevon tasty and less particle left after chewing. The weak positive correlation was observed between flavour with residue and off-flavour. In general, flavour determines the smell and taste of meat (Auvray and Spence, 2008). Therefore, if chevon has sour taste or unpleasant smell more particle would be left after chewing.

The findings that tenderness decreases quadratically with increased boing time, suggest that prolong boiling could be avoided by using low to medium boiling were maximum tenderness at approximately 35 minutes of boiling was produced. The muscle glycogen and lactic acids have negative influence in meat toughness (Muchenje *et al*., 2008). Hence could be another factor that have reduced tenderness of chevon. As expected, there was a linear decrease in juiciness as the boiling time increases. The high intramuscular fats are associated with increased juiciness (Thompson, 2004), whereas less intramuscular fats are associated with decrease in juiciness (Schönfeldt *et al*., 1993). The initial increase in residue before it starts to decrease could be attributed to less juiciness and tenderness effect of prolong boiling hence causes more residue left in the mouth after swallowing. The linear decrease in off-flavour of chevon with increase boiling time could be attributed to presence of four methyloctanoic and four methylnanoic acids (Madruga and Bressan, 2011). These volatile acids are associated with negative strong odour that is sour and livery/ bloody like. Dhanda *et al*. (2003) reported that the castrated goat meat at early age has no off-flavour.

The lack of relationship observed in the present study for aroma and flavour could be difficult to explain because for every meat that is cooked would expect to have different smell and taste with the uncooked. The four methylnonanoic acid found in goat meat could be the explanation (Webb *et al*., 2005). This branched chain fatty acid is responsible for a strong goat odour which also affects taste. The decrease and increase in temperature during boiling was ignored and could be the better explanation for the lack of relationship observed. Flavor of chevon were reported to associated with age, breed, body weight, nutrition and method of coking (Webb *et al*., 2005). Presence of participants during preparation and the usage of similar location to serve all chevon boiled under different time intervals might have influenced the observed lack of relationship on aroma as they smelled the meat coming out of pots during preparation before it can be served. Hence, this might have caused masking of weaker odour produced over time of boiling.

3.5 Conclusions

Sensory attributes of chevon were influenced by increasing boiling time. Increasing boiling time of chevon resulted in quadratic decrease in tenderness and residue, whereas juiciness and off-flavour decreased linearly with increase boiling time. Prolonged boiling causes a negative relationship with sensory attributes of chevon. Chevon could be boiled using low to medium time at approximately 35 minutes for optimum sensory attributes. Furthermore, low to medium boiling maintain nutrients. It is, therefore, important to assess the influence of Nguni preservation methods on physico-chemical characteristics of surplus chevon after boiling.

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CHAPTER 4: Indigenous preservation methods of chevon in uMkhanyakude district, KwaZulu-Natal, South Africa

Abstract

The objective of the current study was to assess the influence of indigenous preservation methods on physico-chemical attributes of Nguni chevon. Thirty clinically healthy castrated Nguni goats aged 1.5 years, with an average body weight of 18 ± 1.32 kg were slaughtered using the suprasternal notch piercing method. At 24 hours post mortem, chevon brisket samples were collected (n=16), preserved with river salt (Treatment A), table salt (Treatment B), a combination of river and table salt (Treatment C) and without salt (Treatment D) for five days in a traditional house (rondavel) where fire was prepared every day. After preservation, visible fat and connective tissue were trimmed, briskets were cut into small pieces approximately 3×3 cm, freeze-dried at -54°C for three days, ground and analysed for moisture content, ether extract (EE), crude protein (CP), ash, pH and colour. Moisture content, CP, EE, ash and colour were different among all the treatments ($P<0.001$), except pH which was similar in all the treatments ($P>0.05$). Treatment D showed higher moisture than Treatments A, B and C. The CP content was high in Treatment B compared to Treatments A, C and D. Treatments A and B had similar EE content. Ash content was higher in Treatment B than Treatments A, C and D. Chevon lightness, redness and brightness was also influenced by preservation methods ($P<0.001$). The use of river salt when preserving chevon prevents deterioration of physico-chemical attributes and produces acceptable chevon.

Key words: Ash, colour, crude proteins, ether extract, moisture, pH, Saline solution

4.1 Introduction

The Zulu culture and societies have always ensured that food preservation was done communally so that every household had food throughout the year. Simela and Merkel (2008) reported that goats are slaughtered during cultural purposes such as ancestral worship, weddings and birthday celebrations. If there were chevon that is left, the Zulu households preserve it with river salt. The river salt could preserve chevon for over three days and still maintains its quality in terms of physico-chemical attributes and even improved its taste. The efficiency of the river salt is due to its ability to maintain low rancidity in the preserved chevon. Such indigenous knowledge (IK) base need to be thoroughly investigated through research so that could be used as a feedback to the Department of Agriculture and extension programs for the benefit of the rural communities. The widespread availability of table salt, which, apparently, has a higher salinity than river salt, has made the use of river salt to reduce drastically, threatening the sustenance of that IK.

When societies abandoned indigenous preservation methods, households are exposed to food and nutrition insecurity. There is also overwhelming evidence in the literature reviewed, which shows that the use of table salt to preserve meat results in botulism (Lawrie and Ledward, 2006). Table salt has also been fortified by adding iodine, making it even more ideal for household consumption. In many parts of the world, the households used different indigenous preservation methods for different purposes ranging from vegetables in Nepalesa (*Gundrum*), sweet potato chips in Zambia (*Shilengwa or Insemwa*), fermented bread in Ethiopia (*Injera*) and meat is preserved using bananas leaves in Uganda (FAO, 2013). The reviewed modern diseases such as obesity, diabetes, hypertension and heart diseases were unknown among Nguni societies, when the societies were consuming indigenous preserved foods.

Chevon is the least commercialized meat product worldwide but has a food security input for communal farmers in developing countries (de Andrade *et al*., 2017). Consumers prefer chevon that has attractive physico-chemical attributes, such as light and red coloured. They are also becoming nutritionally conscious hence prefer meat with high nutrients such as protein, minerals, and essential fats to reduce health and malnutrition challenges (Casey, 1992). Salting chevon alone does not stop the enzymatic action that causes degradation and spoilage; it only slows it down, therefore chevon needs to be dried or dehydrated after salting to prevent enzymatic activity, which causes change in colour, flavour and nutrients (Lee *et al*., 2017). Drying involves exposure of chevon to air to reduce the availability of water that is stored in to such a level where microbes cannot survive (Faisal *et al*., 2009). It is the appropriate method for resource-limited households and farmers to control spoilage of chevon, preserve surpluses and to increase its shelf life (Ibnouf, 2012). Chevon products produced by these techniques reduce storage and handling costs as they do not require refrigeration, even during distribution (Chang *et al*., 1996).

A preliminary study indicated that Nguni resource-limited households uses river salt to preserve the surplus chevon to prevent deterioration. River salt is a white rock from the river that is slightly saline. The salt is soaked in water for overnight to dissolve and form saline solution to preserve chevon. These salts are abundant and easily accessible in communal areas, however their contribution to nutrition security is unknown. Some farmers have no access to river salt. They, therefore, use table salt to preserve chevon. Others they use the combination of river and table salt because they have access to both salts. There is no information about how these indigenous preservation methods affect chevon physico-chemical attributes. It is, therefore, important to understand the influence of Nguni indigenous preservation methods on physico-chemical attributes of chevon. It was hypothesised that there is an influence between physico-chemical attributes of chevon and Nguni indigenous preservation methods.

4.2 Material and Methods

4.2.1 Study site, goats and their slaughter

The study site, experimental goats and their slaughter are described in Chapter 3.

4.2.3 River salt, chevon samples and preservation

River salt was found in most rivers, such as the Tugela River in KwaZulu-Natal, South Africa. The salt was crushed using a hammer to fill up a bucket approximately 1kg. It was soaked in about 9 litres of water for overnight to dissolve and form saline solution to preserve chevon. The salt was analysed at the UKZN soil science laboratory using electrical conductivity method. The salt was found to contained approximately 6.73 siemens per meter that is slightly saline.

Goat brisket (n=16) samples were collected approximately 24 hours post mortem. The brisket samples were treated with river salt, table salt, combination of river and table salt and without salt. There were four replicate samples per treatment. The saline solution was boiled, and briskets were immediately immersed for five minutes and allow to cool down for 5 minutes. Briskets preserved with table salt were immediately immersed in boiling water for five minutes, allow to cool down for 5 minutes and apply approximately 125 g of salt on each brisket. Briskets preserved with a combination of river and table salt were immediately immersed into boiling saline solution for five minutes, allowed to cool down for 5 minutes and apply about 125 g of salt on each brisket. Briskets preserved without salt were immediately immersed into boiling water for 5 minutes and allow to cool down for 5 minutes.

All samples were hanged into traditional house (rondavel) where fire wood was prepared every day. The drying period in the current study was chosen based on the outcome from the preliminary interview conducted in Jozini local municipality KwaZulu-Natal, South Africa, in which most of the chevon surplus in the households were consumed and finished within five days after slaughter. After preservation briskets samples from each preservation method were packed separately in labelled polyethylene zip-locked bags and transferred to the Animal Science Laboratory, University of KwaZulu-Natal, Pietermaritzburg, South Africa. Immediately upon arrival at the laboratory, all samples were unpacked and trimmed to remove visible fat and connective tissue using a knife and cut into small pieces approximately 3×3 cm, repacked and freeze-dry at -54°C. After three days, the dried brisket samples were brought out from the drier, ground and packed in labelled polyethylene zip-locked bags and kept in the plastic jar at room temperature for further analysis.

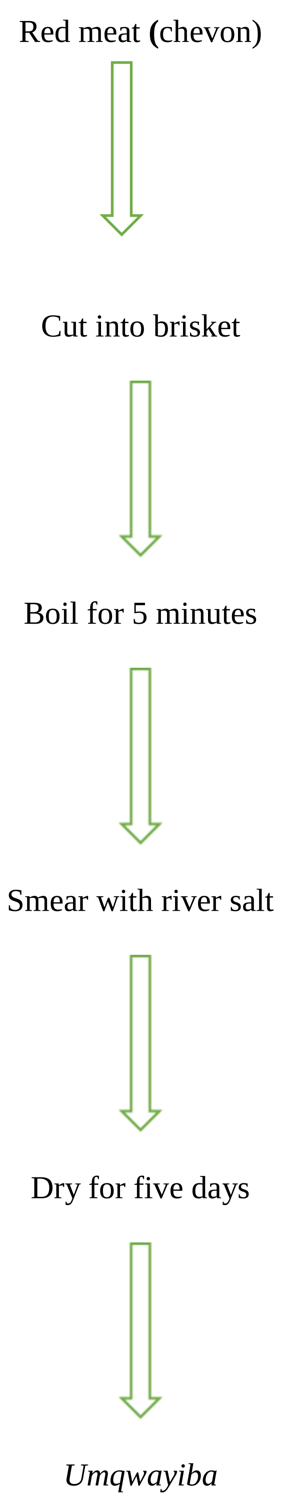

Figure 4.1: Process of preserving chevon using river salt

4.2.3 Proximate analyses

Moisture content, ether extract (EE), crude protein (CP) and ash were determined following the standard (AOAC, 1990) procedures. The dry matter (DM) samples of chevon weighing 2 g were placed in the dry clean crucible and incinerated at 550^0C overnight for ash content determination. After 24 hours of incinerating, crucibles were removed and allow to cool for 30 minutes. Ash samples and crucibles were weighed. The EE was determined using the Soxhlet apparatus. Buchi fat beakers were placed in the oven to dry overnight and after drying were removed and placed in the desiccator to cool and record mass. Dry samples weighing 5 g were placed into the labelled thimbles and oven dried at 95^0C for an hour. The thimbles were plug with cotton wool, approximately ¾ full petroleum ether was poured into beakers and each thimble was placed into single Soxhlet extractor. The beakers were placed onto the heating spaces and close allowing extraction to take place for 4 hours. After extraction, fat free-solvent was left overnight on the beach for residual solvent to evaporate and the beakers were dried in the oven at 90°C for an hour and cooling was allowed, weigh and record the mass. The nitrogen content of the samples was determined using the Dumas Combustion method in a LECO TruSpec Nitrogen Analyser, St Joseph MI, USA. The CP was calculated using the formula: N × 6.25. The pH of the chevon was determined using a pH meter on a homogenate of 2 g of meat sample in 10 ml distilled water.

4.2.4 Colour measurements

Colour was measured using a Colour Flex Spectrophotometer Gerard System 2000 colorimeter (Pacific Scientific, Spring, MD, USA) to determine, L*, a* and b* values, with L* indicating brightness, a* the redness and b* the yellowness range.

4.2.5 Statistical analyses

The preservation methods were analysed using the Statistical Analysis Software (SAS) Version 9.1 (SAS, 2008). The general linear model procedure was used to analyse the effects of river salt, table salt, a combination of river and table salt and without salt. Least square means were separated using the PDIFF. The Pearson correlation analyses was performed amongst MC, EE, CP and ash of chevon to evaluate how they influence one another.

4.3 Results

4.3.1 Influence of preservation methods on chemical compositions of chevon

Chemical compositions of chevon were significantly affected ($P<0.001$) by drying with river salt, table salt, a combination of river and table salt and without salt, except that pH showed no significant different in all the treatments ($P>0.05$) given in Table 4.1. The moisture content varied significantly from 177 to 334 g/kg in different treatments. The highest moisture content was observed in none salted and river salt treated chevon compared to table salt and a combination of river and table salt treated chevon (Table 4.1). The crude protein content varied between 704 to 758 g/kg. Table salt and a combination of river and table salt treated chevon showed highest content of proteins compared to none salted and river salt treatment (Table 4.1). Ether extract content varied greatly between the treatments from 99.2 to 273 g/kg, highest EE content was observed in chevon treated with table salt and a combination of river and table salt compared to none salted and river salted chevon had the lowest EE content. The ash content varied greatly between the treatments from 23.2 to 63.3 g/kg, table salted, and a combination of river and table salt treated chevon showed the highest ash content as compared to river salted and none salted chevon.

4.3.2 Influence of preservation methods on physical characteristics of chevon

Chevon lightness, redness and brightness was influenced by preservation with river salt, table salt, a combination of river and table salt and without salt ($P<0.001$) summarised in Table 4.2. The pH of chevon preserved was similar in all the treatments ($P>0.05$) (Table 4.2).

4.3.3 Correlation coefficients amongst proximate attributes

Table 4.3 summarises the relationship amongst proximate attributes of dried chevon with river salt, table salt, a combination of river and table salt and without salt. There was significant negative correlation between moisture and CP (R^2= 0.82) and moderate correlation between ash and moisture (R^2= 0.51), whereas there was no relationship observed between EE and pH with moisture ($P>0.05$). There was no relationship observed between CP, EE, ash and pH ($P>0.05$).

Table 4.1: Least square means (± SE) for the effect of preservation methods on chevon proximate attributes

Parameter	Treatment				SEM	P value
	River salt	**Table Salt**	**Combination (river and table salt)**	**Not salted**		
Moisture (g/kg)	307.4[b]	177.2[d]	219.6[c]	333.7[a]	0.756	**
Crude protein (g/kg)	719.4[b]	758.3[a]	724.5[b]	703.5[c]	0.405	**
Ether extract (g/kg)	191.5[b]	170.9[b]	99.2[c]	273.3[a]	0.322	**
Ash (g/kg)	29.1[b]	63.3[a]	34.5[b]	23.2[b]	0.676	**

Values with the different superscripts within a row [a, b, c, d] differ significantly * $P< 0.05$** $P< 0.01$; NS: not significant ($P>0.05$)

SEM: Standard error of the means.

Table 4.2: Least square means (± SE) for the effect of preservation methods on chevon physical attributes

Parameter	Treatment				SEM	P value
	River salt	**Table salt**	**Combination (river and table salt)**	**Not salted**		
L*	27.28[c]	32.17[b]	39.22[a]	26.02[d]	0.102	**
a*	4.41[b]	3.69[c]	3.00[d]	4.63[a]	0.047	**
b*	10.05[b]	3.76[d]	6.22[c]	11.70[a]	0.058	**
pH	6.63[a]	6.57[a]	6.47[a]	6.64[a]	0.111	NS

Values with the different superscripts within a row [a, b, c, d] differ significantly * $P< 0.05$** $P< 0.01$; NS: not significant ($P>0.05$)

SEM: Standard error of the means.

Table 4.3: Pearson correlation coefficients amongst chevon proximate attributes

	Crude Protein	**Ether Extract**	**Ash**	**pH**
Moisture	-0.82**	0.15^{NS}	-0.51*	0.45^{NS}
Crude protein		0.12^{NS}	0.24^{NS}	-0.21^{NS}
Ether extract			0.17^{NS}	-0.11^{NS}
Ash				0.17^{NS}

** *P*< 0.001* *P* <0.05; NS: not significant (*P* >0.05).

4.4 Discussion

Communal farmers have, for ages, been using river salt for preservation of chevon, some use table salt whereas others use the combination of two. However, river salt as an indigenous preservation method, need to be tested on how it influences the physico-chemical attributes of chevon, particularly protein, ash, fats and dry matter. This is because consumers are becoming nutritionally conscious and prefer meat with high nutrients such as protein, minerals, and essential fats to reduce health and malnutrition, which is part of food insecurity (Casey, 1992). Consumers are also increasingly avoiding foods that contain too much fat. Chevon is one such appropriate product. Colour of meat play a role that consumer notice when purchasing a product, consumers prefer red- light meat colour (Troy and Kerry, 2010). This necessitates the study of river salt on chevon colours lightness (L*), redness (a*) and yellowness (b*), and pH which is also responsible for the appearance of meat. Therefore, complete understanding of the variation in quality properties associated to colour is important to reduce negative impact of meat colour on processed products.

The decrease in moisture content produced by all the treatments in comparison to none treated chevon was expected because salt drying increases the dehydration rate of meat through osmosis (Lawrie and Ledward, 2006; Teixeira *et al*., 2011). The least moisture content achieved in the current study from chevon preserved with river salt could be attributed to the increase in osmotic pressure that comes with salt drying process. Hence, this causes the water to move from low pressure to high concentration thus microorganisms such as *Pseudomonas spp* and *Eriterobacferiuceae* die as the water is sucked by salt through osmotic pressure and prevents spoilage (Dave and Ghaly, 2011). This is desirable for good tenderness and increased shelf life of chevon thus benefits communal farmers as the produced products can stay long and transported far without the need of refrigerators.

River salt has low osmotic pressure as compared to table salt, this suggests that communal farmers using the combination of river and table salts produces better physico-chemical attributes of chevon. Moreover, combination of river and table salt drying showed the second lowest moisture content, this suggests the preservative ability of river salt drying can be improved by combining with table salt. The results of current study are in line with the finding of Puolanne *et al*. (2001) reported that the addition of sodium chloride lowered the moisture content and *Aw* value of beef and pork meat. Borch *et al*. (1996) stated that adding 4 % sodium chloride in water reduce the *Aw* value from 0.99 to 0.97 thus results in the interruption growth of microorganisms.

Chevon is high in proteins that is desirable for building block of bones, muscles, cartilage, skin, and contributing to wellbeing of the consumers (Webb, 2014). The protein content in the current study was ranging from lowest 703.5 g/kg and increased with the river salt drying. This may be attributed to preferential anion binding (Cl^-) by protein molecules (Girard and Valin, 1991). At pH above the isoelectric point, such preferential binding for chloride ions by protein molecule increases its net negative charge and results in repulsive forces. Thus, permitting additional water absorption within the protein network. Hence, protease which is responsible for breakdown of proteins decreases, and this further prevents chevon in addition to protein breakdown (Armenteros *et al*., 2009). This activity also decreases the heat stability of both myosin and actin, causing less energy input to remain for denaturalisation of protein (Thorarinsdottir *et al*., 2002). The protein content of beef was reported to decrease when frozen (Konieczny *et al*., 2007). This suggests that salting of meat by communal farmers might be better than refrigerating for maintaining the protein content of chevon.

Chevon is characterized by low intramuscular fat content and cholesterol which are good for consumers health (McMillin and Brock, 2005). The decrease in fat content with river salt drying compared to not salted chevon was expected in the current study because salt increases lipid breaks down in the systems containing eroded muscle residue and cytosol that contains iron ions. The increase in lipid peroxidation, increases the amount of catalytic free iron ions which might penetrate the lipid phase that affects the quality of chevon muscle and might lead to the development of off-flavours (McGee *et al*., 2003; Min *et al*., 2009). One of the lipid peroxidation inhibitors is glutathione peroxidase (Rotruck *et al*., 1973). This might suggest that chevon used in the current study had low content of glutathione peroxidase.

The ash content measures the mineral content of meat. Chevon contains high minerals such as iron, potassium and sodium which are important for bodily function of the consumers (Shija *et al*., 2013). These functions include heart function (iron), strong bones (ca), and maintains good blood circulation. The current study observed the increase in ash with river salt drying, which could be explained by effect of salt as contains high amount of minerals, particularly sodium and chlorine. The river salt could be suggested as the suitable treatment to maintain mineral content of chevon. Thus, consumers do not experience health complications such as heart failures and arthritis.

Meat colour is an important factor that consumer use to judge meat quality and acceptability (Hedrick *et al*., 1994; Muchenje *et al*., 2009). The L* values were improved but the a* and b* affected by river salt drying. Light colour attracts consumers, river salt treatment could be good as it increases L* and a*, respectively. The chemical changes in meat like oxidation, changes in pH, enzyme action, hydrolysis and protein denaturation (Kannan *et al*., 2001) could have contributed to the observation of colour in the current study. Kannan *et al*. (2001) reported that the maximum deterioration of the surface colour of chevon to occur within four and eight days. A bright colour is due to high myoglobin reaction with oxygen resulting in bright red colour (oxymyoglobin) of chevon. Hence river salts, increases the reaction of myoglobin with oxygen. The river salt drying did not affect the pH values (6.47 to 6.64 ± 0.111) of chevon. The findings concur with those reported by Lee *et al*. (2017) who observed similar pattern in restructured jerky indigenous goat meat. The pH in the current study agrees with Jama *et al*. (2016) who reported the post mortem pH values of 6.34 and 6.00 for pork at 45 minutes and 24 hours post slaughter. Meat with high ultimate pH retains moisture but may appear dark (Husak *et al*., 2008).

The observation that moisture was negatively correlated with CP and ash in the chevon, is the reflection of non-physiological salt concentrations (Lawrie and Ledward, 2006) as water provides the medium comfort for enzymes to catalyse proteins with help of minerals such as magnesium and iron which are needed for enzyme function. The findings that there was lack of correlation between CP with EE and ash, could be explained that chevon is commonly lean with less fat content and the role of minerals in proteolytic enzymes might not be that effective. The pH did not correlate with any chemical composition, this was not expected because pH of the meat is associated with the water holding capacity in meat which is the contribution of fats, proteins and minerals.

4.5 Conclusions

The preserved chevon with salt or without salt produces individual physico-chemical attributes that are desirable. Hence, salting Nguni chevon with river salt indigenous preservation method improves colour, ash and proteins, control the lipid oxidation and moisture content to a level where microbes won’t be able to survive thus produces acceptable physico-chemical characteristics. Furthermore, compounds responsible for salt gain and content were not determined.

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CHAPTER 5: General discussion, Conclusions and Recommendations

5.1 General discussion

The main hypothesis of the current study was that the influence of indigenous preparation and preservation on sensory attributes and physico-chemical attribute of Nguni chevon depends on increasing boiling time and river salt drying. Prolong boiling result in cooking loss which decreases juiciness of chevon (Webb, 2014). As boiling time increases the solubilisation of collagen and marbling occurs result in tender meat thus linear relationship achieved. Resource-limited household use different boiling time when preparing chevon dishes, some boil for less time as they want bloody like product when worshiping their ancestors, while some boil for long until it peels off from bones as they don't have strong molars to apply force when chewing. Therefore, boiling time could be restricted to produce desirable sensory attributes such as tenderness, juiciness, flavour, aroma, residue and off-flavour that are preferred by consumers. Fresh chevon may not be consumed at once and finished after slaughter, especially during cultural functions were some meat must be left for relatives that stay far to arrive on the day of the function, therefore river salt is used by resource-limited household to preserve chevon to prevent deterioration. Some households have no access to river salt and they are using table salt, while others they combine the two salts. The evaluate of these preservation is important river to produce physico-chemical attributes preferred and needed in consumers diet. This could improve acceptability of chevon and it could be commercialise thus contribute to food security.

Relationship between boiling time and sensory attributes of chevon in Chapter 3. The hypothesis tested was that incremental boiling time linearly increases the sensory attributes of chevon. The findings that tenderness decreases quadratically with increased boing time, suggest that prolong boiling could be avoided by using low to medium boiling were maximum tenderness at approximately 35 minutes of boiling was produced. The observed linearly decrease in juiciness and off-flavour with increase boiling time was expected. The high intramuscular fats are associated with increased juiciness (Thompson, 2004), whereas less intramuscular fats are associated with decrease in juiciness (Schönfeldt *et al*., 1993). Boiling time was expected to increase the sensory attributes of chevon in the current study. However, the results showed that sensory attributes individually decrease with an increase in boiling time. This suggest that boiling time should be restricted to avoid overcooking which reduce desirable sensory attributes. Moreover, avoiding stress on goats before slaughtering by stunning or resting them is essential to preserve the good sensory attributes of chevon.

In Chapter 4, the hypothesis tested was that river salt drying influences physico-chemical attributes of chevon. The observation that moisture decreased with river salt preservation, suggest that river salt drying as a preservative was effective. Through osmotic pressure river salt dries the chevon, decreasing the chances of spoilage by microorganisms. The river salt produced good protein content which is attributed to ability of salinity to inactivate enzymes that breakdown proteins. The decreased in lipids could be explained by activation of peroxidation of fats by saline process. The increase in ash content after river salt treatment was expected as compose of minerals such as potassium, calcium, iron, magnesium and sodium. River salt improve light and decrease red and yellow colours, light colour in chevon is due to myoglobin reaction with oxygen resulting in light red colour (oxymyoglobin) of chevon. This suggests that river salt increases the reaction of myoglobin with oxygen. It was observed that pH of chevon did not influenced by river salt preservation. Since chevon preserved with table salt might be harmful to consumers, river salt produced good physico-chemical attributes of chevon in the current study. Hence, chevon preserved with river salt could be commercialise.

5.2 Conclusions

The increase in boiling time resulted in a negative quadratic relationship with sensory attributes of chevon. Chevon requires low to medium boiling up to 35 minutes to produce and maintain desirable sensory attributes. The use of river salt to preserve chevon influences moisture, ether extracts, ash and colour attributes. River salt preservation produce acceptable physico-chemical attributes of chevon, thus, contribute to food and nutrition security.

5.3 Recommendations and further research

Chevon consumers could reduce undercooking and overcooking by using low to medium boiling time of 35 minutes. Consumers needs to weigh amount of river salt when preserving chevon as they need enough to produce desirable physico-chemical attributes.

Areas suggested for further research are:

- To determine the amount of salt gain in Nguni chevon preserved with river salt.
- To determine level of acceptability of preserved Nguni chevon on different markets
- To determine microbial level in Nguni chevon preserved with river salt.
- To determine the effect of river salt treatment on physico-chemical attributes based on length of preservation (daily basis).
- To evaluate sensory attributes of Nguni chevon compared to non-descriptive indigenous goats preserved with river salt.

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Appendix 1: Sensory evaluation form in isiZulu version

Ukuhlolwa kwezinzwa kwenyama yembuzi

Ubulili: Owesilisa □ Owesitazane □

Iminyaka: ≤20 □, 21-30 □, 31-60 □, ≥60 □

	Izici sezinzwa	**Isikala**	**Isikhathi sokupheka**				
			20	35	50	65	80
1	**Izinga lephunga**	1=Ayinaphunga 2=Liyezwakala kancane 3=Izwakala okukahle 4=Inephunga elikholu 5=Inephunga eleqile					
2	**Ubusobo kwenyama**	1=Yomile ngokweqile 2=Lomile kakhulu 3=Yome okuphakathi nendawo 4=Likhona isojana 5=Inesobho eliningi					
3	**Ukuthamba kwenyama**	1=Iqine ngokweqile 2=Iqine kakhulu 3=Iqine okuphakathi nendawo 4=Ithambe kakhulu 5=Ithambe okweqile					
4	**Ubumnandi benyama**	1=Imnandi ngokweqile 2=Imnandi kakhulu 3=Imnandi okuphakathi 4= Ayimnandi 5=Ayimnndi ngokweqile					
5	**Ukuzwakala kwemisipha**	1=Miningi ngokweqile 2=Mningi kakhulu 3=Kuphakathi nendawo 4= Mincane 5= Ayitholakali					
6	**Ingabe iyezwakala yini ukuthi inyama yembozi**	1=Cha 2=Kancane 3=Izwakala okuphakathi 4=Izwakala kakhulu 5=Izwakala ngokweqile					

Appendix 2: Sensory evaluation form in English version

Sensory evaluation of chevon

Gender: Male □ Female □

Age: ≤20 □, 21-30 □, 31-60 □, ≥60 □

	Sensory characteristics	**Rating scale**	**Cooking times**				
			20	35	50	65	80
1	**Aroma**	1=Extremely bland 2=Slightly bland 3=Slightly intense 4= Fairly intense 5= Very intense					
2	**Juiciness**	1=Extremely dry 2= Slightly dry 3=Slightly juicy 4=Fairly juicy 5=Very juicy					
3	**Tenderness**	1=Extremely tough 2= Slightly tough 3=Slightly tender 4=Fairly tender 5=Very tender					
4	**Flavour**	1=Extremely intense 2= Slightly intense 3=Slightly bland 4= Fairly bland 5=Very bland					
5	**Residue**	1=Extremely abundant 2= Very abundant 3= Moderate 4= Slight 5= None					
6	**Off-flavour**	1= None 2= Slight 3= Moderate 4= Very bland 5=Extremely bland					

Appendix 3: Ethical clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

2 August 2016

Mr ZM Mdletshe 208504445
School of Agricultural, Earth & Environmental Sciences
Pietermaritzburg Campus

Dear Mr Mdletshe

Protocol reference number: HSS/1071/016D
Project Title: The influence of indigenous slaughter methods for goats and chevon preservation on chevon quality of indigenous Nguni goats

Full Approval – Expedited Application

In response to your application received 14 July 2016, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

Cc Supervisor: Dr Michael Chimonyo
Cc Academic Leader Research: Professor Onisimo Mutanga
Cc School Administrator: Ms Marsha Manjoo

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