Indigenous knowledge on preservation and quality of chevon

By

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A Thesis submitted for the requirements for the degree of Masters of Science in Agriculture (Animal Science)

In the

School of Agricultural, Earth and Environmental Sciences

College of Agriculture, Engineering & Science

University of KwaZulu-Natal

2017

Pietermaritzburg, South Africa

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Declaration

I, *Khumalo Sonto*, declare that this is my original work conducted under the supervision of Professor Michael Chimonyo at the University of KwaZulu-Natal (Pietermaritzburg). This dissertation has and will not be submitted to any University. All the assistance towards the production of this thesis, including all the references contained therein, are fully acknowledged.

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Khumalo Sonto Date

Approved by

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Professor M. Chimonyo (Supervisor) Date

Indigenous knowledge on preservation and quality of chevon

General Abstract

The study was conducted to assess the indigenous methods on preservation of chevon and their effect on its quality. A case study approach was conducted in Nongoma to identify indigenous knowledge on chevon preservation and their effect on quality. Face to face interviews were conducted in isiZulu and 13 elderly, seven sangomas, four chiefs and experts in the Zulu culture were interviewed. Goats are used for barter trading, a source of food and income and are a symbol of wealth. Goats are also generally used for cultural purposes. The reason of slaughter determines the method of slaughter used. Good quality chevon comes from a fat goat, with shiny skin coat and castrated bucks. Four indigenous preservation techniques were commonly used. These include salting, drying, preboiling, underground preservation, river soil and wrapping using animal skin are also used. Households used varying methods of preserving meat-even those within the same community. Both Nongoma and Jozini community have a common preservation method. However, preservation of chevon by river salt is only known in Nongoma community. Indigenous preservation methods are greatly influenced by availability of resources and purpose of storage.

Furthermore, an experiment was conducted to compare indigenous preservation methods on chevon quality. Fifteen clinically healthy one-year-old Nguni wethers were used. Five preservation methods used were tested. These were (1) Pre-boiling with water (PWT), (2) Pre-boiling with river salt (PRS), (3) Pre-boiling with common salt (PST), (4) Pre-boiling with double salting (PSS) and (5) Storage without boiling and salting (NBS). The chevon was kept for up to four days at room temperature. The untreated meat (NBS) spoiled faster ($P<0.05$) than preboiled chevon. Changes of meat colour to green was considered to be the best indicator of the meat becoming unfavourable for household consumption. Colour was significantly influenced by the indigenous preservation method used ($P< 0.05$). Storage of chevon without pre-boiling and salting (NBS) turned green earlier than preboiled chevon followed by pre-boiling chevon with water (PWT) and river salt (PRS). Unpleasant smell, larvae production and manifestation of maggots and rancidity were all differed ($P< 0.001$) with preservation method used. Storage of chevon without pre-boiling and salting developed unpleasant smell and became rancid faster than pre-boiled chevon. In addition, dryness also varied with the preservation method used ($P<0.05$). The PSS method led to the least levels of spoilage. It was concluded that pre-boiling with double salting were the most effective in inhibiting chevon spoilage by providing an unsuitable environment for microbial growth. Furthermore, the addition of river salt had little effect of reducing chevon spoilage. Combining indigenous and modern preservation method was suggested to enhance chevon preservation and for resource limited households, use of pre-boiling with double salt was recommended as an ideal method

Key words: indigenous knowledge, preservation methods, chevon.

Acknowledgements

It is said that 'education is the key to success' and that 'hard work pays' but it is seldom said that along the journey of education God sends angels in the form of human beings to help you obtain such success. With that said I would like to first of all extend my gratitude to my supervisor Professor Michael Chimonyo for his guidance and supervision right from the start till the completion of my thesis.

- I extend my appreciation the National Research Foundation for funding my project, without their sponsorship I would not have obtained such an achievement.
- I also thank the research team that I worked very effectively with throughout my thesis.
- Also, not forgetting the staff of the Animal and Poultry Science and all my fellow postgraduates for their moral support.
- I thank the Nongoma Municipality for allowing me to conduct my research in their area, in particular Mr M Zulu for assisting me with open arms.
- I also thank the Jozini community for opening their environment and their homes to assist me in conducting the required experiments towards the completion of my dissertation, not forgetting Mr M. Khanyile, Mr Nkosi and Mr M.V Mkhwanazi for their guidance and assistance where required.
- Without the support of friends and family in any given situation, it is not easy to keep going strong and therefore, I thank my father Mr Mbongeni Khumalo and my sister Miss Londiwe Khumalo for always being my pillar of strength even when I felt like giving up.
- I would like to thank my mother Miss Fikile Nxumalo and my aunt Hlengiwe Nxumalo for their support.
- I thank my friends Miss Senzy Nxumalo and Miss Nomfundo Mkhize for being my support structure and my fuel to my engine going.

- When all is said and done I greatly and ceaselessly thank the Almighty God for giving me the opportunity to work with the abovementioned individuals and for being with me all the way.

Thesis Outputs

Khumalo S and Chimonyo M (2016). Indigenous knowledge systems of chevon presentation review, *African Journal of Indigenous knowledge system* (under review).

Conference Abstract

Khumalo S and Chimonyo M (2016). Indigenous knowledge systems of chevon presentation. BRICS Indigenous knowledge system (IKS) conference. 12 September 2016. KwaZulu-Natal Durban.

Dedication

This *dissertation* is dedicated to both Nxumalo and Khumalo family, to my parents Mbongeni Khumalo and Fikile Nxumalo, to my dearest grandparents whom I love the most (MaDlamini and Makheswa), to my aunt Hlengiwe Nxumalo, to my beautiful siblings Londiwe, Uminathi, Slindile and Ntando, to my friends Senzy Nxumalo and Nomfundo Mkhize.

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List of Abbreviations

BW	Body weight
CNS	Coagulase-negative staphylococci
CO_2	Carbon dioxide
DFD	Dark, firm and dry meat
FAOSTAT	Food and Agriculture Organization Statistics
GDP	Gross domestic product
HHP	High hydrostatic pressure
IK	Indigenous knowledge
IKS	Indigenous knowledge system
KG	Kilograms
KM	Kilometres
LAB	Lactic acid bacteria
LD	Longissimus dorsi muscle
µS/CM	Micro siemens per centimetre
ML	Millilitres
NaCl	Sodium chloride
NBS	storage without boiling and salting
NH3	Ammonia

NS	Not significant
PRS	Pre-boiling water with river salt
PSE	Pale soft exudative meat
PSS	Pre-boiling with double salting
PST	Pre-boiling with common salt
PUFA	Polyunsaturated fatty acids
PWT	Pre-boiling with water
SAS	Statistical analysis system
SEM	Standard error of means
SEMR	Standard error of meat for rancidity
WHC	Water holding capacity

Zulu terms

Imphepho	Plant scientifically called *Helichrysum* used to connect with the ancestors
Umemulo	Is a ceremony done by Zulu tribe to report to the ancestors that they girl is matured and ready to get married
Ugobho	Plant scientifically called *Gunnera perpensa* known to healing broken bones
Ithala	Is the upper place in a traditional house where preservation of meat occurs.
Uqgoko	A traditional tray mostly used by Zulu tribe
Isithebe	A traditional mat used by Zulu tribe.

CHAPTER 1: General Introduction

1.1. Background

Indigenous knowledge (IK) is an alternative way of encouraging development among resource-limited communities in many parts of the world. Indigenous knowledge is defined as undocumented skills, experience, ideas, information and insight about survival and livelihood developed over generations by local people within their community (Okorafor, 2010). The knowledge is vigorous, relies on memory and is transmitted systematically and orally. Indigenous knowledge plays a significant role in food security which is one the biggest challenges in Southern Africa. The demand for food in Africa has increased for the past 40 years due to a rapid increase in population growth. Food security is defined as the ability of households to have adequate food to lead a healthy and active life at all times (Lang and Heasman, 2015). Introduction of technologies has taken control over indigenous practices that were used for ages in food storage and preservation causing a risk of indigenous knowledge to vanish. Indigenous practices adapt slowly and are hence dominated by modern techniques. The use of IK systems to address food security among poor households is low and inadequately documented and thus under the threat of extinction (Kamwendo and Kamwendo, 2014).

Goats play a significant role in livelihoods of rural dwellers (Webb *et al.,* 2003). Most communal households own more goats than cattle and thus goats have a high potential of being utilised in enhancing food supply and security for households. Goats produce meat (chevon), milk, hair (cashmere) and skin. Chevon production is regarded as the most important use of goats in resource-limited rural communities (Webb *et al*., 2005). Resource-poor communities are faced with high levels of food insecurity. Women are responsible for the preservation of food in their households. This gives them a greater knowledge, skills, and experience over their male counterparts as they are the ones who sustain their households when there are food shortages. Furthermore, goats are preferred over other species because they require low levels of management, ability to adapt to harsh environmental condition, better utilization of limited or fibrous feed resources and the resistance to various diseases. Goats are prolific and require less input for moderate level of production, they mature early. They are kept for slaughter when performing rituals and for emergency cash flow (Webb and Mamabolo, 2004a). Although conventional methods to improve chevon quality are available, there is no indigenous knowledge on the preservation of chevon. Meat quality includes colour, tenderness, juiciness, flavour and aroma (Webb *et al*., 2005).

Persistent droughts have posed a threat in food production in Sub-Sahara which causes drastic changes in dietary habits from predominantly grain-based products to animal-based products. Animal products are inherently perishable. Therefore, food wastage is likely to increase due to spoilage. Indigenous preservation techniques have been an important strategy for food storage, but the information and skills have not been captured and documented to prevent them from extinction. Preservation is the processing of food that includes treating or handling food to stop or reduce spoilage and enhance its shelf life (Warriss, 2001). This process is the way of storing excess food that is abundantly available at certain times or season of the year so that in times of food scarcity this food can be consumed. Meat is usually available in excess during festive season and thus raise the need to be preserved for future consumption. Preservation of chevon is not only done to retard its spoilage but also to control undesirable changes of wholesomeness, nutritive value, and growth of microorganisms (Faisal *et al.*, 2009). Advanced meat preservation techniques such as freezing, irradiation, canning, and the addition of chemical additives are unavailable to rural households. Resource-poor rural households do not own electrical appliances such as refrigerators to preserve meat. Therefore, an approach that involves the local experience of households might result in a balanced mix of local and modern techniques, to reduce the risk for food wastage, loss of nutrients, flavour, and taste. Indigenous knowledge on the preservation of chevon needs to be captured, preserved and transferred to the next generation. It is, therefore, crucial to identify indigenous methods that are used for chevon preservation and their effect on quality. Furthermore, the effectiveness of these indigenous methods in storing chevon need to be understood to identify the most appropriate method under different circumstances. These indigenous methods may if well understood, be scrutinized and improved to enhance their effectiveness and efficiency.

1.2 Justification

Limited information is available on indigenous methods on chevon preservation. The information needs to be gathered and documented to prevent it from extinction. Goats are dominant to rural households and chevon consumption is high, therefore goats have a potential in reducing poverty and improve the livelihood of rural households. Consumers demand to know the nutrient quality of meat they consume because they are conscious of their health and are increasingly focusing on their eating habits (Katekhaye, 2014). It is important to explore indigenous preservation methods and considering the spoilage of chevon to provide nutritious and healthy meat that is appropriate for human consumption and prevent malnutrition. This improves the quality of chevon and the use of indigenous goats as a source of food than other livestock. Identifying an appropriate and less energy requiring preservation method can be achieved through research. The knowledge can be used during load shedding which is the major challenge in many countries in Southern Africa, causing households to run a risk of food insecurity. Developed countries are using advanced preservation methods, though there is a minority that still lives of traditional preservation methods such as drying, smocking and fermentation. However, on the other hand majority of the African countries especially in rural areas do not have access to advance preservation techniques and the indigenous methods they are using for meat preservation are at risk of extinction thus need to be captured and documented. Indigenous preservation methods contribute to the reduction of food wastage. Understanding indigenous preservation methods can also bring a balanced mix of local and modern techniques to reduce the risk of food wastage, loss of flavour, nutrients and taste in chevon. These methods assist households reduce meat wastage, spoilage and enhance food security especially resource-poor households.

1.3 Objectives

The broad objective of the study was to assess the indigenous knowledge on preservation methods of chevon and their effects on quality. The specific objectives were to:

1. Identify the indigenous preservation methods of chevon and their effect on quality; and
2. Compare indigenous preservation methods on chevon quality.

1.4 Hypothesis

The hypotheses tested were that:

1. There are different indigenous preservation methods used.
2. Indigenous preservation methods affect chevon quality differently.

1.5 References

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CHAPTER 2: Literature review

2.1 Introduction

Indigenous knowledge is the systematic body of knowledge attained by local people through the build-up of experiences, informal experience and intimate understanding of the environment in a given location. The knowledge is unique to every culture or society and it is communally owned (Kamwendo and Kamwendo, 2014). Indigenous knowledge is dynamic and adaptive. It changes as the society changes socially, economically and culturally. The knowledge is transmitted orally and by participating in the indigenous practices (Msuya, 2007).

Goats are the second most important livestock species after cattle in Southern Africa and they play a significant role in eradicating food scarcity in communal areas (Rumosa Gwaze *et al*., 2009). Households are willing to part with a goat than other livestock and that gives the goat a greater chance of being a source of food than other livestock (Homann *et al*., 2007). Chevon is a red meat from goats with greatest production and consumption in Asia and Africa (Kannan *et al*., 2001). In Africa especially in rural areas, goats provide the necessary nutrients that humans require (Rumosa Gwaze *et al*., 2009). Chevon is nutritious, leaner, healthy with low cholesterol and high protein and iron content than other types of meats (Webb *et al*., 2005).

Processing and preservation have become an important strategy for storing excess food for future use and it is an important manufacturing step that is used to provide food safety, maintain quality, extend shelf life and prevent meat spoilage (Rahman, 1999). Indigenous knowledge plays a significant role in sustaining many households worldwide. Indigenous preservation methods of meat were practiced enhancing food security. Modern technologies being dominant over indigenous knowledge are however threatening these skills with extinction. The review discusses the goat production in communal production systems, chevon consumption patterns, slaughter methods, causes of meat spoilage, the importance of meat preservation as well as methods used to preserve meat including modern and indigenous preservation methods.

2.2 Communal goat production systems

The world total number of goats is 861.9 million heads and the largest number of goats is found in Asia, followed by Africa, representing about 59.7 % and 33.8%, respectively. Goats production worldwide has been increasing by 1to 4% annually, while that of sheep decreasing by 10 %, reflecting the emergence of goat as a major livestock species (Aziz, 2010). In South Africa, 50 % of goats are kept under small- sale conditions (Shabalala and Lehohla, 2002). Furthermore, goats represent the principal economic output, contributing to the large amount of income of the resource-poor farmers (Salem and Smith, 2008). The goat is reputable for its hardiness, prolific breeding, early maturing and low requirements for input. Moreover, goats are also desired for their ability to utilize low quality feed (Olivier *et al*., 2002; Kouakou *et al*., 2008; Simela and Merkel, 2008). In addition, goats play an essential role in the livelihood of the resource-poor through risk mitigation and accumulation of wealth. Goats are, therefore, an ideal vehicle for generating cash returns to meet food security needs and improve welfare among rural households (Rumosa Gwaze *et al*., 2009). Communal goats are important for fulfilling multiple roles such as the provision of meat, milk, manure, skin, cashmere, mohair (Haenlein and Ramirez, 2007), draught power (Saico and Abul, 2007) and barter trade (Morand-Fehr *et al.,* 2004). Goats are also exchanged or loaned to neighbours to enhance kinship ties (DeVries and Pelant, 1987). In other communities, goats are used for guiding sheep during herding of the latter (Rumosa Gwaze *et al*., 2009).

Indigenous goat breeds available in Southern Africa includes Nguni, Mashona, Matabele, Tswana, Malawi and Landim goats. The adoption and performance of these breeds to local production conditions are usually confounded by the low standard of management under which these breeds are kept as well as high diseases, parasite challenge and low nutrition (Peacock, 1996; Mpofu, 2002). When a productivity index, which compromises fertility, survival and yield traits, is used to compare goat breeds raised under rangeland conditions indigenous goats outperform imported breeds (Mpofu, 2002; Monkhei and Madibela, 2005).

Communal goats are usually managed by herding or tethered (Rumosa Gwaze *et al*., 2009). Goats are herded during the day and penned at night. Goats are rarely supplemented and the low intake of poor quality feed limit productivity. However, they are allowed to utilize crop residues until the beginning of the rainy season when the goats have to be herded (Peacock, 1996). Tethered goats are normally secured with a rope and tied to a leg to prevent them from damaging crops and enable farmers to conduct other farm activities (Webb and Mamabolo, 2004b).

2.3 Chevon consumption patterns

Chevon consumption is low compared to other livestock such as beef, mutton, and chicken. Tshabalala et al. (2003b) reported that meat yield from indigenous goats is limited due to the traditional low economic significance of goats in formal market. Casey and Webb (2010a) reported that low chevon consumption is also due to the preference of beef, mutton, and chicken by a majority of urbanised households. Chevon is mostly consumed in rural households and most of it is consumed during cultural ceremonies and events. Most of the chevon is consumed directly by the producer or locally and only about 0.5 % of goat meat is formally traded internationally (Dubeuf *et al*., 2004). Different age groups of goats are used for human consumption. In the Middle East, and Asian southwest region, the meat of young goats is preferred. Goats are slaughtered weighing 13-25 kg males and 11-20 kg females at the age of

12-24 months. Adult goat meat is consumed in Africa and India where goats are slaughtered at the age of 2 to 6 years, weighing 20-30 kg (Madruga and Bressan, 2011). Meat from goats that is up to three months of age is consumed in Portugal and this type of meat is expensive in the market. Spain, Portugal, Greece, and Italy are among the countries that consume meat from a young goat with increasing demand during Christmas and Easter holidays. Chevon production is much appreciated in these countries and an important part of the income of breeders (Santos *et al.*, 2007). There is an increasing demand for chevon in the United States of America due to increasing number of people from Africa, Asia, middle-East and Hispanic origin. Usually chevon is produced in the southern US state (Texas) and traded in the Eastern metropolitan area. Nonetheless, other states including Carolina and California are now much interested in goat meat production especially the newly imported Boar goat breed (Dubeuf *et al*., 2004).

2.4 Slaughter methods of goats

Poor handling practices pre-slaughter or post slaughter affect the quality and shelflife of meat(Gregory and Grandin, 1998; O'Neill et al., 2006). Both conventional and traditional slaughter techniques are used for transforming animals to meat. The widely used methods are the conventional method, ritualistic and traditional slaughter method. Traditional slaughter methods are commonly used in developing countries and in addition the ritualistic slaughter method widely known is the Islamic or Halal method (Clottey, 1985).

2.4.1 Stunning

Although stunning is currently considered as the best slaughter method, it however contributes to stress imposed on animals during slaughter. Both electrical and carbon dioxide stunning trigger a massive secretion of adrenaline and other catecholamines in cattle, pigs, and sheep (Lambooij, 2014). Epinephrine levels induced by electrical stimulation in pigs is higher than the level which can be induced by environmental or physiological stress. Adrenalin is a hormone that is secreted by the adrenal gland in response to physical and mental stress (Muchenje *et al*., 2009). Acute stress such as fear, or excitement caused by handling methods occur in the slaughter yards or stunning pen. Animals that are accustomed to being handled are most likely to be less severely stressed than animals which has no experience with people. Improper stunning may lead to animals kicking violently and following concussion, haemorrhages, a rapid drop in pH, faster development of rigor mortis, reduced water-holding capacity and this can increase the rate of postmortem muscle glycolysis (Gregory and Grandin, 2007). However, stunning pigs with CO_2 can inhibit the incidents of ecchymosis and bone fractures, enhance meat quality and improve worker safety compared to electrical stunning. Use of gas further imposes economic advantages as well as reduce animal welfare concerns (Channon *et al.,* 1997; Channon *et al*., 2002).

All the stunning methods increase catecholamine levels by a factor of seven in pigs, however, nothing has been documented on the level of catecholamine-induced by stunning in goats. Adrenalin and other catecholamines which are released during stunning increases the incidents of PSE meat in pigs. In contrast, beef or lamb should be bled as soon as possible after stunning by captive bolt since, if the circulation of adrenalin is permitted for few minutes, it may toughen the meat. However, triggering the adrenalin during captive bolt stunning may improve the colour of beef and this would be especially true for animals which had endured prolonged stress before stunning. Conditions in PSE increase the chances of microbial growth resulting in the reduced shelf life of meat (Lambooij, 2014). Stunning affect eating quality of meat. Channon *et al*. (2002) reported that stunning greatly affect pork quality attributes such as drip loss and pork colour. A combination of low pH and high temperature result in reduced solubility of protein and therefore influence pork colour. Pale colour has been accredited to denaturing of sarcoplasmic and myofibrillar protein (Pérez *et al*., 2002). Pre-slaughter stress caused by the practices conducted before slaughter causes a depletion of muscle glycogen reserves antemortem and to an insufficient meat acidification postmortem, which leads to increase in meat pH. The rate and extent of postmortem glycolysis and ultimate pH of the muscle are important factors that determine meat quality (Casey and Webb, 2010b). High ultimate pH values of goat meat suggest that goats are generally highly prone to stress. Simela *et al.* (2004); (Webb *et al*., 2005) confirm this suggestion about the antemortem concentrations of glycolytic metabolites in muscles. Glycogen content of animal muscle is reduced when exposed to stress which causes changes in pH of meat to high or lower levels, depending on the invention of lactic acid (Rahman, 1999; Chambers *et al*., 2001; Kerry *et al*., 2002). Lactic acid is produced due to the breakdown of glycogen content of animal muscles via an anaerobic glycolytic pathway.

Higher levels of pH (6.4-6.8) result in dark, firm and dry (DFD) meat. Depletion of glycogen in animal muscle cause major effect on the storage of meat. Long-term stress causes DFD meat which has a shorter shelf life (Chambers *et al*., 2001; Miller, 2002) Severe short-term stress results in a pale, soft and exudative (PSE) meat. PSE meat has a pH lower than the normal ultimate value of 6.2 which is responsible for the breakdown of proteins, providing a suitable medium for the growth of bacteria(Rahman, 1999; Agbeniga et al., 2013).

2.4.2 Islamic slaughter (Halal)

Islamic slaughter (Halal) is the common ritualistic slaughter used all over the world. This method is derived from the Koran, the law governing Halal slaughter stipulated that the name of Allah (or God) should be mentioned at the initiation of the operation (Farouk *et al*., 2014). The aim of Halal slaughter method is to remove blood as quickly as possible and stop the delivery of oxygen to the brain and that the blood must flow out completely from the animal (Gregory and Grandin, 2007).

Aksu *et al.* (2006) compared the captive bolt stunning with Halal slaughter and reported no differences in meat quality. Restraining animals during Halal slaughter reduces pain, bruise, and injuries from animals (Lambooij *et al.*, 2012; Velarde *et al*., 2014). Furthermore, birds are restrained using cones and shackling (Lambooij *et al.*, 1999). Lambooij *et al.* (1999) compared carcass quality of corned and shackling birds and reported that occurrences of thigh muscle haemorrhages were high in shacked birds than corned. However, shacked birds had slightly high blood loss than corned and their meat was more tender than corned restrained birds. This could be attributed to high pH values observed in the meat of cone-restricted birds. These incidents could be avoided by ensuring that restraining objects do not have sharp edges to avoid injuries as well as control of pressure to avoid excessive pressure (Farouk *et al*., 2014). High voltage in chicken induces heart fibrillation resulting in inefficient bleeding, increased haemorrhages and even death prior exsanguination. This further increase dislocation, broken bones, red wing tips and haemorrhages of the deep breast muscle in broilers (Ali *et al*., 2007).

López *et al*. (2008) assessed the welfare, bleeding, efficient and meat quality in rabbits subjected to slaughter through either Halaal slaughter without stunning or electrical stunned prior slaughter. Halal slaughters rabbits had higher blood loss and lower pH values in Longissimus dorsi muscle and Biceps femoris muscle. Aksu *et al*. (2006) compared Halal slaughter with captive bolt stunning and neck cutting and found no effect on the removal of haem or blood in sheep and cattle.

2.4.3 Jewish slaughter (Kosher)

Kosher is the most widely used ritualistic slaughter method following Halal slaughter (Farouk *et al*., 2014). Agbeniga *et al*. (2013) reported that captive bolt stunning before sticking result in higher cooking losses and yielding less tender meat compared to the Kosher slaughter method. Ritualistic slaughter has been reported to produce meat with high pH after extended storage. However, Holzer *et al.* (2004) reported low pH in Kosher meat compared to non-kosher slaughter method. There was a perception that blood loss is greater in animals slaughtered using Halal and Kosher post-slaughter. Empirical studies have, however, reported no differences in blood loss in sheep and cattle slaughtered with or without Halal or Kosher stunning (Agbeniga, 2012).

Mast and Macneil (1983) reported that chicken had high water uptake during immersion chilling and lost more weight during storage. However, meat from kosher slaughter was more tender than conventional breast meat. Koshering affects meat quality by removing some myoglobin and other sarcoplasmic proteins due to the use of water for shriah which is soaking in cold water for 30 minutes and extensive use of salt for Hadacha which is salting of surface using kosher coarse salt for about a one hour (Asghar *et al*., 1990). This, therefore, affects the colour, flavour and the overall product quality, especially protein loss due to oxidation. Compared to conventional slaughter method, kosher has high salt concentration. Increase in salt concentration persists in meat and was not affected by rinsing the meat and cooking (Angel *et al*., 1989). Mast and Macneil (1983) reported that sodium content in meat and skin of the kosher chicken to be 4 to 6 folds greater than non-kosher chicken (Powers and Mast, 1980) and beef (Zuckerman and Mannheim, 2001). Salt is the catalyst that increases lipid oxidation (Kanner *et al*., 1991), thus kosher meat develops unpleasant odour during postmortem refrigeration (Holzer *et al*., 2004). Kosher meat has been reported to have a low microbial count and slightly higher thiobarbituric acid peroxide values than its conventional complement. Kosher reduce the level of *Escherichia coli* and *Salmonella* spp due to its preservative action such as alteration of water activity and ionic strength of the meat as well decreases the amount of salmonella on the surface of the chicken (Hajmeer *et al*., 1999; Oscar, 2008).

2.4.4 Indigenous slaughter methods

Indigenous slaughter methods have been used and are still commonly practised by developing countries especially in rural areas (Clottey, 1985). Indigenous Slaughter method are mostly practised in rural areas within South African context especially by the Zulu and Xhosa tribe when performing rituals and slaughtering for meat consumption (Webb and Mamabolo, 2004a). Prior to slaughter, sheep and goats are securely held on their back on the ground by two or three men while the mouth is grabbed tight and drawn backward to stretch the neck. Women are not usually involved in slaughtering sheep, goats and cattle. They commonly slaughter chicken. Therefore, this imposes a lot of stress on animals thus contributing to the deterioration of meat. Poor handling practices pre-slaughter or at slaughter affect the quality and shelf life of meat (Gregory and Grandin, 1998; O'Neill et al., 2006). The meat characteristics affected by pre-slaughter stress consist of ultimate pH, colour, water-holding capacity (WHC), shelf life, cooking loss and tenderness (Hoffman *et al*., 2003; Muchenje *et al*., 2009). When animals are stressed, glycogen reserves are depleted resulting in higher pH (Muchenje *et al*., 2009). Numerous studies have been conducted on the effect of pre-slaughter handling on the quality of meat (Gregory and Grandin, 1998; Kerry *et al*., 2002; Muchenje and Ndou, 2011; Nahman *et al*., 2012; Agbeniga *et al*., 2013; Vimiso and Muchenje, 2013; Toplu, 2014). An increase in physiological stress and or physical activity in livestock during transport and pre-slaughter handling result to depletion of muscle glycogen reserves prior to slaughter. The depletion results in a higher ultimate meat pH, greater water-holding capacity, darker meat colour, and tougher meat. Skinning and evisceration of meat in indigenous slaughter methods are not dissimilar to conventional methods, except that they are conducted in the ground with little consideration to reduce contamination with soil (Mnguni, 2006). Contamination of meat during slaughter also affects the shelf life of meat. Indigenous slaughter methods which have lower levels of hygiene compared to stunning causes greater chances of meat contamination. Contaminated meat is more prone to microbial and oxidative spoilage, therefore, affecting storage of meat. Contamination of meat may occur during slaughtering when using a dirty knife, fisting when skinning, contamination with the intestines during evisceration (Roberts, 1980; Gill, 1998; Gill *et al*., 1998). This further reduces the shelf life of meat, therefore appropriate hygiene practices proper handling of animals pre-slaughter and post-slaughter should be taken into consideration when slaughtering animals (Clottey, 1985).

2.5 Causes of meat spoilage

Different methods have been previously conducted to detect spoilage in meat (Barlow and Kitchell, 1966; Gardner and Stewart, 1966; Dainty, 1971; Gill and Newton, 1979), however, there is no specific method that is accurate to measure spoilage in meat. Jay (1972) reported that the method used to detect spoilage must be able to respond and reflect human quality attributes, the method should be based on changes in meat quality attribute in terms of personal taste. Spoilage of meat is greatly affected by microbial spoilage, enzymatic spoilage, and oxidation. These elements may work independently or together to spoil meat (Dave and Ghaly, 2011b).

2.5.1 Microbial spoilage

Bacteria, fungi and yeast are responsible for spoilage of meat. These microorganisms are present in meat and meat product prior to spoilage (Gill, 1983; Borch *et al*., 1996a). Animal skin, feathers, and hides convey a large number of microorganisms including those that cause diseases such as *salmonella, Escherichia coli and* campylobacteria are present in the intestine of the animal. Therefore, pre-slaughter and post-slaughter handling of meat is essential in enhancing the shelf life of meat. For example, poor handling of animal prior slaughter may result in increased depletion of muscle glycogen that further decreases the shelf life of meat. Contamination of meat during evisceration also contribute to spoilage of meat at a faster rate (Dave and Ghaly, 2011b). Pre-slaughter stress reduces the glycogen content in meat by changing the pH, depending on the production level of lactic acid. Long-term stress imposed on the animal before slaughter results in increased pH to 6.4-6.8 and DFD meat. In contrast, reduction in pH causes PSE meat which is caused by severe short-term stress in animals. Pale soft exudative meat has a pH lower than the normal ultimate value of 6.2 which is accountable for the breakdown of protein and creating a conducive environment for bacterial growth (Chambers *et al.*, 2001; Miller, 2002). For these microorganisms to cause spoilage, they must be subjected to environmental conditions that favours their growth.

The acronym FATTORM is generally used to describe the condition that enables microorganisms to flourish or cause spoilage in foods. FATTORM stands for food, acidity level, temperature, time, oxygen and moisture (Ahn *et al*., 1993; Borch *et al*., 1996a; Gill, 1998). Microorganisms need food to grow. Meat provides all the necessary nutrients needed for microbial growth (Gill, 1998). Meat is a good source of proteins, fats, carbohydrates, vitamins and minerals (Simela *et al*., 2004). The acidity level of food determines the growth of microorganisms. Increase in meat pH to 4.6 or less enables the growth of moulds and yeast but inhibit the growth of spoilage and disease-causing bacteria. This could be done by fermentation of food or by addition of acid. Neutral pH between 4.6 and 7 favours the growth of spoilage and illness bacteria. Storage conditions affect the type of microbes found in meat and meat products (Cerveny *et al*., 2009). The appropriate temperature is a prerequisite for microorganisms to grow. Most bacteria, yeast, and moulds grow well at a temperature of 25^{o} C to 40 ^{o} C as well as body temperature 37 ^{o} C. Reduction in temperature reduces the growth rate of the microorganism. Refrigeration or freezing inhibit bacteria, yeast and moulds growth, however, Nedwell (1999) observed the growth of microorganisms at refrigerated temperature. For example *Bacterium listeria* survive cold temperature (van Laack, 1994). Heating in a form of blanching, cooking or boiling kills many microorganisms. Nonetheless, thermophilic bacteria such as *Salmonella species, Listeria monocytogene, Escherichia coli* continue to spoil the meat after application of heat by forming highly resistant spores. These spores require super-heated steam under pressure at a temperature above 116 ^{o} C (Ahmed et al., 1995; O'Bryan *et al*., 2006).

Time is also essential for microbial growth. Some will double within few 20 minutes, some require more time and some less or short time. The increase in storage time under favourable environmental conditions enables the growth of the microorganism and thus increase spoilage in meat (Gill *et al*., 1998). All microorganisms need moisture to grow. 73 % of meat consist of water and therefore a suitable medium for microbial growth (Sørland *et al*., 2004). In general, moulds require less moisture than yeast and yeast require less moisture than bacteria. There are two types of moisture that occur in food. There is free water that is available for the microorganism to grow and bound water that is not available for microbial growth, therefore drying, salting, the addition of sugar (jams, jellies, preservatives) are practices that are conducted to make water unavailable for microorganisms (Scott, 1957; Leistner, 1987).

Microbial spoilage in meat results in the development of unpleasant smell or off-odours and discoloration of meat. Change in meat colour to green is a sign of microbial spoilage. This is caused by bacteria that produce hydrogen sulphide and convert muscle glycogen to green sulphmyoglobin. It is mostly seen as green spot. This bacterial include *Lactobacillus*, however, sulphmyoglobin is not formed in the anaerobic atmosphere. Greening is typically associated with high pH in meat, though this may occur under normal condition (Gill, 1983). This indication has been used over the past years and still a reliable source for spoilage detection in meat. Aerobically stored meat is characterised by off-odours that are sweet, fruity, putrid, sulphur, cheesy and rancid. This is caused by sulphur containing compounds such as *Pseudomonas species, Enterobacteriaceae*. Off-odours of aerobically stored meat are more offensive than vacuum packed meat. Spoilage of meat that results in sour and acid odours are associated with lactic acid bacteria (Borch *et al*., 1996a).

2.5.2 Oxidative spoilage

Availability of oxygen in meat causes undesirable changes in meat. It affects both taste and colour of meat. Colour changes to green with undesirable smell. In contrast fat becomes oxidised or rancid and the colour of meat changes to brown and adversely affect the national content of meat. Aerobic storage of meat enables the growth of micro-organisms and enhance enzymatic activity in meat and therefore reduces the shelf life of meat (Gill, 1983). Therefore, vacuum packing, canning or the use of jars, benching or cooking removes air and thus eliminates the effect of air on meat spoilage (Dave and Ghaly, 2011b).

Pork is generally stored aerobically and beef in a vacuum-packed due to the requirement of tenderising the meat during extended storage (Borch *et al*., 1996a; Gram *et al*., 2002). Lipids contribute a lot to desirable flavour and aroma of meat, however with the presence of microorganisms or through oxidation, fat spoils and form a rancid odour. Spoilage of fat that is exposed to oxygen is subjected to microbial spoilage and result in the development of sweet, fruity, putrid and sulphur and cheesy odours. Sulphur-containing compounds contribute to the production of sulphur and putrid odour. The bacteria responsible for this include *Enterobacteriaceae* (Lerke *et al*., 1965; Roth and Clark, 1975; Jacobs, 2006). Off-odours of aerobically stored meat are more offensive than vacuumed packed meat. Production of sour and acid odour in vacuum packed meat is associated with lactic acid bacteria (Rogers and McCleskey, 1961; Saffle *et al*., 1961). Also, formation of slime is considered as early indication of spoilage, often observed before the sell by date of meat (Susiluoto *et al*., 2003).

2.5.3 Enzymatic changes during meat spoilage

Enzymes are naturally available in meat, poultry, seafood and they continue to deteriorate meat post slaughter. These naturally available enzymes include lipolytic, amylolytic, proteolytic and they are responsible for the deterioration of fat, carbohydrates and proteins, respectively (Belle, 1932). In this process, a complex compound of the tissue (fat, carbohydrates, and proteins) are broken down to simpler once and result in softening and greenish discoloration of meat. These autolytic changes including proteolysis and fat hydrolyses are a requirement for microbial decomposition (Dave and Ghaly, 2011b). It was suggested that activities of enzymes can be stopped by heating (blanching), canning, cooking, inhibited by storage in low temperature, salting or fermentation. However, after these activities enzymes spoil the meat by destroying texture, causing undesirable changes in colour like the brown colour, and changing meat flavour as well as reducing the nutritive value of meat (Gill, 1983; Cheftel and Culioli, 1997). The above-mentioned causes of meat spoilage raise the need for meat storage or preservation to prevent spoilage, loss of nutrients and enhance food security. Preservation of food has been and still an important strategy for storing excess food for future consumption and food availability.

2.6 Importance of meat preservation

Food waste is becoming an accelerating issue worldwide (Nahman *et al.,* 2012). In Europe, food wasted every year is about 220 million tons which are almost equal to the total net of food production in of Sub-Saharan Africa (Gustavson *et al*., 2011; Secondi *et al*., 2015). Therefore, preservation techniques have been implemented to deal with such issues and reducing food wastage. Meat and meat products, particular as a highly perishable commodity, requires proper storage (Gul *et al.*, 2016). Abdulmumeen *et al*. (2012) reported that pork should be eaten within one day if not preserved. Moreover, fish and shellfish should be consumed within few hours after harvesting. Preservation of food is the process of treating and handling food to reduce spoilage which causes loss of quality, edibility or nutritive value of food (Jean, 1994).

Food preservation also ensures the health of people (Gustavsson *et al*., 2011; Aste *et al*., 2017). Meat preservation improves the nutrition of household members by decreasing nutritional inadequacies and malnutrition. Meat preservation should prevent the growth of bacteria, fungi, and other micro-organisms, as well as retarding the enzymatic and oxidative changes of fat that causes rancidity (Dave and Ghaly, 2011; Abdulmumeen *et al*., 2012).

Preserving meat plays a vital role in food security (Kamwendo and Kamwendo, 2014). Sen (1981) defines food security as the sufficiency of food in terms of nutrients, and calories required for an active and healthy life. Preservation of food increases the shelf life of food, therefore, increasing the supply and availability of food during periods of shortages. Proper storage of meat reduces the amount of food wasted by preventing decay or spoilage storing and minimise the cost of purchasing meat when required. Nahman *et al*. (2012) reported that the cost to society associated to food wastage in South Africa approximately R21.7 billion per annum or 0.82% of South African's annual gross domestic product. Not only raw meat is preserved but also cooked or boiled meat can be preserved. This further reduces the preparation time and energy, as the food has already been partially processed. Preservation of meat increases the income of the agricultural sector by exporting good quality meat. Food preservation is essential to fulfilling the food supply and ensuring that food supply is sufficient at all the times. Furthermore, food preservation reduces food shortages or famine (Nahman *et al*., 2012; Kamwendo and Kamwendo, 2014).

Meat consumption in developing countries has increased by 70 million metric tons over the past which is three times greater than it did in the developed countries. Therefore this raises a need to understand the dynamics of preserving meat (Delgado, 2003). Poor households all over the world are consuming more animal products as they become urbanized and their incomes rise above poverty levels (Delgado *et al.*, 1999; Delgado *et al*., 2001). The IMPACT project estimated that the aggregate meat consumption between the late 1990s and 2020 it will project to 106 million metric ton in developing countries and it will be 19 mmt in developed countries (Delgado, 2003; Heinz and Hautzinger, 2009). Meat is defined as all animal tissue appropriate as food for human consumption (Lijalem *et al*., 2015). Meat provides all the amino acids, organic acids that are integral components which cannot be synthesised by the body in a well-balanced proportion and concentrations. Vitamin B_{12} and iron is rich in meat which is essential in preventing anaemia, especially in children and pregnant women. Not all meat or meat products are suitable for preservation. For the preservation of meat by drying, lean meat is recommended. Beef, buffalo meat, as well as goat meat and other certain game meat like deer and antelopes, are best suited for being preserved by drying. Pork is less suitable for preservation by drying even from a very lean muscle as it contains a higher amount of intermuscular and mostly invisible intramuscular fat which is prone to oxidation hence turns quickly rancid. Furthermore, chicken has high subcutaneous fat that easily makes it subjected to lipid oxidation (Heinz and Hautzinger, 2009). Compared to beef, mutton, and pork, chevon is the least preferred meat. However, goat meat is the healthiest meat compared to other meat producers and there is a potential for development of goat meat market since the percentage of consumers preferring low-fat and the high-quality product is increasing. Chevon is characterised by low intra-muscular and subcutaneous fat content and could be used as a nutritional alternative to other meat species such as beef and chicken. Furthermore, goat meat has a high protein and low-fat content and it is also a good source of desirable fatty acids since goat deposit high polyunsaturated fatty acids than the other ruminants which makes it ideal and attractive to consumers as a red meat alternative.

2.7 Methods of meat preservation

Methods of meat preservation may be categorised into modern and indigenous techniques. Both these techniques aim at preserving food in various states, could be raw or cooked meat. Furthermore, preservation methods are a useful tool to store abundant food and enhance food security.

2.7.1 Modern preservation methods

Modern preservation methods include refrigeration (chilling, freezing, super chilling), ionising radiation, use of chemical preservatives and high hydrostatic pressure (Zhou *et al*., 2010a). Advanced preservation methods were implemented to prolong shelflife of meat. These methods require , not cost effective and often not reliable (Dave and Ghaly, 2011b). Chilling is applied at slaughter plants right after slaughtering and during transportation and storage. It is compulsory to reduce the temperature of carcass immediately after evisceration to 4 ^{o}C within four hours of slaughter. Furthermore, chilling is essential for meat hygiene, safety, shelf life, appearance and eating quality (Zhou et al., 2010a; Dave and Ghaly, 2011b). Air-chilling is much better and effectiveQ345 compared to water-chilling. However, the limiting factor in air chilling is the difficulties in removing heat quickly from the deeper tissues of the carcass (Zhou *et al*., 2010a). Young and Smith (2004) reported that water-chilled carcasses absorb 11.7 % moisture in the chillers and on the other hand air chilled carcass lost 0.68 % of their post-slaughter weight in storage before cutting.

Freezing is the process storage of meat by converting water content of meat into ice (Heinz and Hautzinger, 2009). Freezing rate is increased with a reduction in temperature, nearly 98 % of water freezes at -20 ^{o}C and complete crystal formation occur at 65 ^{o}C (Rosmini *et al*., 2004). Nevertheless, more than 10 % of muscle-bound water (chemically bound to specific sites such as carbonyl and amino group of proteins are hydrogen bonding) will not freeze and therefore contribute to deterioration of meat through enzymatic activity, oxidative rancidity and ice crystallisation (Garthwaite, 1997; Rosmini *et al*., 2004; Zhou *et al*., 2010a). Pérez-Chabela and Mateo-Oyague (2004) reported that when a temperature of -12 ^{o} C stops microbial growth and total inhibition of the cellular metabolism in animal tissue takes place below -18 ^{o} C. Hansen *et al*. (2004) suggest -55 ^{o} C as an ideal temperature for meat storage to prevent quality changes of meat. At this temperature, enzymatic reaction, oxidative rancidity, and ice recrystallisation are most likely to be low thus few deteriorative changes will occur during storage.

Super chilling is a different process from refrigeration and freezing and it has the potential to reduce storage and transport cost. The super chilling technology stores meat just above the freezing point. The temperature ranges from 1 to 2 ^{o} C with no generation of ice crystals (Zhou *et al*., 2010a). This method has been effectively used for seafood (Olafsdottir *et al.,* 2006; Beaufort *et al*., 2009). There is now an increased interest in the process for extension of chilled storage life of meat.

Ionising radiation has been and still a method of direct microbial inhibition for preserving meat. Radioactive cobalt decays to non-radioactive nickel by emitting high-energy particles and X-rays. The X-ray kills rapidly growing cells for microbes such as *Trichinella spiralis* but does not leave the product radioactive. Since it is highly penetrating, it can be used to treat packaged food. Advantages of this method include its high efficient inactivation of bacteria, no alteration of the product chemical content and the appreciable thickness of materials, which can be treated after packing in containers (Brewer, 2004; Lawrie and Ledward, 2006; Brewer, 2009).

High hydrostatic pressure (HHP) is nonthermal technology that can inactivate and or inhibit the growth of microorganisms and enzymes at low temperature, without altering the sensory or nutritional characteristics of meat. This method is powerful in controlling the risk associated with *Salmonella species* and *listeria monocytogenes* in both raw or marinated meat.

Chemical preservatives including carbon dioxide, ozone, and sodium lactate have been used in the meat industry because of their ability to prolong shelf life, increase flavour and improve the microbiological safety of meat or meat products. Carbon dioxide and ozone have been used to inhibit the growth of surface microorganisms on beef carcasses during prolonged storage at chill temperatures. Though ozone does not leave toxic residues in meat, it is, however, detrimental to the personnel since it is mostly used in the production environment. Furthermore, it accelerates lipid oxidation and it is more effective against air-borne micro-organisms in meat (Lawrie and Ladward, 2006). The antimicrobial effect of lactates is due to their ability to lower water activity and the direct inhibitory effect of lactate ions. There are different indigenous preservation methods that has been used before the introduction of modern preservation methods. This includes fermentation, smoking, drying, curing and boiling meat for preservation purposes.

2.7.2 Indigenous preservation methods

Conservation of fresh meat in early civilisations was a major challenge due to it highly perishable characteristic. Therefore, meat preservation techniques emerged, making use of extensive salt and drying under the suitable climatic conditions (Zeuthen, 2007). These preservation methods are categorised based on control by temperature, by moisture, by an inhibitory process for microorganisms. Reduction in water activity value protects the meat against spoilage and pathogenic microorganisms (Lawrie and Ledward, 2006). Meat preserved by indigenous methods is known worldwide. This is especially true in China and Asia where they have tsusou-gan, njorsous-gan, sou-song as well as Africa where it is called *biltong, khundi, quanta, pastema, klich, iamkila.* Some intermediate moisture meats are also known in America as charque, *carne de sol* and *beef jerky*. Meat preserved using indigenous preservation methods are nutritious and palatable and they are mostly preferred by consumers as a snack. An indigenous preservation of meat, common humectants (salt or sugar) are used. thus, no chemical overloading in meat occur. Preparation and storage of meat by traditional preservation methods are easy because they require simple equipment. No refrigeration of meat is needed after preserving meat using traditional storage methods, therefore, reduces the cost of purchasing refrigerators and use of electricity. Common indigenous methods includes fermentation, smoking, curing, drying and boiling.

2.7.2.1 Fermentation

The fermentation of meat was initially founded for the development of desirable indigenous flora, such as colour, flavour and taste. However, differences in the site of production, raw materials, and operators frequently changed the composition of such flora and in most cases lacked consistent quality (Leroy *et al*., 2013). A common practice called back-slopping was used in meat fermentation that includes the addition of small amounts of previous fermented meat having good sensory properties. This technique results in fermented meat with heterogeneous quality (Toldrá, 2006). Traditional small-scale producers may not be able to produce good quality since their empiric nature is not always able to deal with specific technological problems. Nevertheless, traditional fermented meat is still perceived as superior to industrial ones in terms of quality. In fermentation of meat, salted mince and fat are normally stuffed together in casings to create alleviating anaerobic conditions. Though, originally animal intestines were used playing the similar role as casings. Fermentation of meat is mostly conducted with pork, beef, and mutton. Although poultry meat and ostrich were initiated for fermentation, it was not successful due to poultry-associated pathogens and the poor technological properties of poultry fat tissue (Santchurn and Collignan, 2007). Subsequently, meat fermentation result from lactic acid production by certain species of lactic acid bacteria that are being selected by the anaerobic environment, which is then followed by drying stage to further stabilize and mature the product (Leroy *et al.*, 2006; Ravyts *et al*., 2012).

Fermented meat presents a high level of convenience and they are suitable for immediate consumption. They have high nutritional value, stable in terms of taste, traits, and sustainability. Furthermore, they are easy to transport and can be stored for several months. The duration of drying period may vary from 7 to 90 days or even longer, depending on the factors such as kind of product produced, diameter, dryness degree, fat content and the desired flavour profile as well as intensity. In Nigeria, drying of fermented meat lasts up to five days (Iwuoha and Eke, 1996). Drying process reduces the water content up to 20% and 30% weight loss in semidry-fermented sausage and dry-fermented sausage respectively. The processing of meat fermentation is illustrated in Figure 2.1. Furthermore, lactic acid bacteria, *Staphylococcus* *xylosus* among coagulase-negative *Staphylococci* are selected by the processing, which contributes a lot metabolically to the flavour, colour and oxidative stability of fermented meat. Furthermore, these bacteria must be tolerant of the high concentration of salt, acidic pH and low water activity typical of fermented sausage.

During fermentation, enzymes from both muscle and microbial origin are responsible for reaction associated with the development of colour, texture, and flavour. Carbohydrates are converted into lactic acid by lactic acid bacteria. The schematic representation of the different biochemical pathway is illustrated in figure 2. pH may drop or increase during fermentation of meat. The pH drops in accordance with the amount of lactic acid generated that greatly relies on the type of microorganisms used as a starter, composition, and content of carbohydrates and fermentation temperature. Reduction in pH is partly counterbalanced by the salt solubilized and partly hydrolysed muscle protein and ammonia production, and in cases where fungal growth occurs, lactic acid bacteria are consumed by moulds on the surface of the meat, and the final pH might increase (Leroy *et al.,* 2006; Demeyer and De Smet, 2010).

Additional smoking and heating treatments have originally been introduced for prevention of bacterial spoilage, uncontrolled molding, and microbial hazards. However, the use of smoking of fermented meat has been identified as a risk due to the formation of polycyclic aromatic hydrocarbons (Santos *et al*., 2011), suggesting the need for good maintenance of smoking equipment and modification of traditional technologies, for example shifting the product position in the smoking room (Roseiro *et al*., 2011). pH drop plays a major role in the safety of meat because it inhibits undesirable pathogens. There is also a joint action of bacteria and enzymes on sausage protein and lipids fraction whose changes signifies another essential transformation during sausage fermentation. There is an intense proteolysis occurring during fermentation and ripening, causing the accumulation of polypeptides that are further hydrolysed to small peptides by muscle and microbial peptidylpeptidases and to free amino acids by muscle and microbial aminopeptidases (Toldra, 1998). Free amino acids are essential not only for taste but also for aroma because they are able to generate volatile compounds through Strecker degradation and Maillard reactions. On the other hand, lipids and exopeptidases also experience an intense lipolysis resulting in the generation of free fatty acids between 0.5% and 7% via the enzymatic hydrolyses of triacylglycerol and phospholipids. They also contribute to flavour development (Toldra, 1998; Toldrá *et al*., 2000). Protein (proteolysis) and lipid (lipolysis) degradation respectively are more extensive in longer ripened sausages. Although all the enzymatic action contributes a lot to flavour of fermented meat, they are partially or completely inhibited at pH lower than 5.0 (Nollet and Toldrá, 2012). Catalases are available in microorganisms such as *Staphylococcus* and they are responsible for peroxide reduction and therefore contributes to colour and flavour stabilization. Nitrate reductase is also present in these microorganisms and it essential for decreasing nitrate to nitrite to slow-ripened sausages with an initial addition of nitrate.

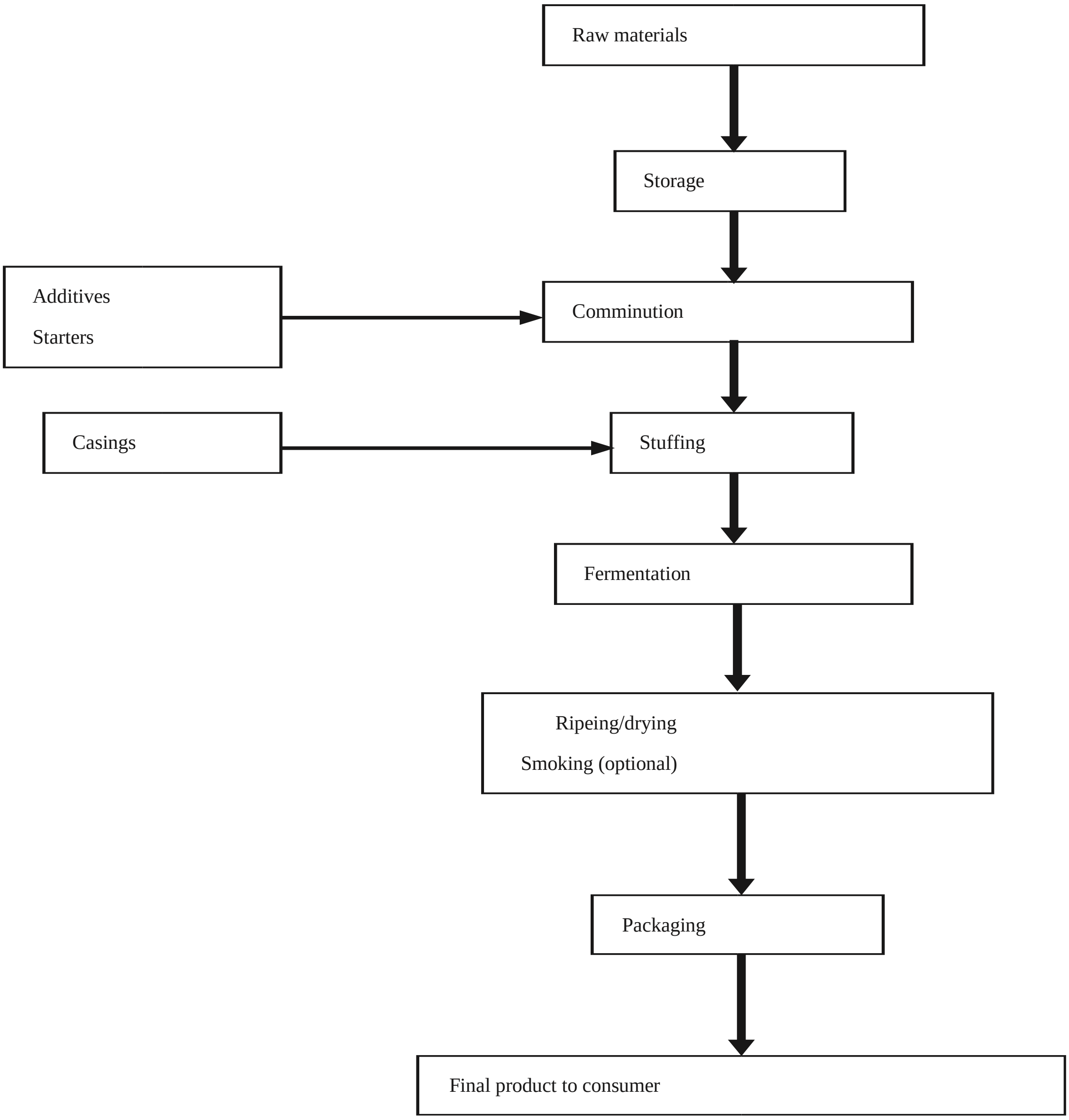

Figure 2.1: Process flow diagram for the processing of dry-fermented sausages

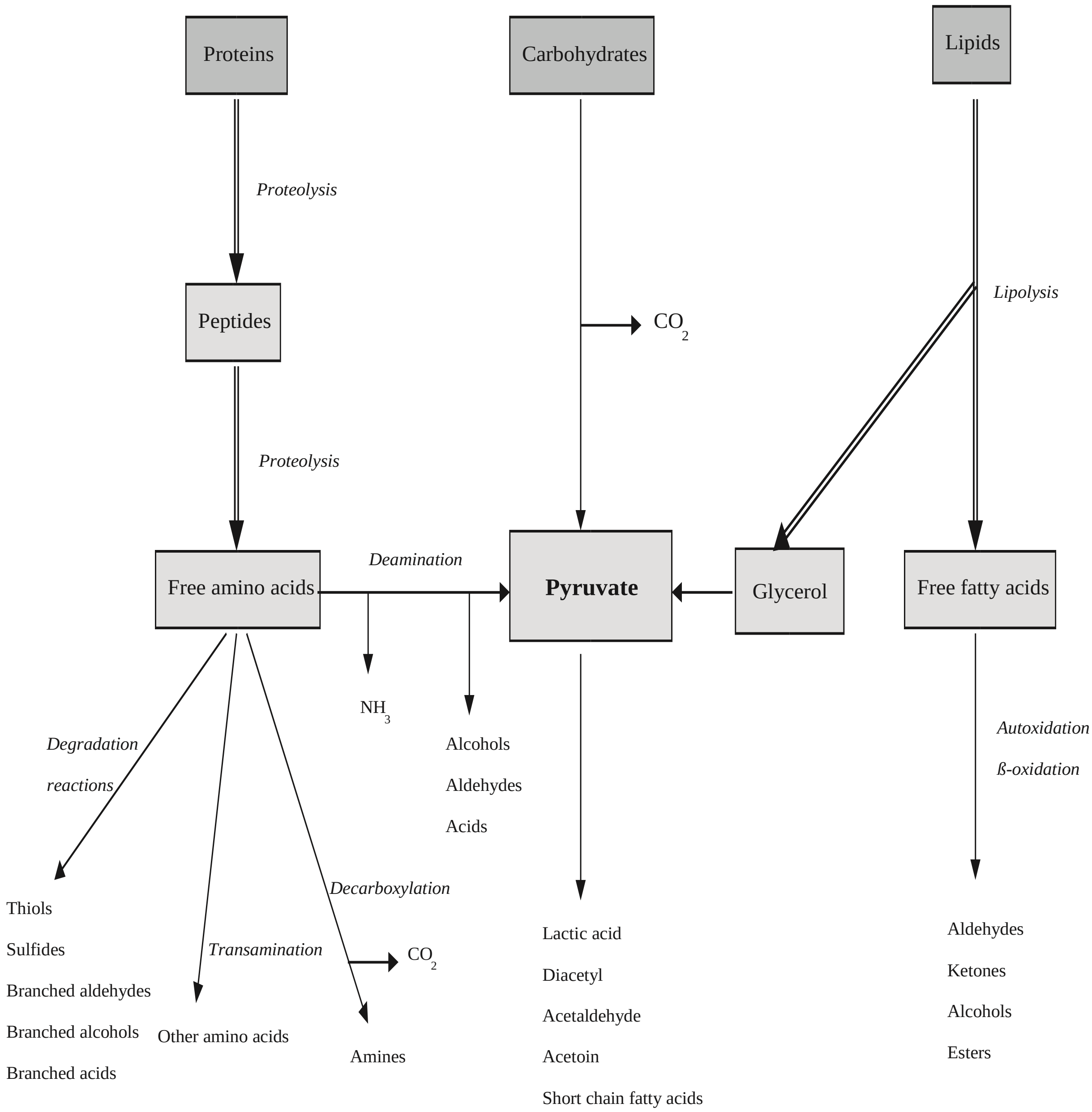

Figure 2.2: Simplified overview of sausage metabolism. Double lines indicate pathways with a major contribution of muscle and adipose tissue enzymes

2.7.2.2 Smoking

Smoking of meat for preservation purposes is an age-old process that may date back to the start of human civilization (Ogbadu, 2004). Therefore, this necessitates the essential of understanding and improving the quality of smoked meat for adequate provision of nutritious food and for food security. Smoking of meat was originally used to enhance the preservative action of curing. However, the smoke flavour is mainly used because people like the flavour of the smoked product (Ciecierska and Obiedzinski, 2007). Currently, liquid smoke is widely used to produce smoked meat and this liquid is only used for the smokeless smoking of meat (Sindelar and Milkowski, 2012). Animal flesh that includes both meat and fish are a major category of food that is manufactured by wood smoking (Yolande *et al*.,2014).

Food industry benefits a lot from the smoked meat product. More than 500 metric tons of smoked fish, for example, is exported from West Africa to the United Kingdom annually. This quality is valued at between 9.3 and 14.9 million United state dollars (Ogbadu, 2004). The ability of smoke to reduce bacterial growth in meat is due to the different content of CO, CO_2, Alcohol, a carbonyl compound, carboxylic acids, esters, hydrocarbons, nitrogen oxides, and phenols. The greatest yield of phenols especially guaiacol and syringol and their respective derivatives are obtained at a temperature of 400-600^{o}C. Phenolic compounds also play an essential role in preventing oxidative rancidity in smoked food and thereby contributing to the preservative of meat by smocking. Guaiacol is responsible for smoky taste and syringol is responsible for the Smokey aroma in smoked meat (Gómez-Estaca *et al.,* 2007; Alexander *et al.,* 2008). Furthermore, formaldehyde, which is one of the carbonyl compounds is also known for its antimicrobial activity. The acidic constituent of wood smoke and high temperature also contributes to the reduction of bacterial growth in meat.

There are different types of smocking and each differs by the temperature used. This includes cold smoking, warm smoking, and hot smocking and they are operated at a temperature of 12-25ºC, 12-4 ºC and 45-90ºC respectively (Alexander *et al*., 2008). Cold smoking is usually used to for the production of dry fermented sausage and pork belly. Warm smoking is normally used for manufacturing of backed or scalded sausages, pork back fat, and ham. The flavour produced by smoking meat differs with the condition used to produce smoke. Furthermore, the same smoke will produce different aromas of different meat. To some extent the flavour of smoked meat greatly depend on the reaction between the component of the smoke and functional group of the meat protein. The colour produced by smoking may be light yellow to dark brown depending on the type of wood and condition of smocking. It is affected by heat and storage (Toldrá, 2017).

2.7.2.3 Curing

Originally, meat curing was the addition of sea salt, rock salt or mine salt to a small piece of unheated meat to reduce the water activity, prevent microbial growth and chemical spoilage, tenderise and add flavour to the meat or meat product (Bender,2016). However, the current understanding of curing is to be the addition of salt with or without nitrate during the manufacturing of meat product (Toldrá, 2017). This practice was followed by using brine when curing meat which is the mixture of salt and water. Dry salt curing and tank curing are still being have been practiced. Vascular pumping or the addition multiple injections of salt solution is now employed to accelerate curing. The purpose of curing is to enhance the shelf life of meat by preserving and preventing spoilage with the help of salt, drying, and smoking. Dry- cured meat are produced in countries such as South Africa (biltong), North America (pemmican), Cuba (nukku) and Europe (pastirma) (Toldrá, 2002). Cured meat is valued for unique quality and development of characteristic flavour (Sindelar and Milkowski, 2012). Generally, cured meat or meat product do not require refrigeration. However, Cassens (1997) indicated that lowering the concentration of salt has resulted in mildly cured or semi-preserved product more prone to spoilage and therefore reintroduce the need for refrigerating the meat after curing. Curing salt (sodium nitrite), plays a significant role in reducing microbial growth in meat and enhance the shelf life of meat (Sebraneck and Bacus, 2007). Salt reduces the water activity in meat and therefore makes the water not available for any enzymatic, chemical or microbial growth and thus increase storage. Furthermore, the salt adds to the the flavour of the cured meat and when brining meat it swells and dissolves proteins and therefore enhance tenderness of raw meat or meat product (Honikel, 2010). Nitrite alone or in combination with other salt are well known for suppressing the growth of *Clostridium botulinum* spores in cured meat as well as *Listeria monocytogenes* under certain conditions (Sebranek *et al*., 2012).

Furthermore, several studies (Haldane, 1901; Watts, 1954; Killday *et al*., 1988) have indicated that the use of nitrite in curing meat results in the production of desirable bright red colour in cured meat, therefore, regarded as a colour fixing agent. This is due to the reduction of nitrate to nitrite and the formation of nitrosamines and reacts with myoglobin through oxidation to form metmyoglobin. This reduction can also be affected by bacteria on the muscle. Haldane (1901) clearly demonstrated the reaction of nitrite with myoglobin to form nitrosomyoglobin and the bright red-pink colour, especially of cure meat. During storage of cured meat enzymatic action also takes place (Toldrá, 2017). Proteases and lipases are the enzymes responsible for degrading proteins into amino acids and deterioration of fatty acids respectively (Watts, 1954). This, therefore, aid in the production of desirable flavour, aroma, and taste. Cured meat product includes raw ham, cooked ham as well as sausages (Toldra, 1998).

2.7.2.4 Drying

Preservation of food materials by drying has been practiced since the early history of human civilization (Prajapati and Nair, 2008). Different food materials have been preserved by drying. This includes drying of meat (fish, pork, beef, and chicken), fruit (apples, grapes) as well as vegetables (maize, pea, onion, cassava) as well as dry milk or powered milk is produced in the food industry (Sabarez *et al*., 2012). Early drying procedures are still practiced even today. In drying meat particularly, meat is cut into strips of about 1x1cm and exposed to sunlight sometimes with the addition of salt, followed by drying as in the production of biltong in South Africa and charqui in South America. Drying meat is incorporated in many traditional preservation methods such as fermentation (fermented sausage), curing (for production of cured ham) and smocking(Sharp, 1957; Toldrá, 2006). Contamination of meat during drying by dust, changes in weather and humidity has been the greatest challenge in the production of dried meat (Toldrá, 2017). However, currently drying meat is developed using drying room with big windows and doors that regulate the temperature in the drying room as well as the use of drying machines (drum drying, tunnel drying). The degree of drying was evaluated by touching the meat strings then eventually evaluate the colour and shape.

Drying inhibits the growth of microorganisms by water reduction. Generally, the moisture content of dehydrated meat is too low for enabling bacterial growth, however, it rises above 10 %, mould growth can occur after some weeks (Sharp, 1957). Ahmat *et al*. (2015) observed that the drying rate falls slowly and the second one with a significant decrease in drying rate. This, therefore, rises the need to understand the movement of water in meat during dehydration to optimize dehydration in meat. The temperature of drying is also essential. Heat damage is characterised by toughness, grittiness and burn flavour. When the water content is still above

77 %, air temperature of 80 ^{o} C can be tolerated for two hours without loss of quality, in contract 50 % can also cause deterioration of meat if the water content is low (Wang *et al*., 1954). Generally trimming of fat prior drying is essential since high fat content retard the drying rate with increase drying periods. Although it has less influence on drying meat initially. Nonoxidative changes whether enzymatic or chemical when drying meat are of secondary importance except at high preservation temperature. Therefore, restriction of oxygen will maintain the flavour of dehydrated meat for 12 months or longer at 15 ^{o}C (Toldrá, 2017).

2.7.2.5 Boiling

Boiling alters the mechanical and chemical properties of meat to improve its eating quality and shelf life (Vasanthi *et al*., 2007). It is done to reduce or eliminate the contaminating microflora accumulated during slaughtering and cutting. Boiling is also done immediately before consumption to enhance texture, flavour and colour (Vasanthi *et al*., 2007; Jabr, 2012; Toldrá, 2017). Boiling is largely used as an effective means of preservation since mankind realized the use of fire for food preservation and preparation. Addition of salt or brine when cooking meat prior spoilage contributes to the reduction of microorganism (Sebranek and Bacus, 2007). Microorganisms degrade proteins into amino acids and contribute to spoilage. Thus, cooking denatures meat proteins as well as enzyme activity and therefore reduce microorganisms, therefore, enhance the shelf life of meat. There are bacteria that are thermophilic or heat resistant and they contribute to spoilage of meat even after exposure to high temperatures. This includes *Staphylococcus spp* (van Laack, 1994). Ways of cooking meat are diverse, however, the main variation amongst these is temperature and time (Vasanthi *et al.*, 2007).

Higher temperatures dramatically increase tenderness. A decrease in shear force values due to collagen shrinkage has been reported with increased temperature and time. Sinha *et al*. (2005)

suggested that an increased risk of colorectal cancer that comes with increased cooking times and temperature. Meat cooked in high temperatures contains nutrigens such as heterocyclic amines and polycyclic aromatic hydrocarbons (Jabr, 2012). The quantity of these is dependent on the cooking method used and the doneness of the meat. Cooking meat in water baths at temperatures above 80 ^{o}C has been found to form hydrogen sulphites and cause a loss of free acidic groups resulting in increased pH. Kong *et al*. (2008) reported no effect of salt on lipid oxidation and Pearson *et al*. (1983) indicated that meat heated at 70 ^{o} C for 60 minutes develop rancidity at a faster rate. Moreover, thiobarbituric acid values were reduced when the cooking temperature was increased to 80 ^{o} C. Increase in temperature causes deterioration of lipids by increasing the cooking loss of meat. Addition of salt, however reduces cooking loss of meat and reduce lipid oxidation in meat. Salt covers the fat particles, preventing their release from heating. This is done by dissolving and swelling the meat protein structure (Fasakin *et al*., 2003).

2.8 Summary

Goats are largely used for meat production in communal production systems. Chevon preservation is essential for storing food for future use and enhancing food security. Slaughter method has a huge effect on meat storage and therefore proper handling of meat preslaughter and post-slaughter is essential to increase its shelf life. Different preservation methods such as fermentation, drying, smoking, curing and cooking are useful in meat preservation and are reliable, and are cost-effective. These methods also help in the production of meat with unique flavour and odour compared to raw meat. Enzymatic, lipid oxidation and microbial activity affect storage of meat but the use of salt as dry or brine helps in inhibiting microbial spoilage and increasing the shelf life of meat. Colour, off-odour, discoloration of meat is considered as the indication of meat spoilage, therefore, they need to be monitored to prevent the consumption of spoiled meat that can cause sicknesses. Preservation of chevon under small system has been documented. Its is therefore, crucial to determine and document the indigenous methods of preserving chevon that resource-limited households produce. The purpose of the study was, therefore, to identify indigenous methods of preserving chevon and asses the effectiveness of these methods in reducing chevon spoilage.

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Chapter 3: Indigenous knowledge systems of chevon preservation

Abstract

A case study approach was conducted in Nongoma to identify the indigenous knowledge systems on chevon preservation and assess their effects on chevon quality. Face to face interviews were conducted in isiZulu and 13 elderly, seven sangomas, four chiefs and an expert in the Zulu culture were interviewed. Goats are a symbol of wealth, a source food and income and a form of savings. Goats are usually slaughtered for cultural purposes and for meat consumption. Good quality chevon comes from goats that are fat, with shiny skin coat and castrated bucks. Four preservation methods were commonly used. These are salting and air-drying, pre-boiling and drying, underground preservation as well as the use of river salt and use of animal skin. Salting and air-drying involve smearing fresh chevon with river salt and slice it to pieces and drying it in the air. Pre-boiling and drying include boiling the meat with river salt and water for between 15 and 20 minutes followed by drying. Underground preservation comprises of digging a 2m hole at the centre of the kraal, smearing chevon with river salt and store it underground and use a stone to close the hole. Chevon was stored for 3das in summer and five days in winter. Chevon was preserved by collecting wet sand in the river and forming a bed in cool dry place usually the (traditional house), wrap chevon with goat skin or hide and preserve it. Indigenous preservation methods preferred are greatly influenced by the availability of resources and purpose of storage. Understanding these methods assist households to reduce meat wastage, spoilage and enhance food security, especially among resource-poor households.

Keywords: Indigenous knowledge systems, food security, chevon preservation.

3.1 Introduction

Indigenous knowledge plays a significant role in addressing food security and improving the livelihood of local communities. Indigenous knowledge is skills, experience, ideas and insight about survival (Okorafor, 2010). The indigenous knowledge system (IKS) is a system where knowledge is transmitted systemically and learned by local people from their ancestors, through building up of knowledge, informal experiences and clear understanding of the environment in a given culture. This knowledge is thus unique to every culture or community. It is viewed as a problem-solving mechanism regarding storage of excess food. Indigenous knowledge is relevant to economic development and cultural preservation. Indigenous knowledge can play a major role in eradicating poverty (Okorafor, 2010). Indigenous knowledge is treated as inferior to modern preservation techniques (Langill and London, 1998).

Goats play an essential role in the livelihood of rural households (Webb *et al*., 2003). Goats are mostly owned by the rural households than cattle and thus goats has more potential of increasing food production for households. They have less management requirements and are adapted to harsh environmental conditions. They utilize poor-quality fibrous resources well and are resistant to numerous diseases and parasites. Goats are prolific and require less input for moderate levels of production and they mature early. Goats kid about three times in two years. They produce meat, milk, hair (cashmere) and skin. Goats are mostly used for meat (chevon) production in rural communities. Chevon has a desirable nutritional content (low fat and cholesterol), sensory features (flavour, juiciness, tenderness), high level of proteins and iron than most other types of meats (Webb *et al.,* 2005). Meat quality is either eating quality or processing quality depending on the usage.

Chevon, like any other meat product is inherently perishable therefore food wastage increases due to increase in food spoilage. Indigenous preservation methods has been an important strategy for food storage, but this information and skills are not captured and documented to prevent them from extinction. Indigenous preservation methods are regarded as primitive. This has led to the abandonment of indigenous ways of chevon preservation, which helps a great deal in sustaining food security in many households (Kamwendo and Kamwendo, 2014). Processes used in chevon preservation are primarily concerned with inhibition of microbial growth, oxidative changes and safety of chevon for human consumption (Zhou *et al*., 2010b). Traditionally methods of chevon preservation may be grouped into three categories based on control by moisture, by temperature, by reducing processes (bactericidal and bacteriostatic, such as ionising radiation) and reducing microbial proliferation (Lawrie and Ledward, 2006). Advanced preservation techniques such as refrigeration, irradiation, canning, freeze-drying and the addition of chemical additives are mostly used.

However, these methods are not unavailable to rural households. Resource-limited households have no electricity and refrigerators to preserve meat. Therefore, an approach that involves the local experience of households, might result in a balanced mix of local and introduced techniques, to reduce food wastage, loss of nutrients, flavour and taste. The benefits of food preservation are that it lengthens shelf and food can be marketed in other countries like America. This also brings an increase in income in the agricultural sector. Preservation of food reduces food wastage and plays an essential role in fulfilling the food supply needs to poor resource households. Indigenous preservation methods ensured that people had at least sufficient if not surplus food for consumption in times of scarcity and this methods are still prevalent and very useful world wide. Therefore, this skills and ideas need to be captured and documented. Identifying these indigenous preservation methods will open ways for policymakers to identify, implement and promote the use of cost-effective and easily accessible preservation methods that are at risk of extinction due to the introduction of advanced storage facilities. This knowledge can also be captured, documented and used during load shedding which is the biggest problem in South Africa. Understanding these methods can assist households reducing meat wastage, spoilage and enhancing food security, especially in poor resource households. Colour changes is generally used to evaluate the quality of meat including smell and rancidity. Therefore, assessing these measurements can assist in identifying the efficient indigenous preservation methods of chevon and also ensure that chevon preserved by indigenous techniques is good for human consumption and will not cause sickness. The objective of the current study is to identify indigenous preservation methods of chevon and the hypothesis tested was that there are different indigenous preservation methods of chevon used by the rural households.

3.1 Methodology

3.2.1. Description of study site

The study was conducted at Nongoma municipality. The selection study site was based on availability of indigenous knowledge and the prominence of goats. Nongoma local municipality is situated in Zululand district in the north part of KwaZulu-Natal province of South Africa. It is situated in the semi-arid area, at 27^o 55'S, 31^o 39'E and it approximately 750m above sea level. The area is classified under semi-arid climate characterised by cool-dry and hot-dry seasons. Nongoma is characterized by mountainous areas with a topography that varies with deep ravines and high cliffs. Annual rainfall averages are 600 mm. Rain falls between November and February (Mpanza, 1996). The highest mean rainfall is recorded during mid-December and lowest rainfall in July. Mean annual maximum and minimum temperature are recorded in January (29^{0}C) and June (7.4^{0}C), respectively. Vegetation is mainly characterised with Zululand thornveld and northern tall grassland. The area is dominated by the Zulu tribe who largely rely on livestock enterprises. Cattle and goat farming are the most predominant agricultural spectrum (Mpanza, 1996).

3.2.2 Selection of key informants and research design

Target respondents were selected based on the knowledge on IKS for goat production, ownership of goats or previous ownership of goats and willingness to participate in the research. Respondents were identified through the help of a local member who was informed about the aim of the study and the participants required. The local member ensured that the respondents identified had the information required before the interview was conducted. The elderly > 65 years of age and local chiefs were interviewed. Local chiefs are heads or ruler of the Zulu tribe and who are very informative about indigenous knowledge. Experts in isiZulu culture and traditional spirituals were also interviewed. The study explored indigenous preservation methods of chevon (Creswell, 2014).

3.2.2 Data collection

Respondents were visited in their homesteads. Face-to-face interviews were used to collect data in their vernacular language (isiZulu). The case study approach was used. The respondents right, religions, culture, and dignity were respected. The respondents were assured that no confidential information will be disclosed, and they have a right to stop the interview whenever they do not feel comfortable. Data were collected from 13 elderly who are members of the community, three local chiefs, four traditional spirituals and one expert in Zulu culture. Open-ended questions were used in the interview to collect data. Verbal probes were used, where necessary to gather more data from the respondents. Respondents could elaborate their knowledge in depth. The interview lasted for 10 to 15 minutes each respondent. A tape recorder was used to record the conversation. The data collected included meat preservation methods known by the respondents could be the method practices within their households or in their community, the importance of goat in rural livelihoods and methods of transfer of indigenous knowledge among generation.

The youngest respondent was 50 years old and the oldest was 80 years old. About 20 respondents were interviewed, including 13 elderly, 3 tribal authorities and four traditional spirituals. Out of the 20 respondents, 15 of them were males and seven were females. Only males were the head of the household, even the one who is a tribal authority. The majority of respondents had no formal education. Only four respondents received primary education. The ones with primary education range from grade 1-4. Livestock owned by respondents includes cattle, goat, sheep, chicken, donkey, duck and turkey. Most livestock owned are goats followed by cattle.

3.2.3 Validation of data

Data were reviewed to ensure that data remain consistent and the participants' views are not misunderstood or misquoted. The words and phrases used were translated that could not be directly translated into English to help in translating data without losing the meaning and context. Zulu translator was also used during translation to prevent losing the meaning of the word. An expert is isiZulu culture was also interviewed using the semi-structured questionnaire to validate the data collected.

3.2.4 Data analyses

Voice recordings were translated into English from isiZulu vernacular and transcribed. The data collected from the respondents through body language and changes in voice tone during interviews were considered during data analyses to prevent loss of data and guarantee the quality of data. Transcripts were re-reviewed to identify indigenous preservation methods of chevon and ensure that the data in the transcripts correspond with the one in the voice records. Data were coded and categorised to the themes and narrated. Importance of goats, indigenous preservation methods identified for different respondents were tabulated and described.

3.3 Results and Discussion

3.3.1 Indigenous knowledge systems

Table 3.1 shows the importance of indigenous knowledge. Indigenous knowledge system is the knowledge that is invented by local people for survival. Sangomas reported that these ideas, skills, and knowledge are extracted from ancestors. All the respondents emphasised that indigenous knowledge is unique to different culture and communities and regarded as the secretive knowledge, only shared with close friends and family (Okorafor, 2010). Indigenous knowledge is slow, and inferior compared to modern knowledge. Households who use this knowledge are considered to be old-fashioned. Indigenous knowledge relies on memory and it is transmitted systematically and orally from ancestors to younger generation and by participating in the indigenous practices (Kamwendo, 2014). Sangomas further elaborated that indigenous knowledge helps in sharing ideas, information, and skills for overcoming common diseases, increasing reproduction and goat management. To increase production in goat, activities such as smoking the goat with *imphepho* and traditional herbs to increases libido in goat. More indigenous knowledge was acquired from respondents of age >65 compared to sangomas of younger age. However, males were more informative compared to women.

This could be associated with more engagement of males in goats farming and preservation of chevon than females. Indigenous skills on goat production, curing diseases are under-exploited therefore more research need to be conducted on this aspect to improve production and reduce disease prevalence in goats. Indigenous knowledge plays an essential role in addressing food security in communal production systems. Food security is a state of having the reliable and adequate amount of food for future consumption. Indigenous knowledge system is under threat of extinction due to urbanisation, civilization, and technology, therefore indigenous knowledge should be captured and documented.

Table 3.1: Importance of Indigenous knowledge system in communal areas

Importance of indigenous knowledge system	
Indigenous knowledge system	The knowledge that is invented by local people for survival an addressing food security, information extracted from ancestors, good knowledge because of it sustainability, viewed as old fashioned, inferior to modern knowledge and a secretive knowledge. Unique knowledge of different cultures and communities
Importance of IKS	Share ideas for goat management and production, reduce food insecurity, useful in overcoming common diseases, increases production in goats
Acquiring and transmitting IKS	Transmitted orally and systematically, rely on memory, participating in indigenous activities and too slow compared to modern knowledge

3.3.2 Importance of goats

Goats play a significance in cultural activities and social customs of a community (Table 3.3). Goats are traditionally known for being a foundation of resource that allows the rural dwellers to become an essential part of the culture as an indication of wealth and a symbolic role in rituals (Casey and Webb, 2010b). Goats are slaughtered for cultural purposes than for consumption purposes, thus making people prefer beef, mutton and chicken because of it against other people religion (Simela and Merkel, 2008). Goats are slaughtered for *umemulo*, paying damages, during funerals, asking for forgiveness and for removing the amniotic membrane from the people who were born with it to remove bad luck. *Umemulo* is a ceremony where a girl is reported to the ancestors that she is getting mature and ready for getting married. When a girl gets pregnant for the first child and unmarried, the family of the father of the child need to send a goat and a cow to pay damages to the family of the girl. During funerals goats plays a major role in preparing for the funeral and when the corpse died because of car accident, they slaughter goat to remove bad luck. When family members had a fight, they use goats to ask for forgiveness to the ancestors for causing trouble in their yard. Goat skins were used to make clothes, shoes, baby carrier and instruments (drums). Selling a goat live gives more value than when selling it after slaughter (Rumosa Gwaze *et al*., 2009). Most people prefer buying live goat since for ancestral connection and they slaughter it on their own. This has a great effect on goat meat market and contributes a lot to delay on the availability of goat meat in butcheries. Urban households also consume less goat meat than the rural areas. These may be caused by goat meat not available in the market. Meat scientist and farmers need to promote the availability of goat meat in the market.

Table 3.2: Functions of goats in communal production systems

Functions of goat	
Cultural purposes	Cultural ceremonies (umemulo, asking for forgiveness, for funerals), worshiping ancestors, paying damages.
Source of food	Meat production and skin for making clothes and instruments
Reproductive trait	Early maturing, kid three times a year, less management requirement and adaptable to various diseases.
Improved livelihood	For statutory value, use as a form of banking and for emergency cash flow
Social customs	Maintaining peace in society, welcoming visitors and exchanging goods with other households

Goats are also useful in maintaining peace in the society. When a community member has done something wrong like stealing and allowing the livestock to graze on another farm, they use a goat to clear those cases. Goats were used to welcome visitors by offering a goat to the visitors and the visitor will decide whether they want their goat slaughtered or take it home live. Goats were used to exchange goods with another household for example when a household has more cows than goats than they will exchange livestock (barter trading). Owning goats improved the livelihood of communal households by adding monetary and statutory value. Households who keep a large number of livestock are considered as the richest people in the community. Goats are used as a form of banking and a source of income. Keeping goat makes life easier because whenever the household are in need of emergency cash flow they sell a goat. The goat is helpful, especially when having to pay for school fees, buying grocery and other essentials.

Goats are used as a source of food in communal areas. Goats are kept for meat consumption and they produce the healthiest meat compared to other livestock especially the intestines. Goats consume most of the healthiest shrubs that are not palatable to humans and other livestock but beneficial to their health. These result in the production of healthy meat in the intestine especially the soup. The soap made of goat intestine were used to heal sick people by mixing it with gunnera perpensa (*ugobho*) and drink it. Goats are resistant to various diseases such as the internal and external parasites, therefore they produce meat that is free of pathogens and readily available for consumption. Goats produce less carcass than cattle thus easy to slaughter when in need of food.

3.3.3 Factors affecting quality of chevon

Meat quality is defined in terms of its physical and chemical properties or in terms of consumer perception. The general explanation of meat quality is that of eating quality that includes palatability, wholesomeness and being free of pathogens and toxin. Palatability comprises of tenderness, flavour, residues-free and succulent (Casey and Webb, 2010a). The meat quality was not a majour concern as it is now but rather the storage of food. The quality of meat is a measurement of juiciness, colour, odour and pH of the meat (Tshabalala *et al*., 2003b). Goats that produce high quality meat are castrated bucks, having short ears, shiny skin and a doe that has exhausted their reproductive expectancy (doe that does not kid or unproductive), well fed and with good body condition.

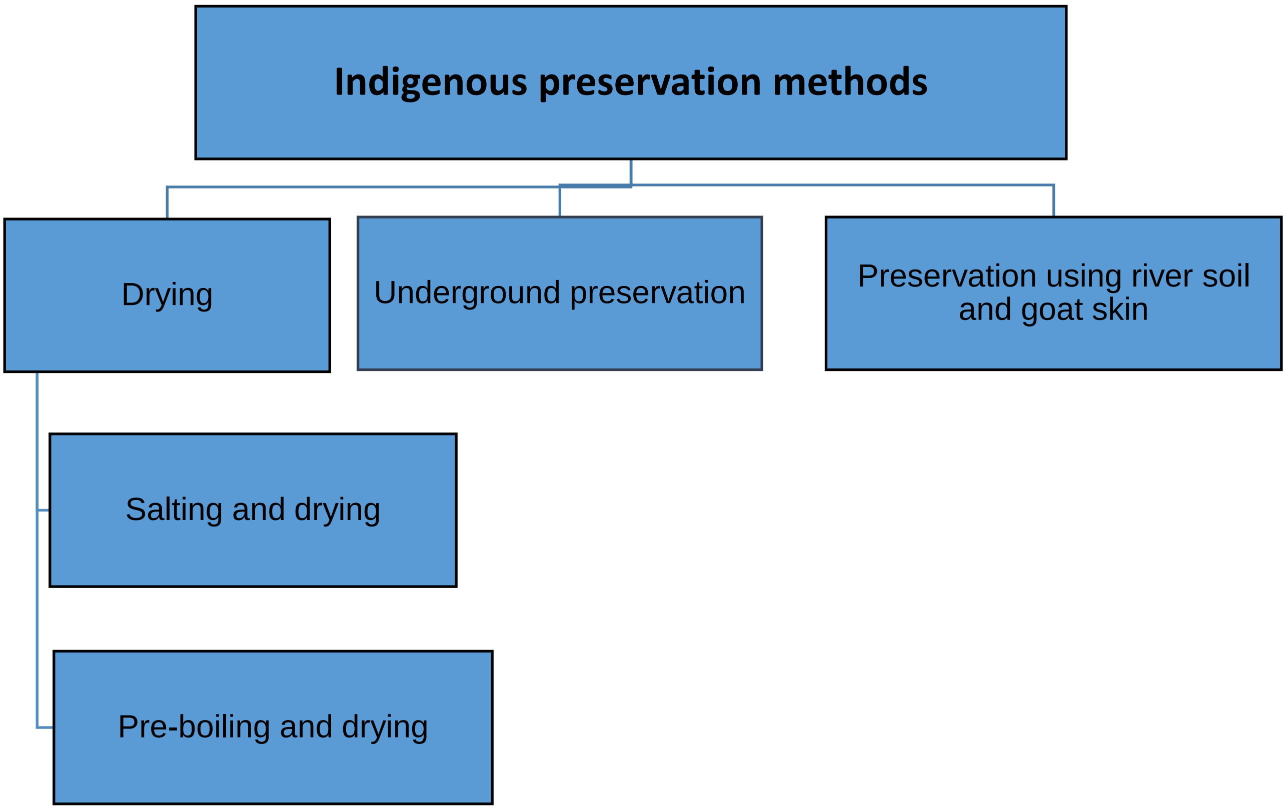
Uncastrated bucks have an unpleasant smell that attracts a lot of flies after slaughter and during consumption and when stored they spoil quickly. Goats carcass needed to have more intramuscular and subcutaneous fat and odourless. Chevon needs to be attractive both roar and cooked by having fat. Goat carcass that has fat does not stick to hands when skinning and during consumption. Tenderness of meat causes rapid release of juice by chewing and fewer remainders remaining in the mouth after chewing (Tshabalala *et al*., 2003b). Goats above the age of three years produce high-quality meat and goats that are too old produce hardy carcass with less fat content. The older the goat, the tougher the meat (Teixeira *et al*., 2011). Chevon should be tender and chewable but not too tender because when it is too tender it loses that unique taste. Preserving chevon reduces wastage of meat and improve its odour and taste than unpreserved chevon.

3.3.4 Chevon preservation methods

Methods used to preserve meat are modified from indigenous preservation methods. Preservation methods include drying, smoking, curing and salting (Teixeira *et al.*, 2011). Four indigenous preservation methods were reported are air-drying, pre-boiling and drying, underground preservation and the use of river soil and goat skin. Preservation of chevon by pre-boiling and drying takes precedence over salting and drying, underground and use of river sand preservation method. Meat preservation is the proper storage of meat in a cool, dry place preventing it from flies. This helps in saving meat for future use. The determinant of the use of preservation methods is largely dependent on the household size. Households with larger households would usually consume all the meat at once since the goat is a small animal and not get to preserve anything unlike in small households where they will not be able to finish the meat at once calling for a need to use one of the indigenous preservation methods.

The preservation methods that the households use is largely dependent on the individual choices. One can preserve goat meat because they want a different taste in meat than the fresh meat, dried meat or they will preserve the meat for future use. The indigenous preservation methods reported are instigated by males who are head of the households. Preservation methods were used because there were to store excess food and that food is available for consumption when needed. Men are responsible for protecting their families and making sure that they have food to eat all the times, thereby implementing their knowledge and ideas on chevon preservation to secure food for their families

Figure 3.1: Common indigenous preservation methods used in Nongoma



3.3.4.1 Drying

One method is to dry without pre-boiling. Preservation of meat by sun-drying has been carried out since the early recorded history of human civilization (Sabarez, 2016). Salting and air-drying meat is the indigenous preservation method used to store excess meat. Air drying involves smearing of meat with salt and exposing the meat to air and letting it dry. This process is done in cool, dry places. Meat is cut into small pieces, smear it with salt solution puncture on a stick and hanged outside, exposing it to air so that it can dry. The river salt is a mixture of salt collected from the river with water. Meat is smeared with water mixed with river salt. Preservation of meat by river salt was carried out by households who stay near the river. The method is determined by the desire to change the flavour and the colour of chevon which result in a different taste than fresh meat. This method is normally conducted but males who are the head of the household or the males in the family. This process was done for a week to get the meat completely dry. When the meat was completely dry, it was hanged in a cool dry place in a traditional house and ready for consumption. Goat meat that was dried was red meat, not the internal organs. Both chevon and beef were preserved by drying. The drying of meat was preferred because it stored the meat for longer periods without getting spoiled. Dried meat becomes hard, dark and not easy for flies to attach and spoil it. Drying meat result on colour change, from cherry red to dark red. Drying reduces texture and water content in meat resulting hardness (Teixeira *et al.*, 2011). After drying and preserving the meat, it was possible to wash and cook the meat again if household wanted a cooked meat. The meat will become tender and available for consumption when in need. The aging process is crucial in terms of meat texture because the longer you dry the meat, the tender it becomes reducing toughness or hardness after cooking (Zhou *et al.*, 2010a). When river salt was not prepared, chevon was consumed alone without any additives. Drying without pre-boiling has a limitation, this includes controlling the drying process and parameters, weather uncertainties, requirement of large drying area, insect infestation as well as mixing with dust (Jain and Pathare, 2007). Meat needs to be dried in an open space and be removed when the weather changes and at night. If the meat gets wet from the rain it will easily spoil.

Goat meat was preserved by pre-boiling, puncture and hang it in a traditional house. This house was kept cool and dry with no fire. The meat was pre-boiled in a three-legged pot. To the pot, one put sticks underneath, add water and let the steam pre-boil the meat for 10- 15 minutes. The chest of a goat is for the head of the household. This method was invented through the rule that when the goat is slaughtered, the chest of the goat should be stored for the head of the household, not consumed on the same day as the other carcass. These preservation methods resulted in a different smell of goat and taste that were desired by the ancestors. As the day goes by the worms will appear on the meat, but they will just shake them off and still consume the meat because the food was not thrown away. River salt was used to preserve meat by pre-boiling and drying. River salt was collected from the river and mixed with water to prepare a brine, this water solution was therefore used when pre-boing chevon. Other households preserve the meat after pre-boiling and other will smear the river salt after pre-boing and preserve chevon.

Normally in winter, there are fewer flies, therefore, river salt incorporated to meat when pre-boiling was considered to be enough compared to summer seasons where flies are a major problem. However, the preferred method was pre-boiling chevon with common salt and smearing with salt because it enhances preservation of chevon. Modern preservation methods are more health conscious than indigenous preservation methods. Spoil meat is considered unhealthy and detrimental to be consumed by humans. This preserved the meat for two to three days in summer and five days in winter. The temperature during winter is low which reduces the rate of meat spoilage and inhibit the growth of micro-organisms responsible for meat spoilage (Koutsoumanis *et al*., 2006).

Pre-boiling chevon, covers or coat the outer layer of the meat to increase the duration of preservation. There are some bacteria that are found in meat and they grow and affect the meat. This includes moulds, yeast, ordinary types of bacteria and spore-forming spoilage bacteria. Oxygen in air and enzymes in the meat causes changes in meat and spoil it (Ashbrook, 1955). This preservation method was normally done by males who are the head of the household. Both beef and chevon were preserved in this manner. Respondents mention that there was a place called *ithala* in the traditional house where goat meat was preserved. On the roof poles, two poles were placed horizontally, and they believed that a higher place was the coolest place in the house. Goat meat was placed on a traditional tray called *uqgoko* and placed parallel to the two poles on the roof. The meat was separately placed so that air can circulate around to dry it. This was another option of preserving goat meat if hanging it was not preferred.

3.3.4.2 Underground preservation

Goat meat was preserved underground in the kraal. The kraal was the most treasured place by the heard of the household and considered the safest place. These places were chosen over other places because it was regularly monitored by the head of the household and the hole dug on the kraal will be easily seen if the hole is getting covered by the soil. Holes dug at anyplace poses a danger to the kids and other livestock owned by falling inside the hole. Underground preservation method was conducted by the males especially the head of the household. A two-meter hole was dug in the centre of the kraal, the meat was placed on the traditional mat called *isithebe* spaced out. The hole was covered with dung at the bottom and at the top of the hole to form a barrier for soil pathogens not to enter the meat and to prevent dust. Underground was considered as the coolest place since it was not exposed to the sun. After placing the meat on the hole, a big round stone was used to close the hole so that flies and dogs will not reach the meat. When the household is in need of meat, they opened the whole and take the amount of meat they need and close the whole again. Cooked meat was not preserved in this manner only fresh meat. Goat meat was kept there for a three day in summer and five days in winter.

3.3.4.3 Use of river soil and goat skins

Chevon was preserved by using river soil and goat skin. A thick layer of river soil was made in a cool, dry place in a traditional house. After slaughter, chevon was wrapped with goat skin and placed on top of the river soil. These preservation methods were conducted for 3 days in summer and five days in winter. The river soil (sand) is cold and stored the meat for three days. Furthermore, these method was mostly used by people who stayed near the river. After three days the soil will be dry due to excessive loss of water in the soil, but the soil was collected in the river after three days to carry on with preservation and discard the dry soil. Only chevon was preserved using river soil and animal skin. These methods were done by the heads of the household after slaughtering the goat for meat production or when there was a ceremony. Preservation in this manner is associated with the Zulu culture and the use of goat skin. This preservation method was more effective in winter where there are fewer flies and heat. In summer the meat got spoiled more easily.

3.4 Conclusions

Indigenous preservation methods used do not require electricity, cost-effective and are environmentally friendly. The mostly used preservation method is drying with pre-boiling followed by drying without pre-boiling. Indigenous preservation methods used in ages was influenced by the availability of resources. Indigenous knowledge system is not only used for food security, however, it is used to share ideas for goat management and production as well as overcoming common diseases in goats. Abandonment of indigenous knowledge system is one of the causes of food insecurity, therefore, it is crucial to gather and document this knowledge. Understanding these methods can assist households to reduce meat spoilage and wastage and enhance food security especially to poor-resource households. These therefore, raised the need to comparing indigenous methods of preserving chevon and identify which method is more efficient.

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CHAPTER 4: Comparison of indigenous methods of preserving chevon

Abstract

The objective of the current study were to compare indigenous preservation methods on chevon quality. Fifteen clinically healthy one-year-old wethers were used. The bucks weighed between 16 and 20 kg. Five preservation methods used were tested. These were (1) Pre-boiling with water (PWT), (2) Pre-boiling with river salt (PRS), (3) Pre-boiling with common salt (PST), (4) Pre-boiling with double salting (PSS) and (5) Storage without boiling and salting (NBS). The chevon was kept for four days at room temperature. The untreated meat (NBS) spoiled faster ($P<0.05$) than preboiled chevon. Storage of chevon using the NBS method turned green earlier ($P< 0.05$) than preboiled chevon followed by the PWT and PRS methods. Unpleasent smell, larvae and manifastation of maggot and rancidity were all highly significant different ($P< 0.001$) in preservation methods of chevon. Storage of chevon without pre-boiling and salting developed unpleasent smell and became rancid faster than pre-boiled chevon. In addition, dryness also varied with the preservation method used ($P<0.05$). Chevon preserved by the PST and PSS turned green last however, no rancidity was observed. Number of maggot were higher in NBS initially and decreases with increase in storage time and dryness also increases. Moreover, in preboiled chevon dryness was initially high with no maggot but at the final stage of storage maggots were high and dryness was reduced. There was no difference in the time to spoilage between chevon preserved using the methods PRS and PWT. The PSS method led to the least levels of spoilage. It was concluded that pre-boiling with double salting were effective in inhibiting chevon spoilage by providing an unsuitable environment for microbial growth. Furthermore, the addition of river salt had little effect of reducing chevon spoilage.

Keywords: Decoloration, off-odours, river salt, sodium chloride

4.1 Introduction

There is relatively high production and consumption of chevon in Africa and Asia (Kannan *et al.*, 2001). This is largely because chevon contains high protein and less cholesterol (Casey and Webb, 2010b). In addition, its fat content makes it an ideal red meat for low fat diets such as chakna, mute soup and chivito (Gadiyaram and Kannan, 2004). Meat-based products are highly perishable compared to the grain-based product due to their chemical composition (Zhou et al., 2010a). Fruits, vegetables, meat and meat product are all preservable for future consumption for example grains, cassava, apple, fish, and beef (Robert, 1962; Anyanwu, 2004). The presence of proteins, fatty acids, minerals and vitamins its mild pH (5.5-6.0) and high water activity enables meat to be a suitable environment for the growth of micro-organisms making it to easily spoil. It is, therefore, essential that appropriate preservation techniques is applied to maintain meat safety and quality (Aymerich *et al.*, 2008).

Meat spoilage is caused by a variety of processes such as enzyme action, micro-organisms and by a wide range of physical and chemical reactions. Meat preservation includes the application of measures such as refrigeration, salting, drying or heating to prevent or delay microbial, oxidative and enzymatic actions makes meat undesirable (van Laack, 1994; Zhou *et al.*, 2010a). Likewise, meat preservation is also an effective way of saving food and preventing it from being wasted and lost (van Laack, 1994). Preservation is mostly done to inhibit microbial spoilage, to minimise oxidation and enzymatic spoilage (Zhou *et al.*, 2010a).

Common preservation techniques are chilling, canning, use of chemical additives, freeze-drying and irradiation. Rural households usually preserve their meat by salting and drying, smoking, curing and by fermentation (Dirar, 1993; Dave and Ghaly, 2011b). In contrast, these result in undesirable flavours, discolouration and off-odours in meat. (in't Veld, 1996). Drying is dehydration of lean meat under natural conditions (Sharp, 1957). When salting and drying, meat is cut into pieces of about 1x1 cm, smear with salt or use brine and puncture it on a wooden stick and expose to light and air. The same applies to curing meat, however, the salt that was used was sea salt, mine salt, and rock salt. Furthermore, smoking meat is carried out by setting a wood fire under the meat and let the smoke cover the meat. In fermentation of meat, salted mince and fat is stuffed together in the animal intestine to create alleviating anaerobic conditions and allow fermentation of meat. Followed by drying the meat to stabilise and mature the product (Dave and Ghaly, 2011b).

Recently advanced preservation techniques are not readily available to poor- resource households. Therefore, an approach that includes the local experience of households in meat preservation, might result in a balanced mix of local and introduced techniques to reduce the risk of food wastage and loss of nutrients, flavour and taste. Understanding these methods assists households in reducing food wastage and brings alternative preservation methods that are cost-effective and reliable especially to poor-resource households.

Rural households preserve chevon by pre-boiling with river salt, common salt and drying. However, no study has been conducted to assess the effect on indigenous preservation method on chevon quality. Therefore, the study will compare the effect of indigenous preservation method on chevon and identify an indigenous method that influence chevon preservation and assist rural-households in reducing food wastage and enhance food security. The objective of the study was to compare indigenous preservation methods on chevon spoilage and the hypothesized that different preservation methods will affect chevon differently was tested.

4.2 Materials and methods

4.2.1 Study site

The study was conducted in Jozini community. The Jozini local municipality is situated in uMkhanyakude district in the extreme north of KwaZulu-Natal province, South Africa. The site was selected based on the availability of indigenous knowledge of chevon preservation. The area is classified under sub-humid climate characteristics by hot-dry and cool-wet seasons. Annual rainfall averages of 600 mm. Most rains are received between January and March, in the month of June and July being dry and cool. The highest temperatures are recorded in January (30^{o}C) and the lowest temperatures are recorded in July being (11^{o}C). The vegetation type consists of coastal sand, veld, bushveld and foothill wooden grasslands. The area is dominated by Zulu tribe who largely rely on livestock farming. Cattle and goat farming are the most predominant species.

4.2.2 Experimental goats

Fifteen clinically healthy Nguni wethers were used in the study. The bucks were purchased at the age of one year old. The body weight of goats ranged from 16 to 20 kg with a body condition scoring of between 2 and 3. Goats that were having a BCS ranging below 2.5 were thin with less back fat, the backbones were still visible with continuous ridge. Ribs were still felt and the intercostal space was smooth and still penetrated. The backbone of bucks with the body condition scoring of 3 was not prominent and the lumbar vertebrae were not easily grasped because the tissue layer covering the vertebrae was thick. However, the bucks with body condition scoring of 3 had a backbone that was not prominent and the spinous process of the lumbar vertebrae was not easily grasped because the tissue layer covering the vertebrae was thick. Futhermore, that indicated that the fat content in goat was different. A completely randomised design was used. Goats were randomly assigned into the treatments.

All the goats were slaughtered using the suprasternal notch piercing (with blood loss) and they were slaughtered by a member of a community who is an expert in slaughtering the goats. The slaughtering technique is a common method used for goat before preserving chevon by indigenous preservation methods, for example, drying the meat. With this methods goats were held with its forelimbs spread apart, allowing them to stand on their hind legs. The slaughterer was holding the head of the goat while holding the spear that is specifically designed to slaughter goats. The spear was used to pierce the suprasternal notch of the goat targeting the heart and allow the blood to bleed out. This was done to prevent blood clots in meat after slaughtering. Skinning and evisceration were also done by the slaughter. The slaughterers were the elders who had experience in slaughtering goats using suprasternal notch piercing (with blood loss) and who usually slaughter the goats in the community.

Dressed weights of the bucks were between 7.5 to 15 kg. After slaughtering, the pH of chevon was measured using a pH meter. The pH of meat after 45 minutes and after twenty-four hours was measured. The goat's chest area was removed 24 hours after slaughter and subjected to five indigenous preservation techniques.

4.2.3 Chevon preservation methods

The methods used were pre-boiling of chevon with common salt (PST), pre-boiling with river salt (PRS), pre-boiling with water (PWT), pre-boiling with double salting (PSS) and storing without pre-boiling and salting (NBS). In the preservation of chevon with common salt (PST), brine was prepared by using common salt (NaCl). The methods testes were based on finding from Chapter 3.

4.2.4 Meat preparation

Five table spoons of salt and 200 ml of water were mixed to prepare a brine. Firewood was prepared for pre-boiling chevon and a traditional tree leged pot of size 1.6 kg was also used. The traditional pot was placed on the firewood and 5 liters of water was poured into the pot. Goat chest was punctured using a wire stick and placed into the three-legged pot. Brine was also poured into the pot and the meat was allowed to boil for 15 minutes. Chevon was removed from the pot when the colour change to brown and with no blood dripping. Therefore,this was an indication that the outer layer of meat is successfully boiled. After boiling, the meat was cooled at ambient temperature and hanged on a traditional house (rondavel) for preservation. On the other hand, preservation of chevon by pre-boiling with salt and salting was conducted by following the procedure mentioned above. However, in the preservation of chevon by double salting (PSS) includes smearing of common salt after boiling and hanging on a traditional house for preservation.

Preservation of chevon by pre-boiling with river salt (PRS) was conducted by preparing a brine. Seven spoons of river salt and 200 ml of water was used for river salt brine. River salt is the soil collected from the river that was used back in the days as salt. The salt contained 6.73 µS/cm (micro Siemens per centimeter) which means that it was slightly saline. Firewood and the three-legged pot were used to pre-boiled chevon. 5 liters of water and brine was poured in the pot, boiling was conducted for 15 minutes at 100 ^{o} C. After boiling, cooling of chevon at room temperature was allowed followed by handing in the traditional house for preservation. Furthermore, chevon was pre-boiled with water, no addition of salt or river salt for 15 mints at

100 ^{o}C using 5litter of water like other methods and hanged on a traditional house for preparation. The final method used for preserving chevon was the storage of chevon without pre-boiling and salting. After pre-boiling chevon was allowed to cool down and chest area of the goat was removed, punctured on a wooden stick and hanged on the traditional house for preservation. Storing of chevon without pre-boiling with brine and salting was used as the control in the study. measurement of water salt and river salt were taken after an elderly who is an expert in indigenous preservation method confirmed the amount that needs to be added when preparing the brine for pre-boiling chevon. Temperature for preservation ranged from 23 to 30 ^{o}C and chevon was preserved for four days.

4.2.5 Measurements of chevon quality

Evaluation of meat quality measurement was conducted by categorising the dependent variables as follows. Green spots were evaluated in chevon colour, where no green spots was recorded, green spot and when the meat turns completely green. Chevon with green spots indicate deterioration of meat quality and that chevon is no longer addible , therefore not good for human consumption. The smell of chevon spoilage was also categorised to no smell, smelly and to stench which means that chevon was extremely smelly. Presence of flies was measured as no flies, moderate flies, and extreme flies. Eggs laid by flies on chevon during storage were evaluated and categorised to no eggs, eggs and more flies eggs. Maggot manifestation was also measured in chevon and categorised to no maggot, present maggot, and extremely high maggot. The level of rancidity of meat was measured according to the presence of rancidity, no rancidity and extremely high rancidity. Smell of chevon changes with increase in duration of preservation and that further leads to development of desired taste and flavor. However, development of rancid odour and unpleasent smell show that chevon has spoiled. Dryness of meat was categorised to moist, dry and extremely dry. Dry meat was prefered because it protect the meat from flies and enhance preservation of meat. Measurements were assessed by experts in indigenous preservation methods and who possess a wealth of experience in indigenous preservation methods and evaluating acceptability of meat for human consumption. Expect were sangomas and elderly who are heads of the households. Data were collected for four days and due to excessive spoilage of chevon during storage, the study was discontinued.

4.2.6 Statistical analyses

The PROC MIXED procedure of SAS (2008) was used for the analyses with the effect of preservation method and the duration of preservation on colour, smell intensity, the presence of flies, the presence of larva, appearance of maggots, rancidity, and dryness. During analyses, the effect of day was included as a repeated measure. The model was used was:

$$Y_{jkl} = \mu + C_i + P_j + (C \times P)_{ij} + E_{jkl}$$

Where:

Y_{jkl}= response variable (colour, aroma intensity, presence of flies, presence of larva, appearance of maggot, rancidity, and dryness);

μ= population mean common to all observations;

C_i= effect of method of preservation (Pre-boiling with salt, Pre-boiling with river salt, Pre-boiling with water, storing without boiling, Pre-boiling with salt X2).

Pj= effect of duration of preservation (j=0, 1, 2, 3, 4 days)

$(CxP)_{ij}$= the interrelation between preservation method and duration of preservation .

E_{jkl}= residual error~ N (O; Iq2)

4.3 Results

4.3.1 Summary statistics and level of significance

The summary statistics of meat spoilage parameters tested in chevon stored using indigenous preservation methods are presented in Table 4.1. Indigenous preservation methods that were used to preserve chevon (breast region) were PST, PRS, PWT, PSS as well as NBS. The river salt used to pre-boil chevon contained 6.73 us/cm of salt which means that it was slightly saline. The measurements tested on putrefaction of chevon were the presence of flies and larva, manifestation of maggot, colour, smell (off-odour), rancidity and dryness as shown in Table 4.1. In the current study, interaction ($p<0.001$) between treatments and storage days was observed. There were significant differences in indigenous preservation methods in terms of chevon spoilage P (<0.001). The study discovered that chevon spoilage was faster when stored without boiling and salting (NBS) than pre-boiling chevon for storage purposes (PSS, PST &PWT). Pre-boiling and drying prolong chevon spoilage, however the (PWT)or the PRS spoiled chevon quicker. Meat colour was significantly different ($p<0.05$) in preserved chevon. Presence of flies was highly significant different ($P<0.001$) in chevon. Exhibition of larva in stored meat was different in indigenous preservation methods ($P<0.001$). There were significant differences in the manifestation of maggot in chevon ($P<0.001$) and there were differences in lipid oxidation of chevon preserved using indigenous preservation methods ($P<0.001$). Dryness of chevon was significantly different in preservation methods ($P<0.05$).

4.3.2 Meat quality measurements

Flies are the major contributor to meat spoilage. NBS had moderate flies (mean value 6.8) on the first day of storage and other preservation methods had fewer flies. Table 4.2 indicates that pre-boiling chevon with river salt (PRS) and water (PWT) respectively had more or less the same amount of flies during storage. Pre-boiling with salt and salting had fewer flies compared to other indigenous preservation methods. NBS had high mean value of 7.5 for the presence of larva than other preservation methods. Preservation of chevon by pre-boiling with river salt (PRS) and pre-boiling of chevon with water had moderate larva respectively. Pre-boiling chevon with double salting had moderate larva of 3.0 and decreased to 1.8 on the third day of storage. Presence of larva decreases as the period of storage increase.

In Table 4.2, the NBS method had the appearance of maggot earlier than preboiled chevon. However, (PRS) and (PWT) had the same least square mean of 5.0, which indicate that they both had moderate maggot manifestation. Although maggot started dropping on the second day in control, it has the lowest mean of 1.3 on the fourth day of storage. Compared to other indigenous preservation method. Maggot started dropping on day three of storage in all pre-boiled chevon. Elderly mentioned that this is the time where they will shake off the maggot and cook the meat again and it will be ready for consumption.

Meat colour varied with indigenous preservation method used. No green spot was observed on early days of storage, however an increase in duration of preservation increase amount of green spot in meat. Table 4.3 indicates that chevon that was stored without boiling and salting turned green faster than pre-boiled chevon with the highest least square mean of 7.3. Colour changes of chevon stored by the PRS and PWT was similar. White spots were also observed in pre-boiled chevon however only a few green spots were present during storage compared to storage of meat without boiling and salting. Furthermore, there were differences between preboiled chevon. Preservation of chevon by pre-boiling with water and river salt spoiled faster than that of preservation with salt and salting. The unpleasant smell of chevon varied with preservation method. In Table 4.3, PRS and PWT had the same least square mean of 7.5 for smell and storage without boiling and salting was stench faster than all the indigenous preservation method. Although storage of chevon without pre-boiling and salting was smelly faster than the rest of chevon. Chevon turned green and had an unpleasant smell before the final day of storage, therefore, the study had to be discontinued.

Table 4.4 shows the significant differences in rancidity and dryness of chevon. Storage of chevon without boiling and salting and pre-boiling with water had the highest least square mean of 8.0 and 7.0, respectively. This indicates that rancidity in this preservation methods was extremely high. Rancidity in pre-boiling of chevon with the PRS, PST and PSS method was extremely low. Pre-boiling with common salt and pre-boiling with double salting reduces lipid oxidation. Chevon preserved by pre-boiling either with common salt, river salt or water was drying in a similar manner. However, storage of chevon without boiling and salting was getting dryer quickly compared to other preservation methods. Increased in the duration of preservation yields in extremely dry chevon that is stored using the NBS and pre-boiling and PSS methods chevon improves tenderness of chevon.

Table 4.1: Levels of significance for indigenous preservation methods and duration of preservation (days) on meat spoilage measurements such as colour, aroma, the presence of flies, the presence of larva, and appearance of maggot, rancidity and dryness

	P values		
	M	Days	(MxD)
Flies	**	**	**
Eggs	**	**	**
Maggots	**	*	*
Colour	*	**	**
Off-odour	*	**	**
Rancidity	**	**	**
Dryness	*	**	**

**P<0.01; *P<0.05

Abbreviations: M= Methods; D=days; (MxD) = Interaction between preservation method and duration of preservation (days).

Table 4.2: Least square means (±SEM) for contribution of housefly on meat spoilage in different indigenous preservation methods

SM	DAYS	Preservation methods					SEM
		PRS	PST	PSS	PWT	NBS	
Flies	0	3.0^{a}	1.3^{b}	1.0^{b}	2.3^{c}	6.8^{d}	
	1	4.8^{a}	3.5^{b}	2.3^{c}	5.5^{d}	8.0^{e}	
	2	5.8^{a}	5.2^{a}	4.0^{b}	6.0^{c}	7.5^{d}	
	3	1.8^{a}	1.7^{a}	1.0^{a}	1.8^{a}	2.0^{a}	
	4	1.3^{a}	1.7^{a}	1.8^{a}	2.3^{a}	1.8^{a}	0.35
Larvae	0	1.0^{a}	1.0^{a}	1.0^{a}	1.5^{a}	2.0^{a}	
	1	5.0^{a}	2.0^{b}	3.0^{c}	4.8^{d}	7.5^{e}	
	2	3.5^{a}	2.0^{b}	1.8^{b}	3.5^{d}	4.5^{e}	
	3	1.0^{a}	1.3^{a}	1.0^{a}	1.0^{a}	1.0^{a}	
	4	1.2^{a}	1.2^{b}	1.8^{b}	1.0^{b}	1.3^{b}	0.35
Maggots	0	1.5^{a}	1.2^{a}	1.5^{a}	1.3^{a}	4.0^{b}	
	1	5.0^{a}	1.5^{b}	1.5^{b}	5.0^{c}	7.3^{c}	
	2	4.0^{a}	1.7^{b}	2.3^{b}	4.3^{c}	7.3^{d}	
	3	7.8^{a}	2.3^{b}	7.0^{b}	7.0^{b}	8.0^{c}	
	4	7.8^{a}	7.0^{b}	8.0^{a}	7.8^{a}	1.3^{b}	0.29

$^{a, b, c, d}$ Within rows, means with the different superscripts differ ($P<0.05$).

Abbreviations: SM=spoilage measurement; PRS=Pre-boiling with river salt; PST=Pre-boiling with common salt; PSS=pre-boiling with double salting; PWT= Pre-boiling with water; NBS= storing without boiling and salting, SEM=Standard error mean.

Table 4.3: Least square means (±SEM) for different indigenous preservation method on meat spoilage measurements such as colour and off-odours

		Preservation methods					
Measurement	**DAYS**	**PRS**	**PST**	**PSS**	**PWT**	**NBS**	**SEM**
Colour	0	1.8[a]	1.7[a]	2.0[a]	1.8[a]	1.5[a]	
	1	1.3[a]	5.0[b]	5.0[b]	1.0[c]	5.3[d]	
	2	6.0[a]	5.3[a]	5.2[a]	5.3[a]	7.3[b]	
	3	7.5[a]	7.6[a]	7.0[a]	7.5[a]	7.3[a]	
	4	7.5[a]	7.6[a]	8.0[a]	7.5[a]	7.5[a]	0.34
Smell	0	2.0[a]	1.8[a]	2.0[a]	1.5[a]	2.5[b]	
	1	2.5[a]	2.0[a]	2.5[a]	2.3[a]	2.3[a]	
	2	5.3[a]	5.2[a]	5.3[a]	5.5[a]	7.5[b]	
	3	7.5[a]	7.0[b]	6.8[c]	7.5[d]	7.5[a]	
	4	8.0[a]	7.7[a]	8.0[a]	7.8[a]	7.5[a]	0.25

[a, b, c, d] within rows, means with the different superscripts differ ($P<0.05$).

Abbreviation: PRS=Pre-boiling with river salt; PS=Pre-boiling with common salt; PSS=pre-boiling with double salting; PWT= Pre-boiling with water; NBS= storing without boiling and salting; SEM= standard error mean.

Table 4.4: Least square means (±SEM) for different indigenous preservation methods on oxidation of fat and dryness of meat during storage

		Preservation methods					
Measurements	**DAYS**	**PRS**	**PST**	**PSS**	**PWT**	**NBS**	**SEM**
Rancidity	0	1.8^{a}	1.7^{a}	1.8^{a}	1.3^{a}	2.0^{a}	
	1	1.5^{a}	1.3^{a}	1.8^{a}	2.0^{a}	1.3^{a}	
	2	3.0^{a}	1.7^{b}	2.3^{b}	2.3^{b}	3.0^{c}	
	3	3.3^{a}	3.0^{a}	1.0^{b}	7.0^{c}	8.0^{c}	
	4	3.5^{a}	5.7^{b}	1.3^{a}	5.3^{d}	7.8^{d}	0.25
Dryness	0	3.5^{a}	3.5^{a}	2.8^{a}	3.3^{a}	1.8^{b}	
	1	4.8^{a}	5.0^{a}	5.0^{a}	4.8^{a}	3.8^{b}	
	2	5.8^{a}	5.8^{a}	5.8^{a}	5.5^{a}	4.5^{b}	
	3	3.5^{a}	3.3^{a}	4.3^{b}	4.3^{b}	6.5^{c}	
	4	2.8^{a}	3.2^{a}	2.8^{a}	3.5^{a}	8.0^{b}	0.29

$^{a, b, c, d}$ within rows, means with the different superscripts differ (P<0.05).

Abbreviations: PRS=Pre-boiling with river salt; PS=Pre-boiling with common salt; PSS=pre-boiling with double salting; PWT= Pre-boiling with water; SWBS= storing without boiling and salting, SEM=Standard error mean.

4.3.3 Correlations

The result presented on correlation are based on Table 4.5. There was a positive correlation among all the meat spoilage parameters tested, except for smell (off-odour) and maggot which was negatively correlated. Meat colour was positively correlated with the smell (off-odour) of meat. That means that when the meat colour change to green the meat become smelly. No correlation was observed between flies and rancidity as well as between meat colour and eggs. The smell of meat was positively correlated to rancidity. The more the meat get smelly the more rancid it becomes. Lastly, smell was negatively correlated to flies and maggot was also negatively correlated to dryness.

4.4 Discussion

Earlier spoilage in the storage of chevon without boiling and salting (NBS) compared to pre-boiling of chevon with common salt, river salt, water and pre-boiling with salt and salting could be attributed to variety of factors. This includes post-slaughter handling, differences in processing of meat prior storage and storage temperature (Adzitey and Huda, 2012). In this study, it was discovered that storage of meat without pre-boiling and salting (NBS) contribute towards early spoilage of meat as expected. High spoilage rate in control could be due to the contamination of breast region during skinning, evisceration, and handling when puncturing the meat on a wire stick prior storage. The result obtained in this study are in line with (Adzitey and Huda, 2012) who discovered that poor handling of meat post-slaughter and when processing the meat contribute to spoilage of meat.

Storage of control in ambient temperature (20-45^{o}C) provided a conducive environment for microbial growth responsible for meat spoilage such as *Cladosporium, Salmonella, Cryptococcus species* hence the control spoiled quicker (Gram *et al.*, 2002). Sentence (1991) reported the growth rate of *Pseudomonas species* at 0^{o}C-2^{o}C and observe that the bacterial growth is high at 2^{o}C compared to 0^{o}C and had a great effect on meat. He also discovered a slow *Salmonella* growth below 7^{o}C, which increased above 7^{o}C and affected the shelf life of meat. Belitz *et al*., 2009 stated that shelf life of a frozen chicken is also affected by storage temperature. Delays on chevon that was preboiled prior storage including pre-boiling with common salt, river salt, pre-boiling with salt and salting and could be associated with exposure to meat to boiling water (100^{o}C). These findings correspond with Ellebracht *et al*.,1999 who finds that exposure to boiling water is sufficient to destroy viruses, bacteria, and fungi associated with early meat spoilage. Furthermore, heat kills microorganisms by degrading nucleic acid and denaturing enzymes and other proteins and disrupting the cell membrane. Storage period of meat can be improved by performing hygienic slaughtering and clean handling practices of the carcass (Adzitey and Huda, 2012). Therefore, boiling of chevon reduces the amount of micro-organism contaminating the meat during post-slaughter handling and extends it's the shelf life.

Flies were least attracted to pre-boiled chevon compared to control as expected however the proportion of flies in PRS and PWT was greater compared to the salted chevon. Flies particular housefly which is scientifically called *Musca domestica Linnaeus* favour damp, compost and other decomposing organic matter for laying their eggs (Warburton and Hallman, 2002). It was discovered that pre-boiling chevon reduces the number of flies attracted to meat. This could be due to drying of the outer surface of chevon after pre-boiling and salting. In contrast, the addition of salt (NaCl) keeps away the flies more compared to all the indigenous preservation methods. This could be attributed to physiological properties of salt by reducing water content, drying the surface of the meat and providing an unfavourable environmental condition for flies to lay their eggs. Differences in presence of eggs in chevon could also be due to brine, however, river salt had little effect on minimising the presence of flies. Presence of eggs in chevon was the number of eggs laid by flies in chevon during storage. Households make use of river salt because it might have been the only resource available to use at that particular time and the river salt was slightly saline. Maggot increased with duration of storage in pre-boiled chevon compared to control. The decrease in maggot manifestation in control could be caused by an increase in hardening of the surface and depletion of nutrients in chevon for maggot, early dropping of maggot and seeking for a darker place to transit from a maggot stage to pupae. Increased in maggot in pre-boiled chevon could be caused by the delay of maggot in getting proper nutrients on the surface of chevon. Only those eggs that were laid on the least salted surface of chevon had access to inner part of the meat that contained all the required nutrients for growth of maggot. Moreover, the maggot started growing from within the goat chest and cracking the outer surface from the inside hence maggot got extremely high on the third day and start dropping on the fourth day.

Meat colour varied with indigenous preservation method used. Green spot in chevon preserved without pre-boiling and salting could be associated with autolytic enzymatic spoilage and microbial growth. Autolytic enzymatic actions are a natural process that takes place in a muscle cell of an animal after slaughter that results in deterioration of meat due to the presence of enzymes (Dave and Ghaly, 2011b). Amylolytic, proteolytic are enzymes that are responsible for breaking down of carbohydrate and proteins respectively into smaller particles that result in softening and discoloration of tissue (Simpson *et al.*, 2012). Green spot or changing of chevon colour to green was an indication that the meat is spoiling and no longer edible. Green spot in control could also be related to yeast, moulds and bacteria growth such as *Lactic acid bacteria, Enterococci and Micrococci* (Robach and Costilow, 1961). Bacteria produce hydrogen sulphide that converts the muscle pigment (myoglobin) to green sulfomyoglobin.

Hydrogen sulfide derived from cysteine, which is metabolised when glucose and oxygen availability are limited (Kröckel, 1995). Sulfomyoglobin is associated with high pH (>6.5) but also occur in normal pH (5.8), It is however not formed in an anaerobic environment. Sulfomyoglobin is also responsible for a green spot in meat (Bala *et al*., 1977). H_2O_2 is synthesized by LAB in the aerobic atmosphere resulting in oxidation of nitrosohaemocrome to cholemyoglobin producing a green spot on meat. (Vihavainen and Bjorkroth, 2007) reported that the bacteria *Leuc.gelidum subsp.gasicomitatum* is indeed known species that is able to cause green colour in chilled and packed meat. Formation of a white and green spot in PRS, PSS, Pwater, and PS could be ascribed to the presence of thermophilic bacteria such as *Alicyclobacillus*.

Unpleasant smell in control could be caused by microbial spoilage as a result of nutrient degradation. The most common bacteria associated with meat spoilage are *Acinetobacter, Pseudomonas, Bronchonthrix, Flavobacterium, Psychrobacter, Moraxella, Staphylococcus* and *Micrococcus*, lactic acid bacteria and various genera of the *Enterobacteriaceace* Pennacchia *et al*. (2011). Bell *et al*., 2001 reported that all the bacteria that cause meat spoilage make use of insoluble compounds contained in muscle tissue for their growth particularly glucose and amino acids. He further elaborated that the preferred substrate is glucose and when it is readily available on the surface of the meat, no significant degradation of another substrate will take place. However, when glucose is depleted micro-organism begin to utilise amino acids through proteolysis. Large quantities of ammonia, a lesser amount of organic sulphides and amines are than degraded causing the release of unpleasant smell in meat. In contrast, the treated meat took longer to release off-odours due to exposure to boiling temperature and addition of antimicrobial preservative such as sodium chloride (NaCl). Boiling meat at 100^{o}C destroys spoilage microorganism and denatures proteins available on the surface of the meat.

These delays the bacteria from utilising amino acids in the muscle tissue hence delaying off-odours in meat. Addition of sodium chloride provided unfavourable growth conditions for microbes by increasing the osmotic pressure and decreasing water availability in the micro environment aiding in the reduction of unpleasant smell (Dave and Ghaly, 2011a). Furthermore, differences between pre-boiling with river salt and pre-boiling with water compared to pre-boiling with salt and double salting could be due to the presence of salt that inhibits microbial proliferation. River salt is slightly saline therefore had no effect on inhibiting microbial growth hence spoilage in pre-boiling with river salt was similar with Pwater. There are some bacteria that are heat resistance (*Lactobacillus viridescens*) and others are resistant to the high concentration of salt (*micrococci)* (Borch et al., 1996b; Dave and Ghaly, 2011a; Guerrero-Legarreta, 2014). These bacteria dominate and contribute to putrefaction of meat hence all the boiled meat got rotten after boiling and salting. Off-odours in meat are also caused by lipid oxidation (Guerrero-Legarreta, 2014).

Lipid autoxidation that causes the development of rancidity involves the complex sequence of chemical changes that result from the spontaneous reaction of double bonds from unsaturated fatty acids, with oxygen via free radicals reactions and leads to off-odour production and off-flavours in meat (Guerrero-Legarreta, 2014). Availability of oxygen is one of the major factors that result in the development of rancidity in cooked and raw meat (Huang and Greene, 1978). High Rancidity in SWBS compared to boiled chevon (PRS, Pwater, PSS and PS) could be attributed to microbial spoilage, enzymatic and non-enzymatic hydrolyses of lipid. In enzymatic hydrolyses, the lypolytic enzymes were responsible for lipid oxidation and these enzymes are present in the skin, blood, and tissues of an animal (Dave and Ghaly, 2011a). During lipolysis, lipase separate the glycerides forming free fatty acids which are responsible for common off flavours and the main enzymes responsible for meat lipid hydrolyses are phospholipase A1 and phospholipase A2 (Toldrá, 2006). In non-enzymatic hydrolyses, heme protein myoglobin (Fe^{2+} protoporphyrine complex (P- Fe^{2+})) was oxidised to (P-Fe^{3+}). The formed superoxide radicals anion O_2^- react with H^- and yield H_2O_2. Hydrogen peroxide was then oxidized (P-Fe^{3+}). To the oxen species P-Fe=O (Belitz *et al.*, 2009). These free iron redox cycles contributed by ascorbic acid are the main initiator of lipid peroxidation in fresh muscle (Ladikos and Lougovois, 1990; Dave and Ghaly, 2011a). Microbial activities result in the production of some compounds that are responsible for rancid odours (Chen *et al.,* 2017). Diacetyl, which is formed by Pseudomonas and some situations by lactic acid bacteria, is also a lipid oxidation product (Guerrero-Legarreta, 2014). Lipid deterioration in control could also be caused by exposure to ambient temperature (20^{o}C-35^{o}C) (Ladikos and Lougovois, 1990). High temperature accelerates lipid oxidation by promoting disruption of esters link to the triglycerides with the liberation of free fatty acids that are more reactive than the esterified acid residues (Kowale et al., 1996). The oxidative rancidity in boiled chevon (PRS and PWT) could be ascribed to haem and non-haem iron (Liu and Watts, 1970).

Sato *et al.* (1973) reported the fact that non-haem iron and ascorbic acids acid catalyse lipid oxidation in cooked meat. Igene *et al*. (1979) further reported that release of non-haem iron during cooking causes increasing rate of lipid oxidation in meat. When the iron of haem pigment is in the ferric state become more active lipid oxidation catalysts, though non-haem iron seems to be more active in the ferrous state. Addition of river salt in PRS had no effect on reduction of lipid oxidation. It was discovered that river salt was slightly alkaline, therefore had no effect on decreasing lipid oxidation. No rancidly was observed in PS and PSS and this could be due to the presence of salt. This is simmer to the findings of (Vara-ubol and Bowers, 2001; Sakai *et al.,* 2006; Kong *et al*., 2008) who discovered that there was no effect of salt in lipid oxidation. In this study, it could be due to the reaction of a secondary product such as aldehydes, ketones, epoxides and another carbonyl group with amino acids, phospholipids and amino groups of nucleic acids during heating with brine. The level of lipid oxidation is also influenced by the intensity of heat treatment (Ladikos and Lougovois, 1990). Boiling chevon at 100 ^{o} C for 15 minutes reduces lipid oxidation compared to uncooked meat. This is in line with the study that was conducted by (Pearson *et al*., 1983) who reported that meat heated at 70 ^{o} C for 60 minutes develop rancidity quicker, however Thiobarbituric acid values (TBA) were reduced when the cooking temperature was increased to 80 ^{o} C. (Huang and Greene, 1978) further elaborated that meat that is subjected to high temperature and /0r a long period of heating develops lower TBA values than the meat that was subjected to lower temperature for a short period of time. Spoilage of cooked chevon could be attributed to oxygen availability, however, addition of salt in meat prolongs the duration of storage for at least two days. Oxygen availability is known to be the important factor that accelerates lipid oxidation (Ahn *et al*., 1993). Chopping and cooking expose phospholipids to molecular oxygen and therefore accelerate lipid oxidation. This is similar to the study that was conducted by (Andreo *et a*l., 2003) who reported that heating and oxygen availability affected the conjugated dienes, hydroperoxides, and 2-thiobarbituric acid reactive substances formation during chill storage.

Increased dryness in pre-boiled chevon than control chevon was observed at early stages of storage, however, and increase in storage time decreases dryness in pre-boiled chevon. This could be caused by the exposure to heat treatment and the addition of salt. Salt has the ability to decreases water content in meat, therefore, aiding in the drying of chevon (Dave and Ghaly, 2011b). A possibility also exists that protein denaturing at the surface of chevon could be the cause of dryness of the meat. Protein denaturing result in contraction of muscle fibre diameter and sarcomere length, causing the water-soluble protein and fats to be eliminated from the tissue, which may lead to an increase in denaturation temperature of proteins (Baublits *et al*., 2006; Gallart-Jornet *et al.*, 2007; Adzitey and Nurul, 2011). (Wierbicki *et al*., 1975) who conducted a study on the effect of salt, phosphate and other curing ingredients of shrinkage of lean pork meat and the quality of smoked processed ham, reported the continuous increase in meat shrinkage with an increase in the salt addition from 5% to 10%. Softening of pre-boiled chevon could be ascribed to continuous exposure to oxygen that promotes the development of micro-organism that causes meat spoilage. The interior portion of boiled chevon is raw therefore the presence of oxygen promotes oxidative enzymes and bacteria to spoil the meat, however, increase in storage time result in the development of desired aroma and taste for the elderly.

Table 4.5: Correlation coefficients among meat spoilage measurements

Measurements	colour	Smell	Flies	Eggs	Maggot	Rancidity	Dryness
Colour		0.8**	NS	NS	0.71**	0.53**	0.19*
Smell			-0.27*	-0.28*	0.60**	0.66**	NS
Flies				0.71**	NS	NS	NS
Eggs					NS	NS	NS
Maggot						0.35**	-0.25*
Rancidity							0.26*

Significance levels: **P<0.01; *P<0.05; NS= not significant (P>0.05).

A positive correlation was observed between colour and smell in preserved chevon. This is due to present of oxygen that promotes oxymyoglobin and oxidation of lipids in chevon, therefore resulting in deteriorating the color and lipids simultaneously. Lipid oxidation results in the development of off-flavors as well as the unpleasant smell in meat (Trindade *et al*., 2010). Several studies have been reported that indicate the influence of lipid oxidation in discoloration of meat (O'grady *et al*., 2001;Nute *et al*., 2007) and the role of heme protein (myoglobin) in enhancing lipid oxidation (Baron and Andersen, 2002; Carlsen *et al*., 2005).

The result that are similar to Zakrys *et al.* (2008) who examined the quality parameters in beef packed under 0, 10, 20, 50 and 80 % oxygen (20 % CO_2, balanced nitrogen). They concluded that changes in oxymyoglobin values seemed to be influenced by lipid oxidation and correlated strongly with thiobarbituric acid reactant substances. Dissociation of both hemes from myoglobin and iron from heme may play a major role in the mechanism by which myoglobin enhance lipid oxidation (Faustman *et al*., 2010). Iron (III) Myoglobin iron can undergo a quick neutralization in the presence of lipids due to the formation of the noncatalytic hemichrome pigment. Nevertheless, further denaturation of the heme protein or more exposure to heme group to the surrounding lipids and thus induce lipid peroxidation. In addition, MbFe(III) was also reported to be able to initiate lipid oxidation in the lipid hydroperoxide depent mechanism at acidic pH (Baron and Andersen, 2002).

Flies and eggs were positively correlated as expected. Increase in presence of flies also increases the number of eggs laid on chevon. Female housefly likes decomposing organic matter for laying their eggs, therefore the more the flies are attracted to meat the more the number of eggs will be available in meat (James, 2012). No significant differences were observed between eggs and maggot as well as eggs and rancidity. The eggs of flies had no effect on lipid oxidation as the eggs are the immature stage of flies that needs nutrients to grow. Animal tissue and bacterial provides a suitable environment for the growth of eggs to the maggots, furthermore, bacteria provides a growth factor such as vitamins and sterols that are essential for growth of maggot (Schmidtmann and Martin, 1992).

Flies and smell were negatively correlated as well as maggot and dryness. Previous studies had reported that flies are more attracted to rotten meat because it becomes moist and soft, thereby provide an ideal breeding condition for fly larvae (Stensmyr *et al*., 2002). In this study, negative correlation in flies and aroma could be ascribed to changes in temperature during the time of preservation. Flies are more abundant in high temperatures. As the meat gets dry the maggot are also reduced in meat. This may be caused by dropping of maggot to the ground and hardening of the muscle tissue in control, not providing a suitable environment for the maggots to grow and causes maggots to die.

Chevon with maggots was preferred by elderly than meat that does not have maggot. After maggot infestation in meat, elderly will simple shake of the maggot and boil the meat again and it will be ready for consumption. Maggots are highly nutritious containing 56.9 % crude protein and 20.9 % crude fat and they are currently used as supplementary feed for animals (Fasakin *et al*., 2003). (Hwangbo *et al*., 2009) conducted a study to investigate the effect of maggot supplementation on meat quality and growth performance of broiler chickens. They reported that maggot supplementation causes a greater increase in live weight, dressing percentage, breast muscle and thigh muscle. Maggot served as good protein source to elderly people, however bacterial growth and nutrient content in meat preserved using indigenous preservation method is not yet known and can be useful in improving indigenous preservation methods and chevon quality.

4.5 Conclusion

Spoilage of chevon varied with indigenous preservation used (Pre-boiling with water-Pwater, Pre-boiling with river salt-PRS, Pre-boiling with salt (NaCl)-PS, Pre-boiling with salt and salting-PSS and Storage without boiling and salting-SWBS). This was attributed to various processing and addition of additive prior storage. Pre-boiling and addition of sodium chloride were effective in inhibited chevon spoilage by providing an unsuitable environment for microbial growth compared to control. Addition of river salt had little effect of reducing chevon spoilage due to it chemical properties. Storage temperature, increase in the duration of storage and oxygen availability had a greater effect on chevon spoilage. Preserving meat with pre-boiling and salting can be useful in improving tenderness of goat meat and production of chevon with a different flavor.

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Chapter 5: General Discussion, Conclusion and Recommendations

5.1 General Discussion

The main hypothesis tested was that different indigenous preservation methods influence chevon quality. Indigenous preservation methods are regarded as primitive compared to modern preservation methods. Modern preservation techniques such as refrigerators, irradiation, canning, freeze-drying and chemical additives have reduced the drive of using indigenous preservation methods. Furthermore, some of the rural dwellers have no access to electricity and cannot afford advance preservation techniques, therefore they depend on the indigenous preservation of meat. This has led to the abandonment of indigenous techniques of preserving chevon, which use to contribute to sustaining food security in many households (Kamwendo and Kamwendo, 2014).

Indigenous preservation methods have been an important strategy for food storage, but such information and skills have not been captured and documented to prevent it from extinction (Maxwell, 1990). An approach that involves the local experience of household, might result in a balanced mix of local and introduced techniques, to reduce the risk for food wastage, loss of nutrients, flavour and taste. For example, the combination of indigenous preservation methods such as drying with modern preservation techniques which is the use of refrigerator to enhance shelf-life of chevon. However, households who do not have access to modern preservation techniques can practice indigenous preservation methods in favourable environmental conditions for example during the winter season where the temperatures are low, and prominence of flies are also low. Furthermore, it should be ensured that high amount of salt is used to enhance preservation of chevon and production of desired flavour and taste. Indigenous knowledge on the preservation of chevon needs to be captured, documented and transferred.

The hypothesis that there are different indigenous methods used for chevon preservation were discussed in chapter 3. Differences in indigenous preservation methods used for chevon could be associated with differences in backgrounds within households residing in one area and that further leads to differences in knowledge of indigenous preservation methods. Households were exposed to different practices of preserving chevon in their upbringing and therefore their knowledge in indigenous methods of chevon preservation vary. Furthermore, differences in preferences of chevon quality such as flavour, aroma, and taste may also contribute to differences in indigenous preservation methods. Some households prefer dried chevon and others desire pre-boiled and dried chevon. Both these methods are used for preserving chevon however they produce chevon with different taste and flavour. Available resources within an area influence the indigenous preservation methods used. Households who reside next to the river have access to river salt and therefore incorporate it when preserving chevon. However, with households who live far from the river would not have the knowledge of preserving chevon with river salt.

Indigenous knowledge (IKS), the importance of goats, factors affecting chevon quality as well as identification of indigenous preservation methods were assessed in chapter 3. Indigenous knowledge is regarded as the system of knowledge invented by local people for survival. This knowledge is extracted from elderly people to the new generation. It relies on memory and transmitted systematically, orally and by participating in the indigenous practices (Okorafor, 2010). Goats are essential species in the lives of rural households. They are important for cultural purposes, as a source of food, for their reproductive traits, improved livelihood and for social customs. However, the use of goats for cultural purposes has reduced the drive of using a goat for meat consumption. Therefore, most consumers prefer beef, mutton, and chicken than goat because of it against their religion (Simela and Merkel, 2008). Goats produce meat, milk, hair(cashmere) and skin (Webb *et al*., 2003). However, goats are largely used for meat consumption in rural areas, therefore they have a potential in reducing food scarcity by increasing food production. Factors affecting chevon were uncastrated bucks because they have an unpleasant smell that attracts flies during slaughter and consumption and when stored they spoil quickly. Goats above the age of three years produce high-quality chevon, however too old goats produce hardy meat with less fat content. The older the animal, the tougher the meat (Tshabalala *et al*., 2003a). Goats that produce high-quality meat are castrated bucks with short ears, shiny skin and a doe that has exhausted it reproductive expectancy and good body condition scoring. Chevon needs to have more intramuscular and subcutaneous fat and be odourless.

Four indigenous preservation methods were identified. This includes drying without pre-boiling, drying with pre-boiling, underground preservation as well as preservation by using river salt and goat skin. Proper storage of meat is carried out in a cool, dry place and preventing it from flies. Drying without pre-boiling is conducted by slicing meat into tiny pieces and smear it with salt or using brine which is a salt solution. This salt used was collected from the river. After smearing with salt, the meat was punctured by a wooden stick and exposed to air and allowed to dry for five days. On the other hand, drying with pre-boiling was conducted by pre-boiling chevon with river salt than expose the meat to air for drying. Goats chest area was the one preserved in this manner. Goats chest was punctured by using a wooden stick and hand in a traditional house (rondavel) for 5 days until maggot start dropping. Chevon was also preserved underground. A two meters hole was dug in the centre of the kraal, the meat was placed on the traditional mat called *isithebe* spaced out. The hole was covered with dung at the bottom and at the top of the hole to form a barrier for soil pathogens not to have access to the meat and to prevent dust. Underground was considered as the coolest place since it was not exposed to the sun. After placing the meat on the hole, a big round stone was used to close the hole so that flies and dogs will not reach the meat. Goat meat was preserved for five days in winter and three days in winter. The last preservation method that was identified was the preservation of chevon by river salt and goat skin. A thick layer of river soil was made in a cool, dry place in a traditional house. After slaughter, chevon will be wrapped with goat skin and placed on top of the river soil. These preservation methods will store chevon for 3 days in summer and five days in the winter season. All the indigenous preservation methods were carried out by the head of the household. The hypothesis that there are different indigenous preservation methods used is accepted based on findings of different indigenous preservation techniques for chevon.

The hypothesis that indigenous preservation methods affect chevon quality differently was assessed in Chapter 4. Indigenous preservation methods result in various meat quality attributes such as colour, aroma, and flavour. Therefore, they affect chevon differently to produce those desired traits. Chevon preserved by salting and drying result in different meat quality traits compared to pre-boiled and dried chevon. Processing of chevon prior storage also plays an essential role in differences in chevon quality. Furthermore, preserving chevon without boiling and pre-boiling also contributes to these differences. Lastly the use of additives before preservation such as the use of common salt or river salt aids in differences in alteration of chevon quality.

Indigenous preservation methods on chevon spoilage were compared in Chapter 4. Chevon preserved without boiling and salting spoiled faster than pre-boiled and salted meat. Poor handling of meat post slaughter and storage temperature contribute to early spoilage of meat (Adzitey and Huda, 2012). Early spoilage of chevon could be attributed to contamination of chevon during skinning and when puncturing the meat on a wire stick as well as the storage temperature. Furthermore, spoilage of chevon preserved by pre-boiling with river salt and pre-boiling with water has the same spoilage pattern. This could be ascribed to river salt being slightly saline therefore having little effect on reducing microbial growth. Pre-boiled chevon had least flies, larva, and maggot compared to raw meat. However, with an increase in duration of preservation pre-boiled chevon had extremely high maggot compared to raw meat. Flies especially houseflies Musca domestica linnaeus favour a damp, compost and other decomposing organic matter for laying their eggs (Warburton and Hallman, 2002). This could be ascribed to the smell of blood in raw meat that makes it attractive to flies and provides all the necessary nutrients for growth of maggot. On the other side pre-boiling chevon and addition of salt harden the outer layer of the muscle and therefore reducing the attraction of flies to goat meat. Moreover, increasing storage time softens the muscle and increases the moist of cooked meat, allowing larva to have access to nutrients available in meat, grow and increase in number. Meat colour and lipid oxidation varied with indigenous preservation method used. Green spots were initially observed in raw meat than later in pre-boiled chevon.

Changes in colour to green is an indication of microbial spoilage and enzymatic activity. This is caused by bacteria that produce hydrogen sulphide and convert muscle glycogen to green sulphmyoglobin (Gill, 1983). In raw meat, the green spot could be attributed to oxygen availability that leads to degradation of nutrients such as proteins, carbohydrates, and lipids by enzymatic action. Green spots in pre-boiled chevon could be caused by thermophilic bacteria, for example, *Alicyclobacillu*s and bacterial that withstand high salt concentration. Unpleasant smell observed in the study may also be caused by bacterial spoilage, enzymatic action and lipid oxidation, especially in raw meat. There was no rancidity in chevon preservation by pre-boiling and salting. Salt enhances water binding in meat and therefore prevent the cookout of water or heating and cover the fat particles, preventing their release on the heat. This is done by dissolving and swelling the meat protein structure (Toldra, 1998). Preservation of chevon by pre-boiling with salt and salting was the effective method compared to preservation without boiling and salting, pre-boiling with river salt and pre-boiling with water and pre-boiling with salt. However, the trial was discontinued due to excessive spoilage of chevon in all the indigenous preservation method used. Therefore, the hypothesis that indigenous preservation method affects chevon differently is accepted. Indigenous preservation methods spoiled chevon differently. Preservation of chevon by pre-boiling with salt and salting stored chevon longer than the other methods.

5.2 Conclusions

Functions of goats are prioritised differently by households. Goats are not only kept for cultural purposes but also used as a source of food especially for meat production and for social customs. Indigenous preservation methods are still a useful tool in storing meat and they are cost-effective, reliable, environmentally friendly and do not require electricity. These methods were influenced by the availability of resources. Preservation of chevon by pre-boiling with salt and salting preserve chevon better than drying without pre-boiling and pre-boiling with water and river salt. This method also reduces lipid oxidation in chevon and can be useful in improving tenderness of chevon and production of chevon with a different flavour. Colour, smell deteriorated with increase in duration of preservation. Addition of salt also contribute to the duration of storage; however, river salt has little effect in storing meat due to its chemical composition. Storage temperature, increase in duration of storage and oxygen availability had a greater effect on chevon spoilage. Abandonment of indigenous knowledge system is one of the causes of food insecurity, therefore, it is crucial to gather and document this knowledge.

Understanding these methods can assist households reduces meat spoilage and wastage and enhancing food security especially to poor-resource households.

5.3 Recommendations

For improvement of indigenous preservation methods both indigenous and modern preservation method must be merged to enhance preservation of chevon. Practising indigenous preservation methods such as pre-boiling chevon with salt and salting can be improved by refrigerating to prevent the growth of micro-organisms and oxidative changes occurring when meat is stored at room temperature. For households who do have access to modern preservation methods can improve chevon by ensuring that a large amount of common salt is applied to reduce water content in meat and inhibit microbial growth to enhance chevon preservation. Therefore, pre-boiling with salt and smearing the meat with salt is recommended to resource-limited households.

The possible aspects that needs future research include:

1. Evaluation of microbial growth in indigenous preservation methods of chevon
2. Identification of bacteria, yeast, and moulds growing in chevon preserved by indigenous techniques.
3. Sensory evaluation of chevon preserved by indigenous methods
4. Mechanism of maggot in the utilization of nutrients available in meat for their growth and how they can be incorporated into meat preservation to add the nutrient content in meat.
5. Effect of cooking time also needs attention since overcooking and undercooking of meat influence shelf-life of meat.

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Appendix 1

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/lnterview 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 discipiine/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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Appendix 2

Identification of indigenous knowledge system of chevon preservation and quality in Nongoma Municipality.

1. What is your understanding of Indigenous knowledge system and how important is it?
2. Why are you farming goats?

3. **Indigenous preservation methods**
    - What are the indigenous preservation methods you know?
    - What are the reasons of preserving chevon?
    - Who implement the preservation method used in household?
    - What are characteristics of a good preservation method?
    - Factors affecting indigenous preservation of chevon?

Follow up questions for Indigenous preservation methods

4. **Air drying**
    - What was used to cut chevon into smaller pieces ?(taking into account that there was no knife back in the days)
    - When was it dried (soon after slaughter or a day after?)
    - Purpose of drying the meat?
    - What was used to hang the meat(considering that there was no wires)
    - What is the origination of this preservation?
    - What influenced the use of air-drying?
    - How long do you expose the meat to light or air?
    - Where do you hang the meat if the weather conditions are not favourable during the drying process ?

5. **Pre-boiling and preservation?**
    - How long do you boil the meat before preserving it ?
    - Do you stir the meat during boiling or only boil one side?
    - Amount of water used when boiling it?
    - Duration of preservation?
    - Purpose of using this preservation?

6. **Use of river soil and animal skin**
    - How old is the animal skin used?
    - Is the soil used dry or wet?
    - Where was this preservation method conducted (place)
    - Duration of preservation?
    - Who is responsible for preserving meat in this manner and why?
    - Purpose of preserving meat in this way?