Effects of goat ecotype and sex on post-mortem muscle energy status and meat quality

by

Diina N. Ndakeva

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ABSTRACT

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Diina N. Ndakeva

Promotor: Professor E.C. Webb

Co-promotor: Dr L. Frylinck

Department of Animal and Wildlife Sciences

Faculty of Natural and Agricultural Sciences

University of Pretoria

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The aim of this study was to investigate the effects of muscle energy metabolism and calpain proteolytic system on meat colour and tenderness in different Southern African ecotypes. A total of sixty-five (65) goats representative of different goat ecotypes namely Northern Cape Speckled (NCS), Eastern Cape Xhosa Lob Ear (XL), Mbusi/Nguni (MBZ), Southern African Boer Goat (SAB), Village type semi intensive (VT) and Village type communal veld (VTV), of A-age class (about nine months old) were used. The does and bucks used ranged between 10-14 and 6-12 animals from each group of goat ecotypes respectively. The VTV goats were transported directly from the communal areas the morning of slaughter and thus were exposed to transportation stress (241 km). Goats were slaughtered and dressed down by means of standard abattoir procedures. Each carcass was subjected to step-wise chilling (10-15˚C for 6 hours and then 4°C overnight). Muscle pH and temperature, muscle energy status, water holding capacity, drip loss, cooking loss, thawing loss, myofibril fragment length, sarcomere length, meat colour and forms of myoglobin, calpain systems were all evaluated in samples of the *longissimus dorsi* (LD) and *semimembranosus* (SM) muscles of the left sides of each carcass.

Live weights of carcasses in goat ecotypes showed that the SAB was significantly heavier (40.88 kg) than MBZ, VT, VTV carcasses which had significantly lighter live weights (22.95 kg, 24.22 kg, 22.00 kg), while the NCS and XL carcasses had moderate live weights (33.13 kg and 29.77 kg) respectively. There were no significant differences in dressing percentage between goat ecotypes (40.8-42.5%). Chilling losses were significantly higher in

the NCS and VTV carcasses (8.41 % and 7.80 %) respectively than SAB carcasses (5.46 %). The XL goats of both sexes were the only group that differed in carcasses characteristics. Interaction effects of ecotype and sex did not differ in terms of chemical composition. There were no sex differences in carcass characteristics. Doe carcasses had twice higher percentage of fat and dry matter percentage than that of the buck carcasses (0.27% *vs* 0.52%).

The ultimate pH values were significantly different between goat ecotypes, but they were within an acceptable range (pH_u 5.6-5.7), except for those of VT and VTV goats that had slightly higher ultimate pH values (pH_u 5.8) for LD. Bucks had significantly higher ultimate pH than does (pH_u 5.7 *vs* 5.6) for the LD. Buck carcasses from VT goats had significantly higher ultimate pH (pH_u 5.9) than that of the doe and buck carcasses from MBZ, NCS, SAB, VTV and XL goats that significantly ranged between (pH_u 5.5-5.8) for LD. Temperature declines and longer sarcomere lengths were indicative of no cold shortening in all goat ecotypes, either sexes and their interactions, which was facilitated by (step-wise) delayed chilling. Energy metabolites (creatine phosphate and ATP concentration) status decreased with post-mortem time, except for the production of lactate concentration, glucose concentration and glucose-6-phosphate concentration. Muscle samples from all goat ecotypes were associated with a lower glycolytic potential. Environmental effects such as transportation stress and production system influenced biochemical status of different goat ecotypes and sexes. There were no interaction effects between goat ecotype and sex on the water holding capacity, drip loss, cooking loss and thawing loss.

Transportation stress in LD of VTV goats significantly increased WHC (0.41) compared to LD of MBZ, NCS, VT, XL and SAB goats but all goat ecotypes caught up after aging as assessed at 4 days post-mortem. Transportation stress lowered drip loss in LD of VTV goats (0.5%) compared to that measured in LD of MBZ, NCS, XL, VT and SAB goats (1.70-1.86%). The SM muscles of MBZ had a significantly higher thawing loss (9.0%) than that of NCS, SAB, VTV, VT and XL that ranged between (6.0-7.2%). Calpain enzymes worked optimally, thereafter causing tenderness and shorter MFL after 4 days post-mortem. Lightness in meat differed significantly at 1 day post-mortem but meat colour of all goat ecotypes caught up at 4 days post-mortem. Oxymyoglobin increased post-mortem giving meat a cherry red colour (favoured by consumers), with only marginal changes in metmyoglobin which eliminated the chances of meat becoming too brown (consumers discriminate). Muscle fibre characteristics in the goat ecotypes were associated with higher percentage of red fibres. Delayed chilling should be considered to help reduce the risk of meat being cold shortened as well as improving the calpain activity, which will ensure the best carcass and meat quality.

DECLARATION

I, Diina N. Ndakeva declare that this dissertation which I hereby submit for the degree MSc Agric Animal Science at the University of Pretoria is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

Signed…..Ndakeva D. N…..…….

Date……28-01-2019...…….

DEDICATION

The study is dedicated to my beloved parents, Hafeni Shilumbu Ndakeva and Helvi Shiwalo Ndakeva, as well as to my small brother Selivanus Panduleni Ndakeva for their encouragement and support.

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LIST OF ABBREVIATIONS

ADP	Adenosine di-phosphate
ATP	Adenosine triphosphate
CCW	Cold carcass weight
CIE	Commission International *De L'Eclairage*
CL	Cooking loss
CP	Creatine phosphate
CSA	Cross sectional area
DFD	Dark firm dry
DL	Drip loss
DM	Dry matter
DP	Dressing percentage
GLM	General linear model
GP	Glycolytic potential
HCW	Hot carcass weight
LD	*m. longissimus dorsi*
LW	Live weight
M.	Musculature
MBZ	Mbusi – Nguni ecotype goat
MFL	Myofibril fragment length
NCS	Northern Cape Speckled ecotype goat
pHμ	Ultimate pH
Pm	Post-mortem
PSE	Pale soft exudative
RPM	Revolution per minute
SAB	South African Boer ecotype goat
SL	Sarcomere length
SM	*m. semimembranosus*
TL	Thawing loss
VIA	Video imager analyser
VT	Village Type
VTV	Village Type raised on veld

WBSF	Warner Bratzler Shear Force
WHC	Water holding capacity
XL	Eastern Cape Xhoza Lob Ear eco-type goat

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1.1 Project title

Effects of goat ecotype and sex on post-mortem muscle energy status and meat quality.

1.2 Project theme

Production physiology and product quality focusing on meat characteristics and composition.

1.3 Aims

- To investigate muscle energy metabolism and meat colour in different South African goat ecotypes (South African Boer, Northern Cape Speckled, Eastern Cape Lob Ear, Mbusi and random Village Type goats) and their sexes (bucks and does).

- To determine the role of calpain proteolytic enzyme system in post-mortem tenderization between the different goat ecotypes and sexes (bucks and does).

1.4 Hypothesis

H_{01}: There are no early post-mortem muscle metabolism differences between the goat ecotypes.

H_{02}: There are no early post-mortem muscle metabolism differences between buck and doe goats.

H_{03}: Calpain proteolytic enzyme activity does not affect post-mortem tenderization in goat meat.

1.5 Motivation

Goats (*Capra hircus*) belong to the Bovidae family of hallow-horned ruminants in the suborder Ruminantia of the mammalian order of Artiodactyla (French, 1970). Goats are prolific domesticated ruminants under tropical and subtropical conditions (Webb et al., 2005). Goat is a multi-functional animal and plays a major role in nutrition of landless, small and marginal farmers in many developing countries (Moela, 2014). Goats can effectively survive on available trees and shrubs in harsh environments in low fertility land all over the world. They play a role in the production of milk, meat, fibre and various by-products, as well as by

controlling many weeds which in return benefits pasture. Goats play a vital role in developing countries, as they contribute to the socio-economic, cultural and recreational needs of communities (Casey and Webb, 2010).

Roughly 88% of the world goat populace is situated in Africa and Asia of which over 80% of those goats occupy the tropics and subtropics (Alexandre and Mandonnet, 2005). The South African chevon industry makes a significant contribution to the economy of the agricultural sector (USAID/South Africa, 1998). According to NAMC (2005) South Africa is the major chevon producer in Africa. Furthermore, it was reported that South Africa is self-sufficient with chevon and exports large amounts to other African countries namely; Namibia, Seychelles, DRC, Bahrain, and lastly Gabon, of which Namibia orders the largest amount (63%) (NAMC, 2005).

The improved South African Boer goat is the most prevalent breed of all goats across the world because of their high fertility, fecundity and capacity to breed in harsh conditions with minimal supplementation feeding (Webb and Pophiwa, 2017). Boer goats were developed in the 1950s by the interbreeding of ecotypes for optimal meat production by M. T. B. Jordann in Somerset East district of the Eastern Cape, South African (Campbell, 2003). However, the unimproved indigenous goats also known as indigenous veld goat/ecotype still exist in limited numbers (Campbell, 2003). Due to interbreeding most of the indigenous goats are referred to unimproved local varieties, associated with the geographical area in which they are well adapted (Visser et al., 2004). Although the unimproved indigenous goats are commonly found the original ecotype can still be found in Southern Africa such as the Mbusi-Nguni, Northern Cape Speckled, Eastern Cape Xhosa (Eastern Cape Lob ear) and Kunene because of a few concerned goat breeders. There is evidence that the goat ecotypes are at danger of extinction because they are being transformed and improved. Therefore, there is a need to study different types of indigenous veld goats to acquire the differences and circulate information to farmers, producers and abattoirs, because indigenous veld goats (ecotypes) have displayed profound characteristics as compared to other breeds (Campbell, 2003). Furthermore, the Indigenous Veld Goat (I.V.G) Society are trying to save the ecotypes and maintain their pure genes just by looking at the phenotypic traits.

Goat meat (chevon and kid) is highly nutritious and it is easily digested due to its molecular structure as stated by Ivanovic et al. (2014). Goat carcasses are small (Casey, 1982), which contains fat content that is between 50-60% lower (DAFF, 2015) and fewer calories. However, the amount of subcutaneous fat cover cannot reach 4 mm to prevent it from cold shortening during post-mortem chilling (Dikeman, 1996). In comparison to beef, chevon has

the same protein content, higher calcium, magnesium, potassium, similar iron, lower vitamin B_{12}, folate contents, low in carbohydrates and no dietary fibre (Anwer et al., 2013). The quality of chevon is affected by many factors such as muscle structure, interaction of chemical muscle structure, chemical composition and environment, interaction of chemical changes in muscle tissues, stress and pre-slaughter (post-mortem) effects, product handling, processing and storage, microbiological numbers and populations (Joo et al., 2013).

The goat sector has been significantly less supported publicly and academically than other animal production sectors like cattle, piggery, poultry and horses (Dubeuf et al., 2004). The reason for this poor support is that it has been a less attractive research subject, as farmers mostly use goats for subsistence farming and because it exists at a small scale in the commercial production sector.

This study will provide information to the farmers regarding the meat quality aspects of the different ecotypes as scientist do not only focus on the phenotypic traits but also on genotypic traits of animals. Moreover, the study of indigenous goats is important as they constitute about 65% of goats found in South Africa (DAFF, 2015). The study and understanding of muscle energy metabolites in goat meat is essential because the rate of increased post-mortem glycolysis might be useful in improving the quality of chevon. This research will help promote the slaughtering of goats in commercial sectors since these aspects are not well understood in formal markets and in commercialising goat meat. This will not only promote goat meat production but will also be profitable in the goat production industry. DAFF (2015) indicated that only 55% of goats are slaughtered in the commercial sector, and that goats are mostly sold at the farm gate and informal markets.

CHAPTER 2: LITERATURE

2.1 Introduction

About 80% of the agricultural land in South Africa is inapt for intensive agricultural production (Schoeman et al., 2010). Meat quality of various goat breeds have been studied all over the world, but the South African indigenous goats have not yet been studied. The handling of carcass at slaughter is of importance due to major processes occur during the conversion of muscle to meat. This chapter enlightens the contribution of goats to South Africa, the description of indigenous goats, conversion of muscle to meat, sarcomere length, carcass composition and meat quality characteristics.

2.1.1 Production of goat and chevon in South Africa

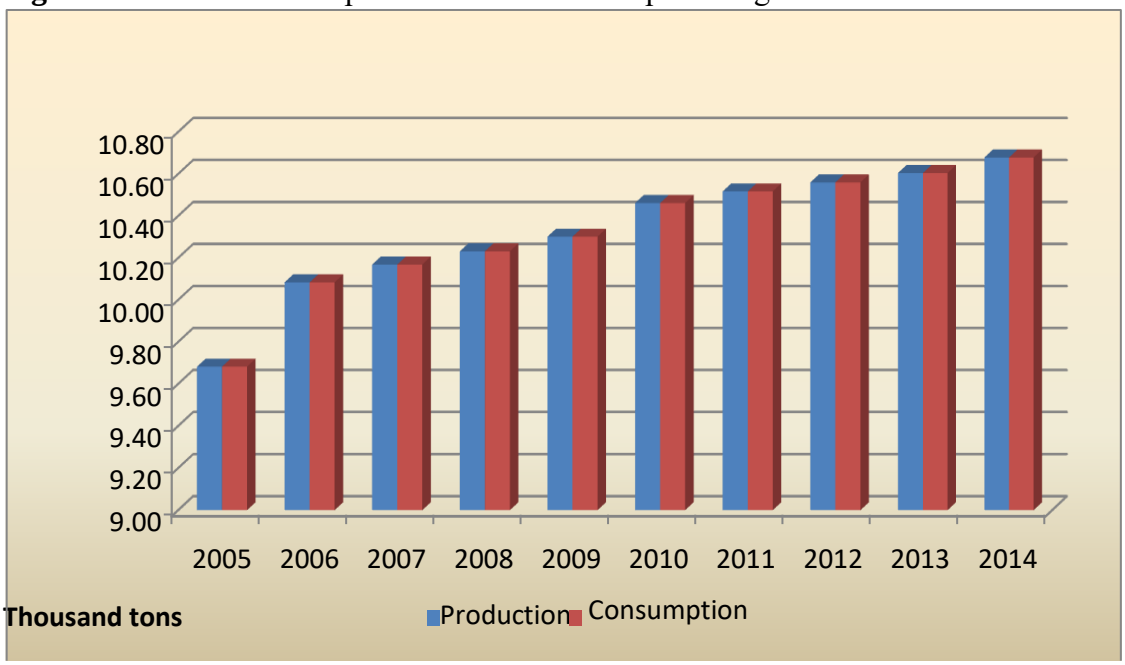
In the developing countries goat have been recognised to make a positive contribution especially to the communal areas (Aziz, 2010). South Africa is known to be a small goat producing country and owns about 3% of Africa's goat population and less than 1% to the world's goat population. According to the statistics of NAMC (2005) there was approximately 6.8 million goats in South Africa, of which 3.2 million goats were found in the Eastern Cape (Table 2.1). The Eastern Cape is dominated by a mixed veld type and a medium to lower rainfall. However, the communal areas were still dominated by a large number of indigenous goats as compared to the improved Boer goats that are farmed with in commercial areas (Mamabolo and Webb, 2004).

Table 2.1 The estimated number of goats per province (NAMC, 2005)

Province	Amount	Percentage
Eastern Cape	3 200 000	(46.7%)
Limpopo	1 000 000	(14.6%)
KwaZulu-Natal	900 000	(13.1%)
North West	771 000	(11.3%)
Northern Cape	513 000	(7.5%)
Western Cape	256 000	(3.7%)
Mpumalanga	100 000	(1.5%)
Free State	90 000	(1.3%)
Gauteng	9 000	(0.1%)

Indigenous goats represent approximately 65% of goats in South Africa (DAFF, 2015). The number of goats produced in South Africa was equivalent to the number of goat meat being consumed, hereafter an increase in production and consumption has been recorded over the past 10 years from 2005 to 2014 as indicated in Figure 2.1 (DAFF, 2015).

Figure 2.1 South Africa's production and consumption of goat meat



Obtained from NAMC 2015

In 1991, Norman described goat as a poor man's cattle, as they are cheap and easy to manage. In comparison to cattle, goats can be used for traditional use, serves as an emergency cash flow and require limited land for use. They are raised to produce meat, milk, wool, skin and good quality manure. Goat meat (chevon) is an important source of protein for humans across the world, thus the cultural, social and economic condition has a huge influence on the consumer's preferences (Webb et al., 2015). In addition, Peacock (1996) stated that goats play a vital role in the social life of communal people because they can be used as gifts and dowry at ceremonies, as well as to perform religious rituals and rites for passage. Also, "Goats represent a valuable contribution to the rich biodiversity of the region" (Bester et al., 2009).

2.1.2 Distribution and description of goat ecotypes (unimproved breeds) and improved breeds

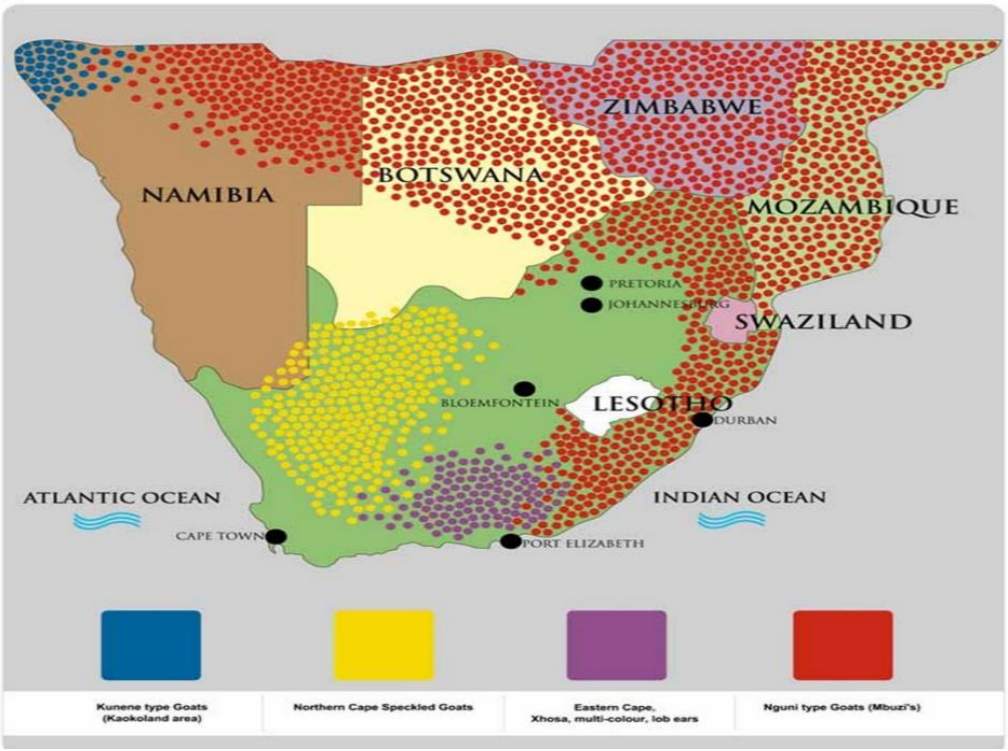


Figure 2.2 Distribution of indigenous goat around southern Africa **(**Campbell, 2003**)**

The improvement of indigenous goats started during the 21st century, where the late Mr. T. B. Jordaan was one of the pioneers of the modern Boer Goat. Unimproved veld goats also known as indigenous veld breeds are pure genotypes of South Africa (Campbell, 2003). The indigenous veld breeds are home to the southern part of Africa and have migrated with different ethnic groups (Snyman, 2014), however they were just registered as breeds in 2006. The indigenous veld goats registered are made up of 4 different ecotypes namely: Nguni Type (Mbusi), Northern Cape Speckled, Eastern Cape Xhosa and Kunene Type (Kaokoland). The indigenous veld goats are antelope-like breeds and vary widely in colour, size and hair length. They have the ability to survive harsh climatic conditions; utilize limited and often poor-quality feed resources and their natural resistance to a range of diseases such as pulpy kidney, gall sickness and internal parasites (Webb and Mamabolo, 2004). However, the existence of those ecotypes almost diffused due to the Boer goats' purification (Morrison, 2007).

2.1.2.1 The unimproved southern African ecotype goats

Figure 2.3 Example of Nguni type goat (Morrison, 2007)

The Mbusi goat (Nguni type) occur more abundantly than other distinct types of indigenous goats. They are medium to small multi-coloured goats, with a variety of uniform colours (white, black, fawn, brown, red-brown, pied and dappled) they have short, glossy hair coat and some grow cashmere in cold winters. They are semi-pendulous but not dwarf, with milk goat ears that are forward orientated. They have a slightly concave or the face profile tends to be flat with a predominantly dark pigmented muzzle (Snyman, 2014).

Figure 2.4 Example of Eastern Cape Xhosa goat (Morrison, 2007)

The Eastern Cape Xhosa lob ear are medium to large multi-coloured (white, black, fawn and red-brown, pied, speckled) goats that occurred in the medium to lower rainfall area of the Eastern Cape. They have short, glossy hair coat and inclined to grow cashmere in cold winters. Their face is slightly convex or flat with a dark pigmented muzzle and long hanging ears. Horns are present in both sexes; however, the female's horns grow upwards and curve outwards, whereas the male horns grow backwards and outwards (Snyman, 2014).

Figure 2.5 Example of Northern Cape speckled goat (Morrison, 2007)

The Northern Cape speckled are medium to large framed red, red-brown or black spotted goats, with drooping lob ears. Their heads are protected by the concentration of colour around the muzzle, eyes and ears with a white blaze on the forehead. The face is slightly convex or flat, with medium sized horns that grow upwards and curved outwards, with the tips inclining to tilt inwards. Horns are present in both does and in buck, they are large and heavy, that grow upwards and curve outwards. The legs have a solid dark pigment. The ecotype is highly tolerant to heat and sunlight. The female can produce up to an average of twins every eight months (Snyman, 2014).

Figure 2.6 Example of Kunene type goat (Snyman, 2014)

Kunene type are multi-coloured (white, black, fawn, brown, red-brown, pied) large frame goats with slender, finely boned legs, hardy, lanky and well adapted to the harsh climate where they have settled. They are excellent walkers and can walk long distances in search for water points. They have a long narrow face with a flat to slightly convex, light to dark muzzle, thus speckled muzzles are also found. They have long drooping ears with horns that that are medium to long and grow upwards and outwards (Snyman, 2014).

2.1.2.2 The improved southern breed goats

Figure 2.7 Examples of Boer goat (http://www.boergoats.co.za/)

This breed was developed from the indigenous goats in the 1950s by a small number of farmers in the Somerset East district of the Eastern Cape in South Africa (Webb and Pophiwa,

2017). It's one of the commercial breeds that has been distributed worldwide for the promotion of indigenous goats and improve meat production (Simela and Merkel, 2008). They have a large framed white body, red-head with round horns that are bent backwards and lopped ears. The body is covered with short, smooth and glossy hair. In addition, Lu (2001) identified the breed for its outstanding body conformation, fast growth and carcass quality. Boer goats are said to be an easy to keep breed to see and manage especially in thorn-bush countries due to their colour (Campbell, 2003).

2.2 Conversion of muscle to meat

The conversion of muscle to meat involves a complex process of changes in the muscular tissues, which determine the effects of meat quality (Simela, 2005; Pulford et al., 2008). This process begins when the animal has been slaughtered, causing the circulatory system to stop functioning, however this does not stop the metabolic processes from functioning (du Toit and Oguttu, 2013). Post-mortem effects such as pH, temperature and sarcomere length are mainly the key determinate of effectiveness of pre-rigor and post-rigor proteolysis which affects the conversion of muscle to meat.

2.2.1 Post-mortem muscle glycogen

Glycogen is a very large branched polymer of glucose stored in the animal muscle and liver, which is responsible for the accumulation of lactic acid post-mortem (Greaser and Guo, 2012; Immonen et al., 2000) in the absence of oxygen. Glycogen plays a significant role in the determination of ultimate pH, thus meat quality. However, too low amount of glycogen in meat deteriorate meat quality (Hocquette et al., 1998). Meat with a high glycogen level at slaughter is associated with a low ultimate pH, results in improved meat qualities. This occurs because glycogen is not completely depleted during the conversion of glycogen to lactate acid (Pethick et al., 1995), which is attributed by physiological factors upon slaughter; namely preslaughter environmental conditions, physical factors and transportation, handling of animals prior to slaughter (Muchenje et al., 2009).

Immediately after slaughter the ultimate pH is at its highest resulting to a low glycogen. Initially, the pH is required to drop from 7.2 to 5.5 and this is attributed by a glycogen level of about 45 mmol to reduce 1 kg of muscle (Immonen and Puolanne., 2000). However, Howard

(1963), Monin (1981), and Wulf et al. (2002) indicated that normal ultimate pH (pHu 5.5) cannot be reached if glycogen is below the threshold of about (45-55 mmol/kg), which can be achieved. When the glycogen is between 50-60 µmol/g it reduces the build-up of lactic acid. Furthermore, when the muscle pHu is at 6.6, the glycogen is at its lowest (10 mmol glucose/kg). Figure 2.8 indicate that ultimate pH decreases with increasing glycogen level in the muscle. Simela et al. (2004) reported an average glycogen concentration of 32.82 µmol/g in indigenous goats at 24 hours post-mortem. Hammelman et al. (2003) reported that glycogen concentrations in pigs decreased from 12.54–72.42 µmol/g within 24 hours of post-mortem. Immonen and Puolanne (2000) reported that glycogen concentrations in beef within 48 hours of post-mortem was between (25.1–49.9 mmol/g). The differences in glycogen concentrations are ascribed by the level of preslaughter stress, nutritional status of the animals, type of muscles and species (Immonen, et al., 2000; Pearson and Young, 1989).

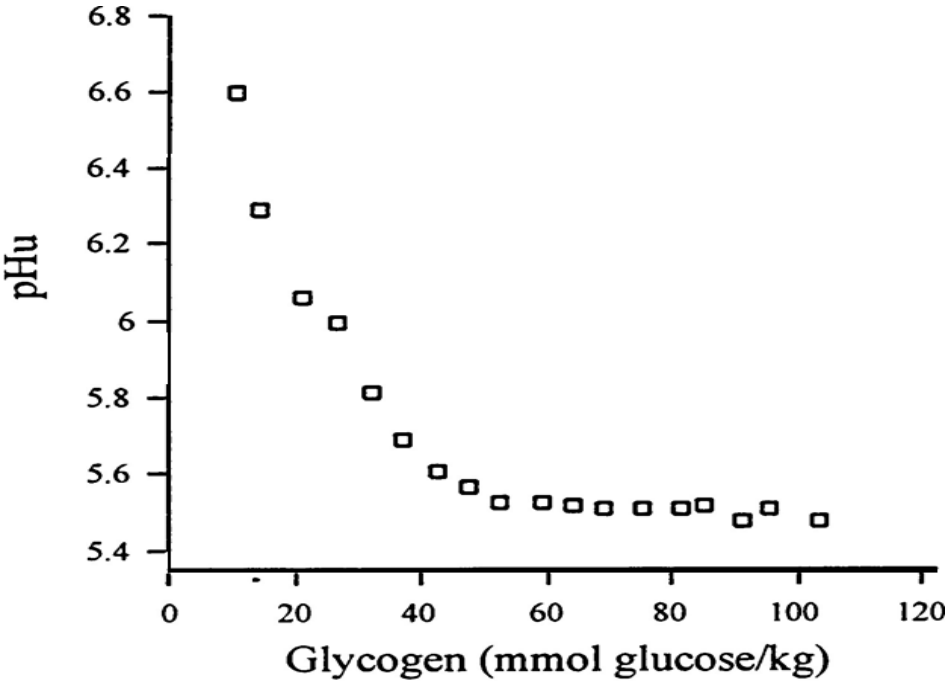


Figure 2.8 Relationship between ultimate pH of meat and the concentration of glycogen in muscle (LD) immediately after slaughter (Warriss, 1990)

2.2.2 The role of glycolysis and rigor mortis in the muscle

The production of energy in animal muscles can be described by the oxidative and glycolytic pathways (Pösö and Puolanne, 2004). Glycolysis occurs in post-mortem muscles where the supply of oxygen is not available anymore or its limited. Thus, glycolysis is essential once the animal has been slaughtered to provide energy to the muscle (Scheffler and Gerrard,

2007). Initially lactic acid starts to build up due the breakdown of glycogen causing the muscle to become acidic which leads to a shift in the muscle cells from aerobic to anaerobic (Mushi et al., 2007). The creatine phosphate is used for the conversion of adenosine di-phosphate (ADP) to adenosine tri-phosphate (ATP), this causes the creatine phosphate to drop as it's used to regenerate ATP from ADP again causing muscle contraction (Pösö and Puolanne, 2004) hence rigor mortis. This leads to a decline in ATP which is below the threshold (5 mmol/kg) at slaughter.

Rigor mortis is referred to death of muscles occurring (Greaser and Guo, 2012) between 2-6 hours after slaughter. The depletion of ATP at about 25-60% which causes actomyosin complex to be formed irreversibly and extensibility is lost in the process indicating the completion of rigor mortis (Pearson and Young, 1989). Rigor mortis occurs in three phases namely; delay, onset and resolution of rigor. During the delayed phase, the presence of ATP causes the muscle to remain in a relaxed state, thus actomyosin complex cannot be broken. The extensibility of muscles is rapidly lost during the onset of rigor mortis and this is highly dependent on the level of ATP present in the muscle (Lawrie and Ledward, 2006). According to Hannula and Puolanne (2004) pH and temperature are the main vital parameters at the onset of rigor mortis to achieve optimal tenderness.

Finally, lactic acid is produced after a reduction of 0.81 g/100 g glycogen leading to pH decline from approximately 7.2 in live animals to 5.3-5.7 after slaughter (Briskey and Wismer-Pedersen, 1961). However, the ultimate pH varies in different muscles and breeds. Thus, a very low pH leads to the denaturation of the enzymes causing the energy metabolism cease. According to Kadim et al. (2006) the ultimate pH is related to the rate of glycogen breakdown and release of lactate during pre-slaughter and post-slaughter, such that when there is sufficient glycogen the ultimate pH is increased to 5.5 after 48 hours. Furthermore, Marsh et al. (1987) quantified that rapid decline in the rate of pH and muscle temperature is caused by the rate of chilling muscles during rigor development. Thereafter, animals go into rigor mortis at a faster rate and its commonly found in stressed animals, (Lian et al., 2013) this consequently effect the rate of tenderization and water holding capacity. The rate of glycolysis is affected by intrinsic (age, sex, species, temperament, type of muscle and breed) and extrinsic (stress levels, environmental temperature, pre-slaughter drug administration and electrical stimulation) factors (Lawrie, 1992).

2.2.3 The glycolysis process during post-mortem

Glycolysis takes place in two phases that are responsible for the production of glyceraldehyde 3-phosphate and pyruvate, thus this is achieved by the catalysation of enzymes at different steps (Ferguson and Gerrard, 2014). Rapid rate of post-mortem glycolysis is associated with low pH which results in increased phosphorylase activity, hence high amount of glycogen and glucose-6-phosphate (Briskey et al., 1966). During the first step of post-mortem glycolysis, the enzyme glycogen phosphorylase catalyses glycogen residual into glucose-1-phosphate. Straight-after, its isomerized to glucose-6-phosphate taking it through the process of glycolysis. However, during the first hour of post-mortem the concentration of glucose-6-phosphate decreased and between 1 hour–24 hours the concentration level is increased reported Hammelman et al. (2003). Consequently, an uneven balance between glycogenolysis and glycolysis occurs (Scheffler and Gerrard, 2007). During the next step in the glycolysis pathway the enzyme phosphofructokinase with the supply of ATP, that is required to catalyse fructose-6-phosphate into fructose-1, 6-biphosphate. Overall, this step is important in glycolysis pathway, subsequently, the ability of the enzyme to initiate 1, 6-biphosphate can be disrupted by low amount of ATP, as well as by citrate and long chains fatty acids which are required for the transfer of phosphate (Pearson and Young, 1989).

2.2.4 Effects of pH and temperature on pre-rigor muscles and meat quality

Temperate and pH play a significant role in post-mortem muscles after slaughter (Pösö and Puolanne 2004; Ertbjerg and Puolanne, 2017; Silva et al., 1999). pH is used to measure the amount of hydrogen ions in a solution. Warris (2000) ultimate pH is very crucial to meat quality as it plays a role during the conversion of muscle to meat (Scheffler and Gerrard, 2007) and used to predicate colour, cooking loss, tenderness (Dutson, 1983), water holding capacity and flavour (Mushi et al., 2007). It's also required for the breakdown of glycogen and production of lactate at post-mortem (Kadim et al., 2006). Immediately after slaughter pH is required to drop from 7.2 to an ultimate pH of 5.3-5.8 (Briskey and Wismer-Pedersen, 1961) thus this value differs in breeds. Prolonged ultimate pH after slaughter improves meat quality as its associated with the activation of calpain enzymes responsible for degrading proteins in the muscle, thus tenderness is experienced in meat (Apple et al., 1995).

Muscle contraction requires energy to be produced, hence the shortening of sarcomere. The sarcomere is found in the skeletal muscle, myofibril, which is responsible for the

contraction and relaxation of the muscles. It's made up of the thick (myosin) and thin (actin) filaments (Swatland, 1982), in which calcium ion binds to troponin, myosin heads start to bind on the actin filament and forms actomyosin. Each time this bond is formed the ATP enzymes are activated, causing the breakdown of ATP and are only replenished once the muscles are relaxed (Lawrie and Ledward, 2006). According to du Toit (2011) the maximum reversible contraction of the sarcomere varies between 20-50% of their normal length at about 3.6 µm. When the muscle is relaxed the sarcomere is about 2.5 µm in length (Pearson and Young, 1989). At the time of shortening (contraction), muscles would have shortened from 2.5 µm to 1.8 µm by 30% (Ertbjerg and Puolanne, 2017). Temperature is significant during early post-mortem due to rigor shortening that is affected (Huff-Lonergon et al., 2010). Alternatively, Kim et al. (2014) suggested that slow glycolysis influences sarcomere shortening and hence toughness due to high pH. Rapid chilling of muscles at temperatures below 10˚C before the onset of rigor mortis leads to cold shortening (Locker and Hagyard, 1963 as cited by Pearson and Young, 1989) and this occurs within the first 1-2 hours stated (Ertbjerg and Puolanne, 2017). Goat muscles are very prone to cold shortening because of their small carcasses. Cold shortening is more intense in red muscles as compared to white muscles (Pearson and Young, 1989).

However, cold shortening in sarcomere is triggered by introducing carcass to cold immediately after slaughter and therefore to reduce cold shortening carcasses should be held between 15˚C and 20˚C until the onset of rigor, hence 10% minimal shortening as stated by (Thompson, 2002; Huff Lonergan et al., 2010). Whilst, low pH associated with high temperatures cause heat shortening in muscles. According to Pophiwa et al. (2016) goats have small carcasses and are more prone to cold shortening because they lose more heat at early post-mortem, thus the risk of cold shortening is increased. In addition, temperatures that are high (0˚C) cause an extreme shortening that is 48% more (Ertbjerg and Puolanne, 2017) or 50% of their normal length (Huff-Lonergan et al., 2010). Alternatively, delayed chilling is used to reduce the extend of sarcomere shortening and muscle toughening, by allowing intact carcass to be held outside of the chilling room for a certain period of time (Pophiwa et al., 2016). When sarcomere length reaches about 2 µm meat should become tender.

Muscles that are associated with high amounts of oxidative fibres during rapid temperature is prone to cold shortening (Huff-Lonergan et al., 2010). Pophiwa et al. (2016) reported pH values between (pH 6.53-5.76) at 5 post-mortem time (30 minutes, 1 hour, 3 hours,

6 hours and 24 hours) between breeds and concluded that breed does not influence pH on the *longissimus* muscle. Furthermore, Shija et al. (2013) and Polidori et al. (1999) reported pH values in the same range as those reported by Pophiwa et al. (2016).

2.3 The relationship between glycolytic potential, ultimate pH and calpastatin and its effects on meat quality

Glycolytic potential refers to the amount of energy in the muscle at a specific time that has the potential to be used by the body (du Toit and Oguttu, 2013). Glycolytic potential predicates the amount of lactic acid, glycogen, glucose, ATP and creatine phosphate content and accurately predicts the ultimate pH. According to Wulf et al. (2002), the crucial threshold of glycolytic potential is 100 µmol/g and anything below that is associated with a high ultimate pH, thus meat will be associated with dark firm dry (DFD). Consequently, low glycolytic potential is an indication of preslaughter stress. On the other hand, Simela et al. (2008) reported a glycolytic potential of 110.89 µmol/g and 97.97 µmol/g in castrates and females respectively with a normal pH and concluded that sex did not have an influence on glycolytic potential. Whilst, du Toit (2011) equally reported high glycolytic potential level over 130 µmol/g -150 µmol/g, however the author found no breed differences. According to Monin and Sellier (1985) glycolytic potential is calculated by: GP = 2 (glycogen + glucose + glucose-6-phosphate) + lactate.

Factors such as ultimate pH, tenderness, meat colour, water holding capacity and aging potential are affected by the depletion of muscle glycogen reserve at pre-slaughter quantified Gregory (2003). A rapid rate of glycolytic leads to pale soft exudative (PSE) meat which is common in porcine muscle of pork meat. Slow chilling of meat at a high temperature denatures sarcoplasmic and myofibrillar proteins as a result of low pH is obtained (Scheffler and Gerrard, 2007). Whereas a slow glycolytic rate leads to high ultimate pH above 6.0, which is associated with dark firm dry meat (DFD). In addition, meat with high ultimate pH is susceptible to microbial organisms which causes spoilage and reduce flavour (Silva et al., 1999).

Furthermore, Gaviraghi et al. (2007) reported that age, sex and pre-slaughter conditions did not influence the glycolytic potential because most goat carcasses had a very low glycolytic potential at slaughter and achieved a high ultimate pH. The ultimate pH of muscle is regarded as one of the most important factor in meat quality stated Kadim et al. (2006). “The ultimate pH of goat meat suggests that goats are highly prone to stress” by carrying out a peri-mortem

concentration of glycolytic metabolites in muscle and blood (Simela et al., 2004). In addition, the development of meat quality is affected by the rate and extent of glycolysis, whereby dark coloured meat with high water holding capacity is produced by a slow glycolytic rate leading to high ultimate pH (Pophiwa et al., 2016). Simela et al. (2004) reported glycolytic potential for high ultimate pH 5.8-6.0 (105.18-87.09 µmol/g) and for low ultimate pH 5.8 (114.82 µmol/g).

According to Mlynek et al. (2012) the value of glycolytic potential depends on the size, type and the number of muscle fibres which make up the muscle structure. Webb and Erasmus (2013) reported feedlot diet to have a significant influence on the conversion of muscle to meat because high-energy content increases the capacity for post-mortem glycolysis. In addition, Kadim et al. (2006) described that the importance of metabolic changes due to pre-slaughter stress is a depletion of glycogen and the consequent inability of muscles to develop adequate acidity levels at post-mortem.

2.4 Effects of stress on meat quality

Transportation is a vital pre-slaughter stressor, which can either be caused by physiological factors, genetic or when animals are introduced to strange environments. An indication of stress in small ruminants can be detected by measuring the concentration of plasma cortisol, high adrenaline, nor-adrenaline and dopamine concentration (Casey and Webb, 2010). Stress therefore causes metabolic changes that can in turn adversely affect meat quality in small ruminants (Kadim et al., 2006). The same author also found that animals transported at high temperatures (37°C) are likely to lose weight through the respiratory tract and animals had a higher plasma cortisol, adrenaline, nor-adrenaline and dopamine levels. Therefore, to maintain an ideal meat quality, it's important to control the rate of pH and temperature decline before the onset of rigor mortis (Hannula and Puolanne, 2004). When goats are stressed prior to slaughter catecholamine is released from the gland causing a change in energy metabolism (Kuchel, 1991 as cited by Ferguson and Warner, 2008) hence high pH and dark coloured meat.

Animals that have severely being subjected to stress are not able to produce lactic acid because the glycogen concentration is exhausted (Grandin, 1980). Transportation stress affects the meat quality by increased ultimate pH, increased shear force, expressed juices and cooking loss, hence reduced meat colour and lower sarcomere lengths (Casey and Webb, 2010) as well

as the depletion of glycogen (Silva et al., 1999) and the produced meat is not acceptable by most consumers. However, in 2014, Kannan et al. reviewed that 2 hours of transportation may not cause sufficient stress in animals that could have caused a change in the ultimate pH of the *longissimus dorsi*.

2.5 Effects of post-mortem muscle proteolysis on meat quality

Proteolysis refers to the breakdown of proteins in the muscle into smaller polypeptides/amino acids. This process takes place before or even after the onset of rigor mortis (Lawrie, 1974). Proteolysis and cytoskeletal proteins play a significant role in the tenderization of meat during meat storage (Dransfield et al., 1992) and overall the meat quality after slaughter. However, the contribution to the post-mortem change in meat still remains unclear. The post-mortem tenderization of meat is affected by the proteolysis and three enzyme groups; calpain, cathepsins (Varnam and Sutherland, 1996; Lian et al., 2013) and multi-catalytic proteinase complex (Koohmaraie and Geesink, 2006) were implicated.

Table 2.2 The activity and function of calpains and cathepsins during post-mortem (Varnam and Sutherland, 1996)

Location	Protease	Activity
Sarcoplasmic	Calpain I (μ-calpain)	Releases α-actinin, Z-nin
		Degrades desmin, filamin, connectin, nebulin
	Calpain II (m-calpain)	Degrades troponins, tropomyosin
		Degrades C- and M-proteins
Lysosomal	Cathepsin B	Degrades myosin, actin, troponin T
		Degrades collagen
	Cathepsin L	Degrades myosin, actin, troponins
		Degrades tropomyosin, α-actinin
		Degrades collagen
	Cathepsin D	Degrades myosin, actin, α-actinin
		Degrades troponins, tropomyosin
		Degrades collagen

The calpain system is made up of three enzymes; namely the µ-calpain, m-calpain and calpain III (p94). The µ-calpain and m-calpain are calcium activated proteases, which therefore require micro and millimolar concentration of Ca^{2+} for activation, as well as optimal temperature and pH (Kemp et al., 2010). Calpains are inhibited by specific inhibitors called calpastatin and this happens when the calcium binds to the calpains. Once calcium ions are released it weakens the walls of Z-disk. µ-calpain is activated at low calcium levels, which occurs in early post-mortem and at a pH level of 6.3 resulting in meat tenderisation as shown by Dransfield (1994). Whereas the m-calpain is activated when the calcium level increases. Furthermore, Koohmaraie (1992) demonstrated calcium ions of about 10 µmol/L and 200-300 µmol/L that is required for the activation of µ-calpain and m-calpain respectively. Additionally, the reduction of pH with a high muscle temperature at an early stage encourages early activation of µ-calpain, hence tenderness (Rhee et al., 2006). A high level of calpastatin reduces calpain activity that degrades the myofibrillar proteins during post-mortem this in return cease the process of tenderisation (Kemp et al., 2010). The activation and inactivation of calcium by proteolytic enzymes easily breakdown the myofibrillar proteins, hence tenderization (Koohmaraie, 1992).

In addition, authors have concluded that calpain system play a significant role in the proteolysis because they are responsible for weakening myofibril fragments during the early post-mortem aging (Kannan et al., 2014) and that is ascribed by their ability to autolysis intracellular calcium ions (Ca^{2+}) which are required for the degradation of Z-disk. A review on "the calpain system and skeletal muscle growth" by Goll et al. (1998) emphasized that calpain contributes approximately 95% to meat tenderization occurring between 7 to 10 days post-mortem aging between 2-4˚C (in beef). On the other hand, Lehman (1907) reported 30% increase in meat tenderness during the first 8 days of post-mortem storage as cited by Koohmaraie (1992). However, calpain activities may differ in different animals as well as different cattle breeds may also act differently. In addition, Ducastating et al. (1985) indicated that µ-calpain and calpastatin activity decrease with time post-mortem, whilst m-calpain decrease at a slower rate with time post-mortem. Furthermore, Zamora et al. (1998) explained that the reduction in µ-calpain is an indication of inactivation of µ-calpain. The variation in calpains are ascribed by muscle types, breed/species and muscle typing (Ouali and Talmant, 1990). According to Nagaraj and Santhanam (2006) a rapid decrease in calpain activity shows that they were activated during post-mortem conditions and were able to break down the myofibrillar proteins as well as to autolysis.

2.6 Acceleration of post-mortem proteolysis and meat tenderisation

Proteins in the muscle are broken down by calpain and cathepsin at different rates (Table 2.2) depending on factors like pH, temperature and the concentration of calcium ions (Koohmaraie, 1992). Actin and myosin are the two major proteins that cannot be degraded by calpains but rather by cathepsin. Calpains are more reactive at higher pH conditions and this is applicable in μ-calpain (Dransfield, 1994). The increased amount of calcium ion is responsible for weakening myofibrillar structures that cause tenderization as reviewed by Koohmaraie (1992). Increased calcium ions reduce the days of aging from 7-14 day to 24 hours of post-mortem (Koohmaraie et al., 1992).

Titin and Nebulin are the largest muscle proteins that are found at the end of N and C-terminalisin the Z-disk towards the centre of the sarcomere (Lawrie and Ledward, 2006). In addition, the degradation of those proteins is intensively involved in the increased weakening of myofibrils during post-mortem aging (Koohmaraie, 1994). Titin is completely degraded at 14 days of post-mortem whereas nebulin is completely degraded at 7 days of post-mortem, however the most tender meat was observed when the titin and nebulin was degraded 7 days and 3 days post-mortem respectively (Huff-Lonergan et al., 1995; Steen et al., 1997). The degradation of titin and nebulin occurs with increase in post-mortem time (aging) (Steen et al., 1997). Nonetheless, latter author concluded that nebulin was not directly involved with m-calpain, calpastatin and calpastatin/m-calpain ratio.

Cathepsins are a group of exo- and endo-peptidases located in the lysosomes, and their location makes it impossible to have access to the myofibrils early post-mortem, thus they are alleged to be unable to contribute to early post-mortem tenderisation (Kemp et al., 2010). Another possible reason was since myosin and titin are not easily degraded by calpain, they are however substrates of lysosomes cathepsins (Koohmaraie, 1994). On the contrary, O'Halloran et al. (1997) reported that increased cathepsin L and B activities leads to tenderness in beef at the early stages of post-mortem and this could be due the experimental condition it was carried out. Those proteins are active at acidic pH (Nagaraj and Santhanam, 2006).

2.7 Carcass characteristics

Carcass refers to the body of a slaughtered animal after the removal of the head, feet, hide and visceral organs. Carcass is therefore made up of meat, bone and fat, of which the ideal

carcass has a minimum amount of bone, maximum amount of muscle and optimum amount of fat. Thus, these differ according to consumer's preference; as some consumers prefer more fat than meat whereas others prefer the opposite (Warriss, 2000). The knowledge of carcass characteristics is of fundamental as it's useful in determining the meat yield and meat quality in the animals (Pophiwa, 2017). In 2003, Dhanda et al. concluded that genotype has a significant influence on the carcass characteristics.

2.7.1 Live weight and dressing percentage

Live weight is an estimation of body mass in animals and it's an important indicator because animals are sold based on live weight and carcass weight. Simela (2005) showed that weight is affected by age and sex. Kirton (1970) found that males are heavier than females. According to Simela and Merkel (2008) animals that weigh 15 kg are more likely to produce meat of high quality. The same authors reported average slaughter weight of 27.83 kg in younger goats and found that male goats were heavier than female goats. Whereas Xazela (2010) reported slaughter weights between 20.3-22.3 kg in indigenous goats. Pophiwa (2017) found that Boer goats were heavier than indigenous goats with an average 6.1 kg difference (39.8 *vs* 33.7 kg respectively). Transportation of animals from the farm to the abattoir has a significant effect on live weights (Casey and Webb, 2010). Kadim et al. (2006) reported that transportation causes a great loss in weight, causing the loss of moisture from the respiratory tract.

Dressing percentage refers to the proportion of live weight that becomes carcass (Warminton and Kirton, 1990). Dressing percentage is influenced by the breed type, gender, degree of the gut fill, level of nutrition and skin and head weight. Furthermore, van Niekerk and Casey (1988) also explained that differences in dressing percentages are ascribed by gut fill and the intestinal content weight at slaughter, therefore the determination and comparison of dressing percentage must be done between the same breed type and species to reduce biasness. Warmington and Kirton (1990) reported dressing percentage of goats between 35% and 53% comparable to Kadim et al. (2003) in Batina and Jabal Akdhar breed. However, in 2003, Tshabalala et al. showed no differences in dressing percentage between the Boer goats (55.72 %) and Indigenous goats (55.68%), on the other hand sheep and goats differed significantly due to the fat content of the sheep carcasses which was over 8-9%. Correspondingly, Bonvillani et al. (2010) in Criollo Cordobe goat kids (55.9-55.1%). In

addition, several authors reported no differences in dressing percentages between goat breeds (Simela, 2005); Dhanda et al., 2003; Santos et al., 2007; Kadim et al., 2003; Pophiwa, 2017; Pophiwa et al., 2016). Johnson et al. (1995) reported no differences in dressing percentage in breed and sex class. However, Nikbin et al. (2016) reported a difference in dressing percentage that was attributed by high amount of stress and energy consumption, whilst Santos et al. (2007) reported no differences on the interaction between breed and sex.

Chilling loss in carcass plays a significant role as carcasses are sold based on the carcass weight. Goat carcasses are more prone to high chilling loss because of their thin subcutaneous fat cover. However, higher chilling loss leads to undesirable weight loss and subsequently meat quality is affected (Pophiwa, 2017). Sanotos et al. (2007) reported a higher chilling loss (7.0%) in Bravia amongst Serrana and their crosses. Whereas Pophiwa (2017) reported chilling loss in Boer goats of 4.81%, hence the differences were attributed by variation in carcass weight.

2.8 Meat quality Characteristics

Meat quality refers to the ratio of lean to fat and its ability to be consumed by the customers based on their preference. Meat quality is clearly described by its components and factors (Hofmann, 1994). It plays a vital role in consumer acceptability; consumers want meat that is tender and meat that exhibit a cherry red colour as its associated with freshness. Water holding capacity and drip loss determines as to whether there will be pressed juice from the meat.

2.8.1 Meat colour

Meat colour is the major quality that plays a role in the acceptability of meat by consumers, as well as in meat identification and selection (Adeyemi and Sazili, 2014). According to Troy et al. (2010) consumers believe that meat colour indicates the freshness and wholesomeness for it to be purchased. Whereby consumers discriminate against meat that is not cherry bright-red in colour. Meat colour depends on several factors and their interaction such as species, stress, sex, age, diet, post-mortem pH rate of decline and ultimate pH of the meat (Seideman et al., 1983), muscle type and training.

Table 2.3 Meat quality parameters (Warris, 2000)

Yield and gross composition	Quantity of saleable products Ratio of fat to lean Muscle size and shape
Appearance and technological characteristics	Fat texture and colour Amount of marbling in the lean (intramuscular fat) Colour and water-holding capacity of lean Chemical composition of lean
Palatability	Texture and tenderness Juiciness Flavour and aroma
Wholesomeness	Nutritional quality Chemical safety Microbiological safety
Ethical quality	Acceptable husbandry of the animal

Table 2.4 Characteristics of different states of myoglobin in fresh meat (Lawrie and Ledward, 2006)

Pigment	**Mode of formation**	**State of iron**	**State of haematin nucleus**	**State of globin**	**Colour**
Deoxymyoglobin (DeoxyMb)	Reduction of metmyoglobin	Fe^{++}	Intact	Native	Purple-red
Oxymyoglobin (OxyMb)	Oxygenation of myoglobin	Fe^{++}	Intact	Native	Bright-red
Metmyoglobin (MetMb)	Oxidation of myoglobin	Fe^{+++}	Intact	Native	Brown

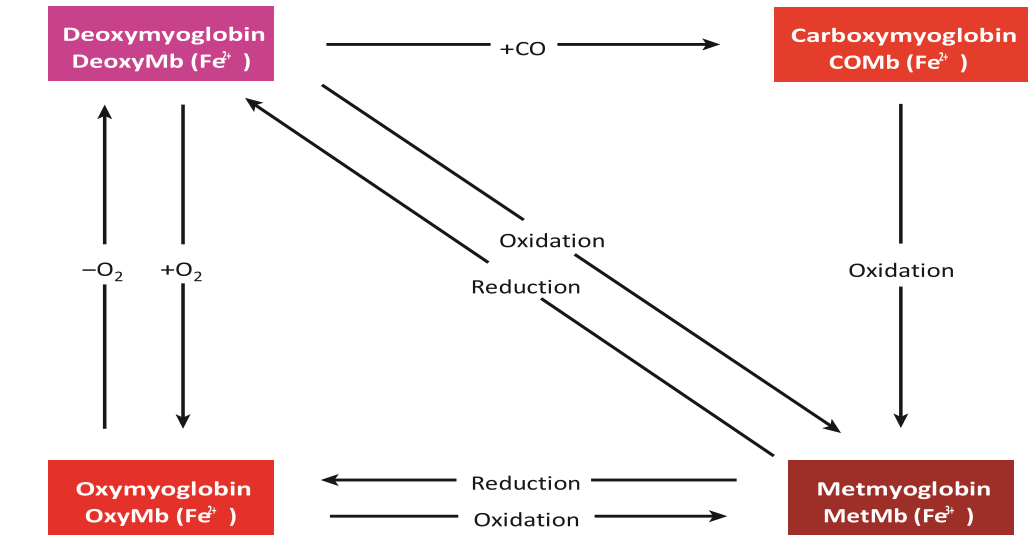


Figure 2.9 The myoglobin redox forms in the fresh meat (Mancini and Hunt, 2005)

Myoglobin is the sarcoplasmic heme protein that is responsible for change in meat colour (Faustman et al., 2010). The colour that appears on the meat surface is determined by the quantity of the three states of myoglobin; deoxymyoglobin (DeoxyMb), oxymyoglobin (OxyMb) and metmyoglobin (MetMb) (Suman and Joseph, 2013). Immediately when the animal is slaughtered the muscle turns into deoxymyoglobin. Whereby a purple colour is formed due to a reduced amount of oxygen that reacts with ferrous in the myoglobin resulting in the absence of ligand. Oxymyoglobin is formed when a cherry-red colour is formed due to a reduced myoglobin in a ferrous exposed to oxygen (Troy et al., 2010). The redness in meat influences the acceptability of consumers, which is associated with freshness of meat by consumers (Seideman et al., 1983). Furthermore, colour in meat is not stable, therefore it changes to another form called metmyoglobin. This refers to the browning of meat colour and its ability to bind with oxygen, however, consumers consider the meat not fresh (MacDougall, 1982). According to Lawrie and Ledward (2006) the presence of brown colour in meat is detected when there is approximately 60% of myoglobin. In addition, Mancini and Hunt (2005) stated that the metmyoglobin pigment is brought about by oxygen partial pressure, temperature, muscle pH, meat's reducing activity and microbial growth.

Goat meat tend to have a darker red colour, coarser texture and with a detectable different flavour and aroma as compared to that of lamb and mutton according to Casey et al. (2003) as cited by Webb et al. (2005). Furthermore, Egbert and Cornforth (1986) explained that dark coloured muscle is caused by inadequate acid formation during the process of post-

mortem glycolysis as the myoglobin remains in the deoxygenated form cited by (Kadim et al., 2006). However, Janz et al. (2000) found that meat tends to be brighter and more intense red when rapidly chilled and when the carcasses has been held at high temperatures until it has reached the onset of rigor mortis. Kim et al. (2014) found increased redness in muscles is ascribed by accelerated glycolysis rate in muscles at high temperatures.

Meat colour is also affected by high ultimate pH (Kadim et al., 2003), due to the absorption of the myoglobin which results to a more intense red meat stated Lawrie and Ledward (2006). In 1958, Lawrie identified an enzyme (mitochondrial oxidase) active at high pH and responsible for the uptake of oxygen, resulting in a reduced amount of oxygen that reacts with ferrous in the myoglobin and as a result meat is dark in colour cited by Kadim, et al. (2006). On the other hand, Kim et al. (2014) reported that a rapid decline in pH at pre-rigor leads to pale coloured meat. Mancini and Hunt (2005) yellowness and lightness of meat colour is caused by the dietary effects on pre-harvest glycogen and marbling levels. Blooming of meat increases light scattering, which causes deeper penetration oxygen into meat which causes a brighter meat after aging (MacDougall, 1982). Meat colour is closely related to the myoglobin forms while the lightness of meat is caused by the muscle structures (Hughes et al., 2014). Meat becomes lighter with the increased aging time.

Table 2.5 Various meat colours for chevon in different breeds

Muscle	Breed	Condition	Gender	Instrumental colour coordinates					Method	References
				L*	a*	b*	Chroma	Hue angle		
Longissimus thoracis et lumborum and gluteobiceps	Bravia Serrana × Bravia Serrana	8-11 kg kids	Females Males Females Males Females Males	49.1 48.7 44.1 46.9 49.9 48.2	16.4 18.0 16.4 	5.9 5.7 5.5 6.6 5.8 5.2			Aged for 24 hours	Santo et al., 2007
Semimembranosus	South African indigenous goats	Non -stimulated		37.85	11.28	9.18	15.13		Bloomed for 3 hours at 2-4 ˚C	Simela, 2005
Longissimus	Nebrodi goats	47 days old	Males Females	51.1 50.3	6.0 6.4	10.1 10.1	11.8 12.0	59.2 57.8	Illuminant D_{65} (stored for 2 hours at 4˚C (aged for 24 hours	Todaro et al., 2004
Longissimus thoracis	Violino		Males Females	37.11 35.18	11.59 13.01	9.83 11.65	15.27 17.55	40.60 41.95		Gaviraghi et al., 2007
Longissimus dorsi Semimembranosus	Boer goats Indigenous Boer goats Indigenous	Delayed chilling		36.3 36.3 39.9 40.2	18.8 18.6 18.0 18.3	12.3 11.8 12.6 12.4	22.5 21.9 22.0 22.1	33.2 32.4 35.0 34.2	Illuminant D_{65} observer angle 10˚C (Aged for 24 hours)	Pophiwa et al 2017
Longissimus dorsi	Dhofari	Non-stressed Transportation stress	Males	34.1 30.7	19.3 23.4	7.4 6.3			Bloomed for 60 minutes at 20 ± 2˚C (Aged for 24 hours)	Kadim et al., 2014
Longissimus dorsi	Balkan Serbian white	4 years	Females	32.77 33.83	19.78 20.46	4.63 4.94			Illuminant D_{65} Standard angle of 2 ˚ (aged for 24 hours)	Ivanovic et al., (2014)
Longissimus muscle	Criollo Cordobes kids	60-90 days old Suckling kids	Females Males	39 42	11.85 10.62	15.61 15.47	19.61 18.80		Bloomed for 1 hr, at 3˚C, Illuminant D_{65} and 10˚ standard angle observer. (Aged for 24 hours)	Bonvillani et al., (2010)
Quadriceps femoris muscle	Crosses (BoerXAngora, BoerXFeral, BoerXSaanen, FeralXFeral, SaanenXAngora, SaanenXFeral)	30-35kg	Kids	37.7-43.6	10.3-12.4	6.7-7.9	12.4-14.8	31.2-35.4	Bloomed for 30 minutes	Dhanda et al., 2003
Longissimus muscle	Crosses (BoerXAngora, BoerXFeral,			34.6-37.7	12.0-14.8	1.7-3.0				Dhanda et al., 1999

	BoerXSaanen, FeralXFeral, SaanenXAngora, SaanenXFeral									
Semimembranosus	Desert goats	35 kg		34.8	13.1	4.9				Babiker et al., 1990
Semimembranosus Triceps brachii Longissimus dorsi	Spanish	8 months old	Does	42.5 42 41.1	17.8 17.3 16.2	8.9 6.9 7.8	19.9 19.5 17.9	26.7 21.6 25.9	Illuminant C	Kannan et al., (2001)
Semimembranosus and longissimus dorsi	Boer goats (1 year old)	NT TLS THS		31.30-31.60 26.61-26.50 26.66-24.97	7.309-8.37 8.21-8.29 8.41-8.82	7.73-8.34 6.62-6.70 6.19-5.80	10.64-11.68 10.56-10.67 10.48-10.55	43.42-45.01 51.14-51.26 53.87-56.85	Bloomed for 2 hours (Aged for 1 and 7 days)	Nikbin et al., 2016
Longissimus dorsi	Dhofari Batina Jabal khaddar (12 months age)	NS TS NS TS NS TS		38.5 34.1 35.2 31.9 39.9 36.5	18.1 23.8 18.2 22.3 19.8 24.5	8.9 4.3 8.6 4.5 8.9 4.6			Bloomed for 60 minutes (Aged for 24 hours)	Kadim et al., 2006
Biceps femoris	Dhofari Batina Jabal khaddar	NS TS NS TS NS TS		42.1 38.8 40.2 35.8 41.5 37.1	15.6 19.3 11.4 15.8 16.9 19.7	10.2 8.0 9.4 8.1 9.7 8.7				
Semitendinosus	Dhofari Batina Jabal khaddar	NS TS NS TS NS TS		41.1 37.8 40.2 36.8 41.5 37.2	15.6 19.3 14.4 18.8 16.3 19.7	10.2 9.0 9.4 9.1 10.8 9.7				

L*- lightness, a*- redness, b*- yellowness; NS- non-stressed, TS-transported stress; NT- non-transported, TLS- transported with low stocking density, THS- transported with high stocking density

2.8.2 Sensory characteristics

2.8.2.1 Tenderness

Tenderness refers to the ease of mastication, associated with the initial ease of penetration by the teeth, the ease with which the fragments are broken down and the remaining residue left after the mastication (Lawrie, 1998). Tenderness is on top of the list of factors that are highly considered by the consumer as they tend to discriminate against meat that is not tender (Maltin et al., 2003). Meat tenderness is determined by three factors: background toughness, the toughening phase and tenderization phase (Luciano et al., 2007). The background toughness occurs at slaughter and does not change during the storage stage. Whereas the toughening phase and tenderization phase occurs during the process of post-mortem storage (Koohmaraie and Geesink, 2006). During the process of rigor mortis, sarcomere shortening leads to toughening phase and a strong negative correlation is obtained between the sarcomere length and meat tenderness (Wheeler et al., 2000). Equally, the shortening of sarcomere decreases meat tenderness, thus toughness (Purchas, 1979).

According to Johnson et al. (1995) breed had no effects on WBS values. In 2007, Santo et al. concluded that shear force was not affected by genotype but there was a significant interaction between sex and genotype and Naudé (1985) also found that tenderness is directly affected by breed type as it influences the solubility of the connective tissue in the muscles. Moreover, Webb et al. (2005) reported that treatments applied to animals during pre-slaughter can influence tenderness meat. Wheeler et al. (2000) reported that the differences in muscle type has some influences on the meat tenderness. According to Pena et al. (2009) and Warmington and Kirton (1990) meat tenderness reduces with maturity but shear force increased with increasing age. Furthermore, Kirton (1970) concluded meat from younger animals have more tender meat as compared to yearlings and older animals, due to the reduced collagen solubility as the animals get older. According to Webb and Erasmus (2013) higher shear forces are indicative of toughness in meat.

Table 2.6 Different Warner Bratzler shear force values for chevon

Breeds	Muscle	shear force	Sex	Age	Method	References
Dhofari goats	Longissimus muscle	10.0 – 6.7 K	Intact males (transported and non- transported stress which were not stimulated	1 year old	Water bath 70˚C for 90 minutes (Aged for 48 hours)	Kadim et al., 2014
Nebrodi goats	Longissimus muscle	6.3 kg 6.5 kg	males Female	47 days old (Aged 24 hours)		Todaro et al., 2004
Violino	Longissimus thoracis	5.14 kg/cm^2 4.85 kg/cm^2	male Female	337 days old	Aged for 48 hours	Gaviraghi et al., 2007
Bravia Serrana × Bravia Serrana	Longissimus thoracis et lumborum Gluteobiceps (female and male)	7.8 10.2	Suckling kids	Slaughtered at 8-11 kg live weight	Water bath (75˚C, heated to an internal temperature of 70˚C) (Aged 5 days)	 Santo et al., 2007
Dhofari Batina Jabal khaddar	Longissimus dorsi	6.4 kg 9.3 kg 7.2 kg 10.5 kg 7.0 kg 11.3 kg	12 months age	Unstressed Transportation stressor Unstressed Transportation stressor Unstressed Transportation stressor	Water bath at 70°C for 90 minutes (aged for 24 hours)	 Kadim et al., 2006
Dhofari Batina Jabal khaddar	Biceps femoris	4.9 kg 7.5kg 4.3 kg 7.6 kg 4.6 kg 7.3 kg		Unstressed Transportation stressor Unstressed Transportation stressor Unstressed Transportation stressor		
Dhofari Batina Jabal khaddar	Semitendinosus	4.5 kg 6.4 kg 4.3 kg 7.6 kg 4.6 kg 8.3 kg		Unstressed Transportation stressor Unstressed Transportation stressor Unstressed Transportation stressor		

Dhofari Batina Jabal khaddar	Longissimus dorsi, biceps femoris, semitendinous, Semimembranosus	4.53 -7.67 kg 5.32-7.98 kg 3.88-5.75 kg 6.59-9.96 kg	Intact males		Water bath 70˚C for 90 minutes (Aged for 1 and 6 days)	Kadim et al., 2003
Boer goats Indigenous goats	Longissimus dorsi Semimembranosus Longissimus dorsi Semimembranosus	4.33 8.06 4.53 8.84	A-age class	Delayed chilling	Boiled in Oven (190˚C)	Pophiwa et al., 2017
Indigenous goats (Boer, Xhosa lop ear, and Nguni)	Longissimus	35.7 N 28.8 N 24.5 N 24.8 N		Non-supplemented		Xazela, 2010
Desert goats	Semimembranosus	4.0		35 kg	Water bath at 80˚C for 1 hour	Babiker et al., 1990
Crosses (BoerXAngora, BoerXFeral, BoerXSaanen, FeralXFeral, SaanenXAngora, SaanenXFeral)	Quadriceps femoris muscle	3.7 – 4.6 kg/cm^2	Kids	30-35 kg	Water bath at 85˚C heated to an internal temperature 70˚C (Aged 24 hours)	Dhanda et al., 2003
Crosses (BoerXAngora, BoerXFeral, BoerXSaanen, FeralXFeral, SaanenXAngora, SaanenXFeral	Longissimus muscle	4.3 – 4.6 kg/cm^2	Buck kids		Water bath at 85˚C for 45 minutes Heated to internal temperature 70˚C	Dhanda et al., 1999
Balkan Serbian white goats	Longissimus dorsi muscle	7.25 ± 0.81 kg/cm^2 7.75 ± 0.73 kg/cm^2	Females	4 years	Boil in water bath 90˚C for 60min (Aged for 24 hours)	Ivanovic et al., 2014
Criollo Cordobes	Longissimus muscles	4.57 ± 0.24 -6.45 ± 0.30	Suckling kids	60-90 days old	Water bath at 75˚C, heated to internal temperature of 71˚C (aged 72 hours)	Bonvillani et al., 2010
Nubian×Forida native, Spanish×Florida native and Florida native	Semitendinosus muscle. Longissimus dorsi, Biceps femoris, Semimembranosus and Adductor	3.6kg – 4.1kg 5.7 kg – 7.6 kg		6-8 months (fed forage diet)	Boiled on farberware open-hearth broilers, heated to an internal temperature 70˚C (Aged 48 hours)	Johnson et al., (1995)
Batina, Dhofari and Jabal Khaddar	semitendinosus (ST) semimembranosus (SM)	3.88 kg – 5.7 kg 6.59 kg and 9.96 kg		1 year old		Kadim et al., (2003)
Boer goat	Longissimus dorsi Semimembranosus	1.81 – 1.56 kg/cm^2 2.09 – 1.69 kg/cm^2 2.26 – 1.81 kg/cm^2		Non-transported and Transported stress at low stocking density	Water bath at 80˚C, (heated to an internal temperature of 78˚C) (Aged for 1 and 4 days)	Nikbin et al., (2016)

				Transported at high stocking density		

2.8.3 Moisture characteristics

2.8.3.1 Cooking loss and water holding capacity

Cooking loss is vital as it determines the sensation of juiciness in meat. Cooking loss can be defined as the total loss that occurs during cooking. Cooking loss constitute of evaporation, dripping and thawing (Obuz and Dikeman, 2003). The amount of available water in the meat is essential because meat is sold based on the weight thus its importance to reduce losses in meat that reduces the weight. Babiker et al. 1990 reported cooking loss between 34-35% on the *semimembranosus* muscles for desert goats, whilst Dhanda et al. (1999) reported cooking loss between 32.5-51.5% on the *longissimus* muscle of male kids, which was obtained using a boiling method. In 2003, Dhanda reported some differences in cooking loss between breeds and concluded that chevon has a high cooking loss (5.64%) as its associated with higher ultimate pH between 5.7-5.9.

According to Schönfeldt (1989) age of the animal has an influence on the total cooking loss, older animals have lower cooking losses then younger animals. In 2013, Shija reported that cooking loss decreases with the aging period of meat in goats and sheep. Todaro et al. (2004) reported males to have a better water holding capacity due to a lower cooking loss of 14.9% as compared to the females with 16.5%. Kadim et al. 2006 reported cooking loss in the range of 11.5-23.5%. Whilst, in 2003, Dhanda reported high cooking values from the *semimembranosus* muscle of goat meat. Peña et al. 2009 reported a much higher cooking loss in the range of 25.04-28.84%. Kadim et al. (2014) reported that transported animals had a significantly higher cooking loss (28.1%) compared to those that were not transported (23.4%). The differences in cooking loss was largely influenced by the cooking temperature and time, the method used, the muscle type and ultimate pH (Kadim et al., 2003; Dhanda et al., 2003, 1999).

Water holding capacity refers to the ability of meat to retain its water (Lawrie and Ledward, 2006). There is about 75% of water present in the muscles at rigor (Huff-Lonergan and Lonergan, 2005). A low amount of water in the muscle affects quality of meat, influencing the consumers purchasing decision because the meat is sold based on their weight (Hughes et al., 2014; den Hertog-Meischke et al., 1997). Water in the muscle can be classified based on three states, namely protein-associated water, free water and immobilized water (Pearce et al., 2011). Most of the water is present in the myofibrils, within the spaces between the thin

filaments of actin or tropomyosin and thick filaments of myosin (Huff-Lonergan and Lonergan, 2005). However, those spaces are reduced during early rigor development, due to sarcomere shortening. Water holding capacity plays a significant role in moulding muscle structure, resulting into the effects of meat quality (Hughes et al., 2014).

The process of glycolysis has an important contribution to the effects of water holding capacity. In 2005, Huff-Lonergan and Lonergan reviewed a decline in pH caused by accelerated glycolytic rate with a high temperature was said to reduce water holding capacity due to attenuation of proteins. Whilst Kauffman et al. (1986) stated that slow glycolytic rate in meat increases pH at approximately 6 or more hence high-water holding capacity. A low water holding capacity results into meat becoming PSE and consequently affect the consumers purchasing decisions. Factors that affect water holding capacity are age, sex and muscular function (Lawrie and Ledward, 2006). In pork, water holding capacity increases with aging time, however, Kristensen and Purslow (2001) stated that water holding capacity is only increased during day 1-2, thereafter it decreases. Bonvillani et al. (2010) reported high water holding capacity in males and females, and further reported that age did not have an effect of age/weight in Criollo Cordobes. In 1995, Zin et al. "stated that goat meat has a good water holding capacity" as cited by Tshabalala et al. (2003). An increase in water holding capacity is ascribed by a decrease in the total water content alleged (Kristensen and Purslow, 2001). In addition, Pearson and Young (1989) stated that variation in water holding capacity between breeds is caused by muscle pH. The latter suggested that an ultimate pH in the range of 5.5-5.8 causes an increased water holding capacity.

2.8.3.2 Drip loss and thaw loss

Drip loss is an important aspect of meat quality that plays a significant role in meat industry, which refers to the amount of fluid that can be expelled from meat without any force or gravity (Fisher, 2007). The development of drip loss occurs during the conversion of muscle to meat. Muscles associated with high temperatures and low pH leads to less water being retained between actin and myosin as a result high drip loss is observed (du Toit, 2011). In addition, drip loss equally affects the nutritive value of meat because meat is made up of two-thirds of protein concentration (den Hertog-Meischke et al., 1997). Therefore, the amount of drip loss from meat are associated with protein denaturation thus water holding capacity is affected by muscle proteins (Filho et al., 2017). According to Ryu and Kim (2005) accelerated

glycolytic rate increases drip loss of fresh meat. The amount of drip loss in meat is influenced by the following factors: sex, age, diet, pre-slaughter stress, slaughter method, storage temperature and time (Lawrie, 1991). Drip loss consist of melted fat flowing out of the heated meat, salts and sarcoplasmic proteins (Paul, 1972). In 2004, Taylor reported that rapid pH decline in muscle during post-mortem caused by white fibres types (IIA and IIB) results in large amount of drip from the meat. Shorter sarcomeres are associated with high drip loss (Honikel et al., 1983).

2.9 Muscle fibre type characteristics

Muscle fibre play an important role in the production of quality meat most especially at post-mortem. Muscle fibre types has an influence on the meat colour, water holding capacity, texture and marbling. Karlsson et al. (1999) stated that muscle fibre typing plays a significant role in muscle metabolism and meat quality characteristics (tenderness, juiciness, colour stability, water holding capacity and aging rate). Muscle fibre types are divided into four groups; red (Type I/β-red) slow-twitch oxidative (SO), intermediate (Type IIA/α-red) fast-twitch oxidative glycolytic, white (Type IIB/α-white) fast-twitch glycolytic and (Type IIC) (Lawrie and Ledward, 2006). Muscle fibres are classified based on their contractile and metabolic activity, total number and cross-sectional area (CSA) (Lefauchur, 2010). They play a vital role in meat quality, as its closely related to the muscle pH.

According to Taylor (2004) red fibres (type I) are the smallest of the three fibres, which are made up of lipids, mitochondria and myoglobin but poor in glycogen and glucose. Due to the large number of mitochondria, they contain high amount of calcium content (Pearson and Young, 1989). In addition, mitochondria associated with red fibres may compete with myoglobin for the uptake of oxygen, thereby reducing the depth of oxymyoglobin during blooming (Klont et al., 1998). The red fibres can sustain long force of contraction, because they are slow contracting muscle fibres (Lefauchur, 2010) and have large number of enzymes that play role in the oxidative metabolism (Choi and Kim, 2009). On the other hand, intermediate fibres (type IIA) are moderate in size, they consist of mitochondria, glycogen and myoglobin. Whilst the white fibres (type IIB) are large, very poor in myoglobin and mitochondria and are able to convert energy for use (Choi and Kim, 2009). However, they have a moderate amount of glycogen to support their glycolytic metabolism (Warriss, 2000). The white fibres withstand short force of contraction as they are fast twitched fibres (Lefauchur, 2010) which is made

possible by the well-developed sarcoplasmic reticulum (Pearson and Young, 1989). Muscles contain about 40% of red fibres and about 40% of white fibres whilst the remaining is intermediate fibres stated Answer et al., (2013). The red fibres and intermediate fibres are mostly found in dark coloured muscles and white fibres are largely found in the light muscles (Karlsson et al., 1999).

An increased amount of red fibres enhances the meat colour, thus the myoglobin (Kim et al., 2010) and plays no role in post-mortem proteolysis, whereas white fibres increase the rate of proteolytic degradation (Ouali, 1990). Muscle fibre type is affected by breed, genotype, sex (Joo et al., 2013), weight/age, nutrition (Waritthitham et al., 2010), physical activity, hormones (Anwer et al., 2013) muscle type and regions within the muscle (Taylor, 2004). Muscle fibres are fixed at postnatal, thus as the animal grows the muscle fibre diameter and percentage changes (Taylor, 2004). Muscle fibre characteristics are known to be affected by the differences in the degree of maturity (Bünger et al., 2009). Marichal et al. 2003 that carried out a research on Spanish goats, found that as their body weight increases it resulted in an increase in glycolytic fibres percentage and a decrease in oxidative fibres percentage. Muscle with type I content are juicier and flavoursome as compared to type IIB muscle which have a low meat tenderness (Anwer et al., 2013). The pleasant sensation from meat associated with type I and IIA are brought about by the fact that they have large amount of lipids and myoglobin with more capillaries (Klont et al., 1998).

CHAPTER 3: MATERIALS AND METHODS

This project was ethical approved by the ARC-API ethic committee (reference number APIEC16/010).

3.1 Management, slaughter and sampling procedure

A total of 65 goats, composed of Nguni-Mbusi (MBZ), Northern Cape Speckled (NCS), Eastern Cape Xhosa Lob Ear (XL), South African Boer Goat (SAB) and Village type (semi-intensive (VT) and rural veld (VTV)), of which (10-14) were does and (6-12) were bucks of A-age class (no permanent incisors) per goat ecotypes were used. Weaner goats were obtained from different farms and raised at the Agricultural Research Council, Animal Production (ARC-AP) - Small-Stock Unit at Irene, South Africa until about 9 months old. On day of slaughter the goats were transported 3 km to the ARC-AP Abattoir and were slaughtered upon arrival, except for the VTV goats, which were brought from Pella Village, North West and transported 241 km and to the ARC-AP Abattoir before slaughtered upon arrival. Immediately after slaughter and dressing the carcasses were weighed to determine the hot carcasses weight (HCW).

Dressing percentage was calculated using the following formulae:

$$\text{Dressing percentage} = \frac{\text{cold carcass weight}}{\text{live weight}} \times 100$$

$$\text{Chilling loss (\%)} = \frac{\text{hot carcass weight} - \text{cold carcass weight}}{\text{hot carcass weight}} \times 100$$

The carcasses were held at 10-15˚C for 6 hours (until LD reached pH 6) and then chilled at 4˚C for 24 hours (step-wise/delayed chilling). The cold carcasses weights were recorded at approximately 24 hours post-mortem before the *m. longissimus dorsi* (LD) and *m. semimembranosus* (SM) were dissected from the left sides. The carcasses were split into two halves along the vertebral column using a saw, and only the left side of the carcasses was used for this project.

Carcass temperature and pH readings were taken at the fourth and fifth last lumbar vertebra and close to the posterior end of the SM by inserting a portable pH meter (Eutech Instruments, CyberScan pH 11) into the muscle at a depth of 1.5 cm. The readings were taken from both the LD and SM at 15 minutes, 1 hour, 3 hours, 6 hour and 24 hours post-mortem. Approximately 10 g each of meat samples were taken at the same time from both the LD and SM muscles and snap frozen in liquid nitrogen (snap freezing) and stored at -70˚C for determination of fibre typing (only at 15 min), calpain system and muscle energy metabolites.

The largest middle part of both the LD and SM muscles were vacuum packed and placed in a chiller for up to 4 days post-mortem and then frozen at -20°C until the determination of drip, thawing loss, cooking loss and Warner Bratzler shear force. About 5 cm of the frozen LD muscle was used for proximate analyses. Water holding capacity (WHC), instrumental colour values (CIE L*, a*, b*, Chroma and hue angle), calculation of surface myoglobin pigment (deoxymyoglobin, oxymyoglobin and metmyoglobin), sarcomere length (SL) were measured on fresh meat samples of approximately 50 g. Further 50 g samples were taken for determination of WHC, instrumental colour values (CIE L*, a*, b*, Chroma and hue angle) and calculation of surface myoglobin pigment (deoxymyoglobin, oxymyoglobin and metmyoglobin) at 4 days post mortem. Samples for myofibril fragmentation (MFL) determination were kept at 4˚C and then snap frozen at 1 day and 4 days post-mortem.

3.2 Laboratory Analyses

3.2.1 Warner Bratzler shear force (WBSF)

The LD and SM samples were vacuum packed and aged for 4 days, then, frozen at -20°C, were thawed at 4˚C for 24 hours. The LD samples were prepared according to an oven-broiling method (dry heat cooking) using direct radiant heat and SM samples were prepared using an oven roasted method (AMSA, 2016). Calibrated electric ovens were set on “broil’’ for 10 minutes prior to preparation (260˚C). The LD samples were placed on an oven pan on a rack, whereas the SM samples were placed in a pan and covered with a pan lid. The samples were grilled for approximately 20 minutes until they reached an internal core temperature of 70˚C. The internal temperature was monitored by placing an iron-constant thermocouple (T-type) (Hand-model Kane-Mane thermometer) in the approximate geometric centre of each sample. The cooked meat + pan + drip was all measured. The cooked samples were cooled for 2 hours at room temperature. Six cores with a diameter of 12.5 mm were obtained from each

sample parallel to the direction of the muscle fibres. The shear force was measured using a Warner Bratzler shear device mounted on a Universal Instron apparatus (Model 4301, Instron Ltd, Buckinghamshire, UK: crosshead speed = 200 mm/min with one shear in the centre of each core).

3.2.2 Drip loss, thawing loss (TL) and cooking loss (CL)

Drip loss in the vacuum bag was calculated using the following formulae:

$$\text{Drip loss} = \frac{\text{mass of bag} + \text{exudate} - \text{mass of bag without exudate}}{\text{mass of raw meat} + \text{drip loss} + \text{bag} - \text{mass of bag without exudate}} \times 100$$

The frozen meat samples from the LD and SM, were both thawed at 0-4˚C for 24 hours. The thawed meat samples were oven boiled to an internal temperature of 75˚C. Thawing loss was expressed as a pre-thawed weight and cooking loss was expressed as a percentage of pre-cooked weight (Molette et al., 2003).

3.2.3 Water holding capacity (WHC)

The samples of LD and SM muscle were aged for 1 and 4 days of post-mortem (described above). Water holding capacity was determined using the filter paper press method as described by Strydom et al. (2005). Samples of approximately 400-500 mg were placed on the filter paper (Whatman 4) (one sample was done at a time) contained between two Perspex plate according to Irie et al., (1996) and constant pressure was applied using a hand operated screw for about 5 minutes (Carver Laboratory Press Model C, 1 metric ton 60 seconds; Carver, Inc., Wabash, USA). The border of meat and fluid expressed from the meat was marked and their areas were measured with a video image analyser (Soft Imaging System, Olympus, Japan) (Irie et al., 1996). Water holding capacity was expressed as a ratio of meat area to fluid area.

3.2.4 Instrumental colour coordinates and surface myoglobin redox

Samples of LD and SM muscles were aged for 1 day and 4 days post-mortem (described above). The meat samples of *ca.* 15 mm thickness from each of the muscle were allowed to bloom for 60 minutes at ± 4˚C before the meat colour values were recorded. The surface absorbance was measured on three different position on the meat samples from 400-730 nm in increments of 10 nm. A Konica-Minolta 600d spectrophotometer with the software package

SpectraMagic NX Pro was used to record the three components; lightness, L* (dark [0] to light [100]) and the two chromatic components; a* (green [-60, 180˚] to red [+60, 0˚]) and b* (blue [-60, 270˚] to yellow [+60, 90˚]) which represented the myoglobin levels in the meat (CIE, 1986). The spectrophotometer configuration consisted of illuminate (A), with an observer angle of 10˚ a spectral component excluded after calibration using the included white reference (Krzywicki, 1978). Chroma (saturation index) and hue were automatically calculated from a* and b*, Chroma measures colour intensity where the higher values indicate more intense red colour in meat. An increase in hue angle between 0˚ and 90˚ corresponds to a blending of yellowness or less of redness, probably due to metmyoglobin formation in fresh meat. The proportions of three different myoglobin redox forms metmyoglobin (MetMb), deoxymyoglobin (DeoxyMb) and oxymyoglobin (OxyMb) were calculated following the Krzywicki (1978) formulae by using the reflex attenuation $log = \frac{1}{R}$. At isosbestic points 473 nm, 525 nm, 572 nm (obtained by linear interpolation) and 730 nm.

3.3 Biochemical analyses

3.3.1 Muscle metabolic status

The concentration of lactate, glucose, glycogen, glucose-6-phosphate, ATP and creatine phosphate in the LD and SM samples were determined using a modified method of Dalrymple and Hamm (1973) at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours of post-mortem. A portion of 2 g was cut from the frozen muscle sample and homogenised in 10 ml of cold 0.6M perchloric acid using Ultra Turrax T5 blender (Janke and Kunkel IKA @ - Labortechnik). The homogenate was centrifuged for 15 minutes at the speed of 10 000 RPM at 4˚C. After centrifugation 100 µl of aliquot sample was obtained for the determination of muscle glucose and glycogen using the amyloglucosidase method (Keppler and Decker, 1974) and were subjected to a water bath for 2 hours at 40˚C. A drop of methyl orange indicator was added to the remaining homogenized sample and was neutralised with a few drops of 5.4 M potassium hydroxide and precipitated out after 20 minutes using a filter paper (Whatman 4).

The lactate concentration was determined using the *L-lactate dehydrogenase* as described by Gutmann and Wahlefeld (1974). Glycogen concentration was determined as glycosyl units after hydrolysis with α-amyloglucosidase and correction for glucose concentration in the extract according to the method of Keppler and Decker (1974). Whereas

the concentration of ATP, glucose-6-phosphate and creatine phosphate were determined in the perchloric acid extracts according to Lamprecht et al. (1974). Glycolytic potential was calculated using Monin and Sellier (1985) formula:

Glycolytic Potential = 2 (glycogen + glucose + glucose-6-phosphate) + lactic acid

3.3.2 Calpain and Calpastatin activity

The m-calpain, µ-calpain and calpastatin were extracted from 3 g LD and SM muscles (15 minutes, 1 hour and 24 hours of post-mortem) homogenised (Ultra Turrax homogeniser equipped with 7 mm diameter probe (IKA,UK)) in 15 ml extraction buffer (75 mM Tris HCL, 10 mM EDTA, pH 7.8, 0.05% [vol/vol] 2 mercaptoethanol (MCE), 2mM phenyl methyl sulfonyl fluoride (PMSF), 1 µl/L pepstatin A) centrifuged at 10 000 rpm (4°C) for 15 minutes (Dransfield, 1996) and was later separated by means of three-step gradient ion exchange chromatography-method according to Geesink and Koohmaraie (1999). Calpain activity were determined using azo-casein assay according to Dransfield (1996) method. The use of azo-casein eliminated the problem of background absorbance of non-specific proteins in the extracts and that's why it was used as a substrate for m-calpain, one unit of calpastatin was defined as the amount that inhibited one unit of m-calpain activity. Whereas, one unit of calpain activity is defined as an increase in absorbance of 1.0 at 366 nm per hour at 25˚C. The data was expressed as units per gram of muscle or units per milligrams of extractable protein.

3.4 Histological analysis

3.4.1 Sarcomere lengths (SL)

For the determination of sarcomere lengths from the LD and SM muscles at 1 day post-mortem the samples were prepared according to Hegarty and Naudé (1970). Approximately 5 g were cut from the frozen samples and homogenised in *ca.* 15 ml of distilled water using an Ultra-Turrax blender at low speed until all the individual fibres were separated. A few drops of homogenate were mounted onto the slide and covered with a cover slip. The slides were immediately viewed under a microscope equipped to a CC12 video camera (Olympus, Tokyo, Japan) and fifty sarcomeres per sample were measured at a 31 000× magnification. Data was processed and quantified using the life sciences software package (soft imaging systems Gimbh, Munster, Germany).

3.4.2 Myofibril fragmentation length (MFL)

Samples used for MFL were aged for 1 day and 4 days post-mortem (described above). Sub-samples of *ca.* 3 g were taken from frozen samples and blended in cold *potassium phosphate* extraction butter at 4˚C to arrest any further proteolysis, as prepared by Culler et al. (1978) and determined according to Heinze and Bruggemann (1944). Droplets of extracted MFL solution were mounted on the slides, covered with a cover slip and viewed under a microscope attached to a video image analysis (VIA). One hundred myofibril fragments per sample were examined and measured at a 40× magnification.

3.4.3 Muscle fibre typing

Samples from both the LD and SM muscle taken and snap-frozen 15 minutes post-mortem were used for muscle fibre determination. The samples were mounted onto slides, stained for succinate dehydrogenase (SDH) activity using nitroblue tetrozolium, covered with a cover slip and viewed under an Olympus B340 microscope system attached to a CC12 video camera (Olympus, Tokyo, Japan) at 100× magnification. Three muscle fibre types were identified; red, intermediate and white according to the nomenclature of Gauthier (1969). Cross sectional areas (CSA) and percentages of muscle fibre types were analysed using the Analysis Life Sciences software (Soft Imaging Systems Gmbh, Münster, Germany).

3.5 Statistical Analysis

The general linear model (GLM) of SAS 9.4 (2013) was used to test the effects of ecotypes and sex on muscle energy metabolites, carcass and meat quality characteristics. The Bonferroni multiple range test was used to test the differences between means and correct for the unbalanced experimental design between ecotypes. The relationship between ecotype and various carcass and meat quality attributes were determined by means of Pearson's correlation coefficients. Microsoft Excel was used to project the data in graphs.

CHAPTER 4: RESULTS

4.1 Carcass characteristics and chemical composition of South African indigenous goat ecotypes (MBZ, NCS, SAB, XL, VT and VTV (semi-intensive and communal veld))

Table 4.1 Mean values and standard deviations (± SD) for the interaction effects of goat ecotype and sex on the carcass and *m. longissimus dorsi* (LD) chemical characteristics of goat ecotypes

Characteristics	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
LW (kg)	23.9^{de} ±3.4	21.3 ^{de}±3.1	31.9^{c} ±4.1	34.9^{bc} ±3.7	42.7^{a} ±3.7	39.2^{ab} ±3.0	24.1^{de} ±3.5	24.4^{de} ±1.9	21.0^{e} ±4.5	23.7^{de} ±5.1	25.8^{d} ±4.8	34.4^{c} ±2.0	0.004
WCW (kg)	9.7^{d} ±1.5	8.9^{d}±1.6	13.4^{c}±1.9	15.1^{bc}±1.5	18.0^{a}±2.5	16.1^{ab}±1.6	9.9^{d}±1.4	9.9^{d}±0.9	8.5^{d}±1.7	10.0^{d}±2.4	10.5^{d}±1.9	14.3^{bc}±1.4	0.004
CCW (kg)	9.0^{d}±1.5	8.2^{d}±1.4	12.4^{c}±1.9	13.6^{bc}±1.1	17.1^{a}±2.4	15.0^{ab}±1.4	9.2^{d}±1.5	9.2^{d}±0.9	7.9^{d}±1.8	9.2^{d}±2.1	9.9^{d}±1.8	13.3^{bc}±1.5	0.006
DR (%)	40.4±0.9	41.7±2.1	42.0±2.4	43.3±2.8	42.6±2.8	41.0±1.2	40.9±2.3	40.6±1.0	40.6±2.4	42.1±3.1	41.3±2.2	41.5±1.1	0.492
CL (%)	7.4±2.3	7.5 ±1.0	7.5±2.8	9.8±4.2	4.8±0.8	6.4 ± 2.1	6.5±1.8	6.8±2.8	7.7 ± 3.2	8.0±2.3	6.2 ±1.2	7.3±2.1	0.862
DM (%)	26.8±0.8	26.2±1.6	27.6±1.9	25.3±0.6	26.8±1.1	24.9±1.3	25.7±1.6	23.6±1.9	24.4±1.6	23.3±1.4	26.9±1.7	25.0±0.8	0.725
Ash (%)	0.6±0.1	0.6±0.3	0.9±0.1	1.0±0.1	1.0±0.1	1.0±0.01	0.8±0.2	1.0±0.1	1.0±0.2	0.9±0.1	0.4±0.2	0.5±0.1	0.476
Protein (%)	24.0±1.6	24.0±0.8	23.5±1.0	23.3±0.6	23.7±1.5	22.5±1.1	22.8±1.0	22.4±0.8	23.0±1.2	23.2±1.0	23.7±1.1	24.6±1.6	0.438
Fat (%)	0.5±0.3	0.3±0.2	0.6±0.5	0.3±0.2	1.1± 0.6	0.4±0.4	0.2±0.1	0.1±0.1	0.1±0.1	0.2±0.1	0.4±0.3	0.2±0.1	0.151

Means in the same row with different superscripts are significantly different (p<0.05). LW- Live weight; WCW- Warm carcass weight; CCW- Cold carcass weight; DR- Dressing; CL- Chilling losses; DM- Dry Matter

4.1.1 Carcass characteristics and chemical composition of LD from different goat ecotypes and their sexes

The interaction effects of goat ecotype and sex on live weight, carcass characteristics and chemical composition of goats in this study are presented in Table 4.1. Interactions of goat ecotype and sex only had live weight effects in XL carcasses, e.g. bucks had heavier carcasses than does (34.4 kg *vs* 25.8 kg; $p<0.01$). Bucks and does of other ecotypes (MBZ, NCS, SAB, VTV and VT goats) had similar live weights. Carcasses of bucks from XL goats had a higher warm carcass weight than that recorded for does (14.3 kg *vs* 10.5 kg; $p<0.01$). On the other hand, bucks and does of MBZ, NCS, SAB, VTV and VT goats) had similar warm carcasses weight (Table 4.1). Carcasses of buck from XL goats had higher cold carcass weight (13.3 kg *vs* 9.9 kg) than that recorded for carcasses of doe. On average, does and bucks of MBZ, NCS, SAB, VTV and VT goats did not differ in terms of cold carcass weight. On the other hand, bucks of XL had similar weights to NCS (does and bucks combined) and does of XL had similar weights as MBZ, VT and VTV (does and bucks combined). There were no significant ($p>0.05$) interaction effects between ecotypes and sex on the dressing percentage and chilling loss, as well as dry matter, ash, protein and fat percentages (Table 4.1).

4.1.2 Live weight, carcass characteristics and chemical composition of LD from different goat ecotypes

The effects of goat ecotypes on live weight, carcasses characteristics and chemical composition (measured in LD) included in this study are presented in Table 4.2. There were differences ($p<0.001$) in live and carcass weights between goat ecotypes (Table 4.1). Live weight of SAB goats was the heaviest (40.9 kg) followed by the NCS (33.1 kg) than that recorded for VT, MBZ and VTV goat (24.2 kg, 23.0 kg, and 22.0 kg) respectively (Table 4.2). The SAB goats had the heaviest warm carcass weight (17.2 kg), followed by NCS carcasses (14.1 kg) than those recorded for of VT, MBZ, VT carcasses (9.9 kg, 9.4 kg and 9.1 kg) respectively ($p<0.001$). In terms of cold carcasses weight, SAB goats were the heaviest (16.3 kg), followed by NCS goat (12.9 kg) than those recorded for VT, MBZ, VT goats (9.2 kg, 8.7 kg and 8.4 kg) respectively. Due to the results obtained in Table 4.1, XL averages cannot be compared with the rest of goat ecotypes.

There were no significant differences between goat ecotypes in terms of carcass yield or dressing % (p>0.05), which ranged between 40.8% and 42.5%. Chilling losses of NCS and VTV carcasses were higher (p<0.05) with about (8.4%) than SAB carcasses (about 5.5%) but on the other hand none of them differed from that of MBZ, XL and VT (about 7.4% and 6.6%) Table 4.2.

Table 4.2 Mean values and (± SD) for carcass and LD chemical characteristics of goat ecotypes

Characteristics	Ecotype						Significance p-value
	MBZ	NCS	SAB	VT	VTV	XL	(p<F)
LW (kg)	23.0^{d}±3.4	33.1^{b}± 4.1	40.9^{a}±3.6	24.2^{d}±2.8	22.0^{d}±4.6	29.8^{c}±5.9	<0.001
WCW (kg)	9.4^{d} ± 1.5	14.1^{b}± 1.9	17.2^{a}±2.3	9.9^{d}±1.1	9.1^{d}±2.0	12.2^{c}±2.6	<0.001
CCW (kg)	8.7^{c} ± 1.4	12.9^{b}± 1.7	16.3^{a}±2.3	9.2^{c} ±1.2	8.4^{c}±1.9	11.4^{b}±2.4	<0.001
DP	40.9±1.5	42.5± 2.5	41.9±2.4	40.8±1.7	41.2± 2.6	41.4±1.7	0.353
CL (%)	7.4^{ab}±1.9	8.4^{a}± 3.5	5.5^{b}± 1.7	6.6^{ab}±2.1	7.8^{a}±2.7	6.7^{ab}±1.7	0.059
DM (%)	26.6^{a}±1.1	26.6^{a}±1.9	26.0^{a}±1.5	24.7^{b}±2.0	24.0^{b}±1.5	26.1^{a}±1.7	0.001
Ash (%)	0.6^{b}±0.2	1.0^{a}± 0.09	1.0^{a}± 0.1	0.9^{a}±0.1	1.0^{a}±0.2	0.5^{c} ±0.2	<0.001
Protein (%)	24.0^{a}±1.3	23.4^{ab}±0.8	23.2^{ab}±1.4	22.6^{b}±0.9	23.1^{ab}±1.1	24.0^{a}±1.3	0.055
Fat (%)	0.4^{bc}±0.2	0.5^{b}±0.4	0.8^{a}±0.6	0.2^{cd}±0.1	0.1^{d}±0.1	0.4^{bcd}±0.3	<0.001

Means in the same row with different superscripts are significantly different (p<0.05); LW- Live weight; WCW- Warm carcass weight; CCW- Cold carcass weight; DR- dressing; DM- dry matter; CL- Chilling losses; DM- Dry Matter.

Proximate chemical analyses showed significant differences between goat ecotypes. Dry matter content was higher (p<0.001) in the SAB, XL MBZ and NCS goat carcasses (26.1-26.6%) as compared to that recorded for VTV and VT carcasses (24.7% and 24.0% respectively). Carcasses of NCS, SAB, VT and VTV goats had higher (p<0.001) ash content of about 1.0-0.9% than that recorded for MBZ and XL carcasses (0.6% and 0.5% respectively). Protein contents were higher (p=0.055) in XL and MBZ carcasses (24.0%) than that recorded for VT carcasses (22.6%), but neither of them differed from the carcasses of NCS, SAB and VTV goats (23.1-23.4%). The SAB carcasses had the highest (p<0.001) fat percentage (correlates with the % intra muscular fat) 0.8%, followed by NCS carcasses (0.5%), MBZ and XL carcasses (0.4%) than that recorded for carcasses of VTV and VT goats (0.2% and 0.1%) respectively (Table 4.2).

4.1.3 The effects of sex on live weight, carcass characteristics and chemical composition of different goat ecotypes

Table 4.3 Mean values and (± SD) for the effects of sex on the carcass and LD chemical characteristics of goat ecotypes

Characteristics	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
Live weight (kg)	28.7 ± 8.2	30.8 ± 7.4	0.073
Warm carcass weight (kg)	11.9 ± 3.7	12.8 ± 3.2	0.072
Cold carcass weight (kg)	11.2 ± 3.6	11.9 ± 2.9	0.191
Dressing percentage	41.3 ± 2.2	41.7 ± 1.9	0.529
Chilling loss (%)	6.6 ± 2.2	7.6 ± 2.7	0.073
Dry matter	26.5^{a} ± 1.7	24.8^{b} ± 1.5	<0.001
Ash	0.8 ± 0.3	0.8 ± 0.2	0.295
Protein	23.5± 1.2	23.4 ± 1.3	0.728
Fat	0.5^{a} ± 0.5	0.3^{b} ± 0.2	0.003

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on live weight, carcasses characteristics and chemical composition of goat ecotype included in this study are presented in Table 4.3. There were no differences between bucks and does in live weight, carcass weights and chilling loss (p>0.05) (Table 4.3). From Table 4.1 above there was significant differences on XL ecotype level where bucks on average were about 8 kg heavier compared to the doe goats. Carcass yield (presented by dressing %) between bucks and does were similar (41.3% to 41.7%). There were no chilling loss differences between buck and doe carcasses. Doe carcasses had higher (p<0.001) dry matter percentages as compared to the buck carcasses (26.5% *vs* 24.8%). Ash and protein content did not differ significantly between buck and doe carcasses of about (0.8%) and (23.5%) respectively (Table 4.3). Doe carcasses had twice higher (p<0.01) amount of fat than that of buck carcasses (0.5%).

4.2 Carcass pH and temperature measured in *m. longissimus dorsi* (LD) and *m. semimembranosus* (SM) of the goat ecotypes

4.2.1 The interaction effects of goat ecotype and sex on the pH and temperature profile

Table 4.4 Mean pH and temperature values (± SD) measured in the *m. longissimus dorsi* for the interaction effects of goat ecotype and sex

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Doe	Buck	Doe	Buck	Doe	Buck	Doe	Buck	Doe	Buck	Doe	Buck	(*p*<F)
pH × Time post-mortem													
15 min pm	6.64± 0.14	6.80± 0.05	6.73± 0.12	6.81± 0.18	6.75± 0.17	6.71± 0.13	6.54± 0.12	6.73± 0.09	6.78± 0.10	6.83± 0.09	6.65± 0.11	6.73± 0.13	0.384
1 hr pm	6.48± 0.14	6.76± 0.12	6.67± 0.11	6.64± 0.20	6.57 ± 0.17	6.55± 0.11	6.47± 0.16	6.60± 0.16	6.65± 0.14	6.60± 0.15	6.51± 0.12	6.62± 0.17	0.111
3 hrs pm	6.19^{d}± 0.09	6.52^{a}± 0.31	6.43^{abc} ± 0.12	6.45^{abc}± 0.17	6.36^{abc}± 0.11	6.41^{abc}± 0.14	6.30^{cd} ± 0.12	6.53^{a}± 0.03	6.47^{ab}± 0.14	6.29^{cd}± 0.10	6.35^{bcd}± 0.10	6.40^{abc}± 0.10	0.004
6 hrs pm	5.95^{dc}± 0.11	6.13^{abc}± 0.22	6.10^{abc}± 0.14	6.22^{abc}± 0.13	5.98^{ab}± 0.15	6.08^{dc}± 0.15	5.83^{d}± 0.23	6.29^{a}± 0.13	6.13^{abc}± 0.19	6.03^{cd}± 0.06	5.99^{cd}± 0.15	6.04^{bcd}± 0.31	0.056
24 hrs pm	5.58^{de}± 0.13	5.72^{bcd}± 0.09	5.60^{bcde}± 0.12	5.62^{bcde}± 0.22	5.50^{e}± 0.09	5.64^{bcde}± 0.09	5.63^{bcde}± 0.08	5.92^{a}± 0.03	5.78^{ab}± 0.17	5.56^{de}± 0.04	5.60^{cde}± 0.12	5.77^{abc}± 0.27	0.014
Temperature × Time post-mortem													
15 min pm	38.9 ± 0.8	37.0± 1.9	38.9± 0.5	37.7± 2.7	38.4± 1.4	38.6± 1.1	39.2± 0.4	37.9± 0.4	38.8± 0.5	38.1± 1.1	39.1± 0.8	39.1± 0.4	0.282
1 hr pm	28.0 ± 1.7	24.0± 3.7	30.6± 1.7	28.7± 1.6	29.1± 5.8	27.5± 2.2	25.4± 3.3	25.4± 4.6	25.2± 1.9	26.6± 6.4	28.6± 2.6	28.4± 3.2	0.615
3 hrs pm	18.1^{bc} ±0.9	16.8^{bcde}± 1.4	18.5^{b}± 0.9	18.4^{b}± 1.4	21.4^{a}± 3.0	18.0^{bcd}± 1.6	17.4^{bcd} ±1.1	16.4^{cde}± 1.6	15.1^{e}± 0.8	16.1^{de}± 1.3	18.6^{b}± 1.2	18.1^{bc} ±1.1	0.035
6 hrs pm	17.2 ± 1.3	15.9± 2.2	18.6± 1.4	17.5± 1.9	18.8± 1.9	18.3± 1.6	17.8± 1.9	17.7± 2.5	14.6± 0.9	15.1± 1.1	18.3± 1.3	17.7± 1.9	0.900
24 hrs pm	7.4 ± 2.5	9.6± 4.0	7.8± 3.3	8.4± 4.5	7.2± 4.5	8.1± 4.0	9.3± 4.5	8.7± 4.0	10.2± 0.6	10.1± 0.4	8.8± 3.9	8.0± 3.8	0.942

Table 4.5 Mean pH and temperature values (± SD) measured in the *m. semimembranosus* for the interaction effects of goat ecotype and sex

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
pH × Time post-mortem													
15 min pm	6.71 ± 0.14	6.92± 0.04	6.76± 0.06	6.70± 0.13	6.66± 0.39	6.76± 0.11	6.73± 0.09	6.80± 0.08	6.91± 0.08	6.83± 0.10	6.78± 0.11	6.69± 0.13	0.268
1 hr pm	6.55^{c}± 0.1	6.81^{a} ±0.14	6.62^{bc}± 0.07	6.62^{bc}± 0.19	6.64^{bc}± 0.08	6.70^{ab}± 0.11	6.57^{bc}± 0.07	6.69^{abc}± 0.10	6.82^{a}± 0.08	6.69^{abc}± 0.12	6.57^{bc}± 0.13	6.60^{bc}± 0.16	0.028
3 hrs pm	6.21^{d}± 0.5	6.62^{a}± 0.20	6.43^{bc}± 0.08	6.42^{bc}± 0.18	6.28^{cd}± 0.11	6.40^{bc}± 0.06	6.41^{bc}± 0.10	6.47^{ab}± 0.21	6.51^{ab}± 0.09	6.41^{bc}± 0.07	6.30^{cd}± 0.12	6.30^{cd}± 0.10	0.001
6 hrs pm	6.02± 0.14	6.24± 0.13	6.11± 0.15	6.09± 0.11	5.96± 0.14	6.13± 0.09	6.07± 0.25	6.22± 0.19	6.16± 0.12	6.18± 0.03	6.02± 0.11	6.02± 0.19	0.305
24 hrs pm	5.57± 0.14	5.77± 0.15	5.59± 0.09	5.6 ± 0.11	5.54± 0.09	5.71± 0.22	5.74± 0.09	5.78± 0.13	5.81± 0.02	5.59± 0.04	5.63± 0.13	5.71± 0.29	0.077
Temperature × Time post-mortem													
15 min pm	38.4± 0.8	37.7± 1.31	37.8± 3.1	37.2± 1.4	38.6± 0.6	38.5± 1.0	38.9± 0.7	37.4± 1.7	36.0± 3.6	38.80± 1.74	38.8 ± 0.7	38.6± 0.6	0.201
1 hr pm	28.0± 2.1	26.4± 3.6	31.0± 2.0	29.8± 3.2	31.1± 3.1	32.9± 1.7	27.0± 4.2	28.3± 2.5	29.3± 4.2	30.13± 4.08	30.6± 2.9	31.6± 1.2	0.680
3 hrs pm	17.7± 1.0	16.7± 0.8	19.1± 1.3	19.7± 2.3	21.7± 3.4	20.6± 1.3	17.8± 1.5	17.2± 1.2	15.6± 1.3	17.27± 2.15	18.51± 1.0	19.2± 1.0	0.428
6 hrs pm	16.5± 1.5	16.4± 1.2	17.8± 1.8	16.9± 1.1	17.5± 1.6	18.2± 1.7	17.9± 1.8	18..0± 2.0	14.7± 0.7	14.50± 0.60	18.0± 1.45	17.6± 1.8	0.890
24 hrs pm	6.2± 2.9	8.9± 4.1	6.5± 4.1	7.4± 5.0	6.4± 4.7	7.7± 4.4	8.7± 4.9	8.0± 4.5	11.0± 1.1	10.07± 0.42	9.1± 4.86	6.6 ± 4.8	0.728

Means in the same row with different superscripts are significantly different (p<0.05).

The effects of interaction between goat ecotype and sex on the pH and temperature on the LD are presented in Table 4.4. Interactions of goat ecotype and sex showed no effects (p>0.05) in LD pH at 15 minutes and 1 hour post-mortem (Table 4.4). At 3 hours post-mortem, LD of bucks from MBZ, VT and VTV goats had a higher pH (p<0.01) (pH ˜6.5) than that of does (pH 6.2 and 6.3) respectively. The pH of bucks from VTV goats decreased faster than that of does (pH 6.3 *vs* 6.5). On the other hand, bucks and sex of NCS, SAB and XL goats had similar pH ranging between 6.4-6.5 at 3 hours post-mortem. At 6 hours post-mortem, LD of bucks from VT bucks continued with higher pH (p<0.05) compared to that of does (pH 6.3 *vs* 5.8) and LD of bucks from MBZ and SAB goats had higher (p<0.05) pH compared to that of does (pH 6.1 *vs* 6.0). The bucks and does of XL, VTV and NCS goats were similar on average.

At 24 hours post-mortem, ultimate pH showed that LD of bucks from VT goats suffered more stress in comparison to does (pH_u 5.9 *vs* 5.6), unlike LD of does for VTV goats that suffered more stress than bucks (pH_u 5.8 *vs* 5.6). Overall LD of does from SAB did not encounter stress with the lowest pH_u of 5.5. Ultimate pH showed no sex differences for NCS, MBZ and XL (Table 4.4). Temperature dropped with hours post-mortem, but only differed significantly at 3 hours post-mortem, with higher LD temperatures in does of SAB goats than that of bucks (21.4˚C *vs* 18.0˚C) (Table 4.4). On average, bucks and does of MBZ, NCS, VT, VTV and XL goats had similar muscle temperature.

The effects of interaction between goat ecotype and sex on the pH and temperature on the SM are presented in Table 4.5. On the other hand, interaction effects of goat ecotype and sex on SM was minimal and only differed at 1 hour and 3 hours post-mortem, e.g. SM pH of bucks from MBZ goats that had higher pH values (p<0.05) than that of does (pH 6.8 *vs* 6.6). No pH post-mortem decrease differences were found between the bucks and does of NCS, SAB, VT, VTV and XL goats (Table 4.5). No interaction effects between goat ecotype and sex (p>0.05) were found for temperature decline with time post-mortem and temperature values ranged between 36.0-38.9˚C, 26.4-32.9˚C, 15.6-21.7˚C, 14.5-18.2˚C, 6.2-11.0˚C at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem respectively (Table 4.5).

4.2.2 Effects of goat ecotypes on carcass pH and temperature

Table 4.6 Mean pH and temperature values (± SD) measured in the *m. longissimus dorsi* of different goat ecotypes

	Ecotype						Significance *p*-value (*p*<F)
	MBZ	NCS	SAB	VT	VTV	XL	
pH x Time post-mortem							
15 min pm	6.70 ± 0.14	6.76 ± 0.15	6.73 ± 0.15	6.63 ± 0.14	6.80 ± 0.09	6.69 ± 0.12	0.075
1 hr pm	6.58 ± 0.19	6.66 ± 0.15	6.56 ± 0.14	6.53 ± 0.17	6.63 ± 0.14	6.56 ± 0.15	0.351
3 hrs pm	6.31 ± 0.25	6.44 ± 0.14	6.38 ± 0.12	6.40 ± 0.15	6.41 ± 0.16	6.37 ± 0.10	0.320
6 hrs pm	6.02 ± 0.17	6.15 ± 0.14	6.02 ± 0.15	6.03 ± 0.30	6.09 ± 0.16	6.01 ± 0.23	0.321
24 hrs pm	5.63^{bc} ± 0.13	5.61^{bc} ± 0.16	5.56^{c} ± 0.11	5.76^{a} ± 0.16	5.70^{ab} ± 0.17	5.68^{abc} ± 0.21	0.038
Temperature x Time post-mortem							
15 min	38.2 ± 1.6	38.4 ± 1.8	38.49 ± 1.22	38.6 ± 0.8	38.5 ± 0.8	39.1 ± 0.6	0.562
1 hr pm	26.6^{bc} ± 3.14	29.8^{a} ± 1.8	28.4^{ab} ± 4.6	25.4^{c} ± 3.6	25.7^{bc} ± 3.8	28.5^{ab} ± 2.8	0.024
3 hrs pm	17.6^{bc} ± 1.2	18.5^{b} ± 1.1	20.0^{a} ± 3.0	17.0^{c} ± 1.3	15.5^{d} ± 1.1	18.4^{b} ± 1.2	<0.001
6 hrs pm	16.7^{b} ± 1.7	18.2^{ab} ± 1.7	18.6^{a} ± 1.7	17.7^{ab} ± 2.0	14.8^{c} ± 0.9	18.1^{ab} ± 1.6	0.001
24 hrs pm	8.2 ± 3.1	8.0 ± 3.7	7.6 ± 4.1	9.0 ± 4.0	10.2 ± 0.5	8.4 ± 3.7	0.737

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of goat ecotypes on the pH and temperature of the LD are presented in Table 4.6 and Figure 4.1. There were no effects (p>0.05) of goat ecotypes on pH at 15 minutes, 1 hour, 3 hours and 6 hours post-mortem (Table 4.6). On the other hand, at 24 hours post-mortem, LD of VT goats had higher (p<0.05) ultimate pH (pH_u 5.8) than MBZ, NCS and SAB goats (pH_u 5.6) but similar with VTV and XL goats (pH_u ~5.7). As indicated in Figure 4.1 pH and temperature decline from the LD of VTV goats differed consistently from that of MBZ, NCS, SAB, XL and VT goats. Since, VT and VTV goats are from the same breed-type the difference is likely because of the different pre-slaughter procedures (see Materials and Methods). From

Figure 4.1 it became clear that the rate of pH decrease was very slow up to 3 hours post-mortem after which there was a turning point, followed by a marked decrease in pH to (about 6) at 6 hours post-mortem. Only after 6 hours post-mortem, carcasses were placed in the chiller (4°C) at about 6 hours post-mortem where after the rate of decrease in both carcass temperature and pH increased.

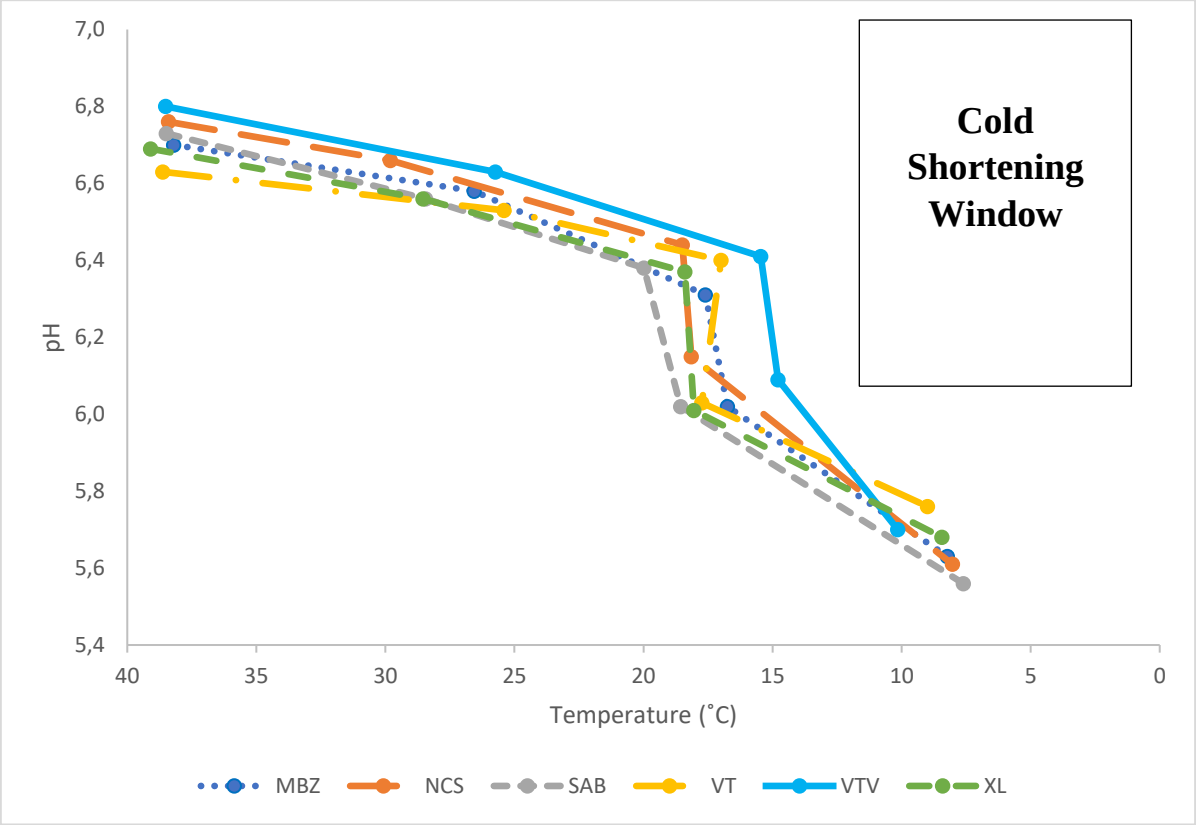


Figure 4.1 pH/temperature decline recorded at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem in the *m. longissimus dorsi* of MBZ, NCS, SAB, VT, VTV and XL goats. Cold shortening window according to Pearson and Young (1989) and as discussed in the review of Thompson (2002) were used to show that none of the goat carcasses experienced cold shortening.

The effects of goat ecotypes on the pH and temperature of the SM are presented in Table 4.7 and Figure 4.2. *Semimembranosus* muscle pH of goat ecotypes did not differ (p>0.05) at 15 minutes, 6 hours and 24 hours post-mortem except at 1 hour and 3 hours post-mortem as presented in (Table 4.7). The muscle pH of VTV goats was higher (p<0.05; 6.8) than that of MBZ, NCS, VT and XL goats (pH 6.6) but SAB goats did not differ from those goat ecotypes at 1 hour post-mortem. At 3 hours post-mortem, SM pH of VTV goats remained (p<0.05)

higher (pH 6.5) than XL, MBZ, SAB goats (pH 6.3) but did not differ on average with NCS and VT goats (pH 6.4).

Table 4.7 Mean pH and temperature values (± SD) measured in the *m. semimembranosus* of different goat ecotypes

	Ecotype						Significance *p*-value (*p*<F)
	MBZ	NCS	SAB	VT	VTV	XL	
pH × Time post-mortem							
15 min pm	6.79 ± 0.15	6.74 ± 0.10	6.69 ± 0.30	6.76 ± 0.09	6.88 ± 0.09	6.74 ± 0.12	0.241
1 hr pm	6.64^{b} ± 0.18	6.62^{b} ± 0.13	6.67^{ab} ± 0.10	6.62^{b} ± 0.10	6.77^{a} ± 0.11	6.58^{b} ± 0.14	0.025
3 hrs pm	6.36^{bc} ± 0.26	6.42^{ab} ± 0.13	6.33^{bc} ± 0.11	6.44^{ab} ± 0.15	6.47^{a} ± 0.09	6.30^{c} ± 0.11	0.022
6 hrs pm	6.10 ± 0.17	6.10 ± 0.13	6.03 ± 0.15	6.13 ± 0.22	6.16 ± 0.09	6.02 ± 0.15	0.210
24 hrs pm	5.64 ± 0.17	5.61 ± 0.10	5.61 ± 0.18	5.76 ± 0.11	5.73 ± 0.12	5.67 ± 0.213	0.146
Temperature × Time post-mortem							
15 min pm	38.2 ± 1.0	37.6 ± 2.4	38.6 ± 0.8	38.2 ± 1.5	37.1 ± 3.2	38.6 ± 0.6	0.275
1 hr pm	27.4^{b} ± 2.7	30.5^{a} ± 2.5	31.8^{a} ± 2.7	27.6^{b} ± 3.4	29.6^{ab} ± 3.8	31.1^{a} ± 2.2	0.002
3 hrs pm	17.3^{cd} ± 1.0	19.4^{b} ± 1.7	21.3^{a} ± 2.7	17.5^{cd} ± 1.4	16.2^{d} ± 1.7	18.8^{bc} ± 1.0	<0.001
6 hrs pm	16.5^{b} ± 1.3	17.45^{ab} ± 1.6	17.8^{ab} ± 1.6	17.9^{a} ± 1.8	14.6^{c} ± 0.7	17.8^{ab} ± 1.5	0.001
24 hrs pm	7.2 ± 3.5	6.9 ± 4.3	6.9 ± 4.4	8.4 ± 4.4	10.6 ± 1.0	8.0 ± 4.8	0.402

Means in the same row with different superscripts are significantly different (p<0.05)

There were no effects (p>0.05) in SM temperature of goat ecotypes at 15 minutes and 24 hours post-mortem except at 1 hour, 3 hours and 6 hours post-mortem (Table 4.7). The SM temperature was higher in the SAB, XL and NCS goats (31.8˚C, 31.5˚C and 31.1˚C) than that of MBZ and VT goats (27.6˚C and 27.4˚C respectively), but those goats did not differ from SM of VTV goats (29.6˚C) at 1 hour post-mortem. At 3 hours post-mortem, SAB goats had higher (p<0.001) temperature (21.3˚C) followed by NCS goats (19.4˚C) than that of VTV goats (16.2˚C). But on average those ecotypes did not differ from MBZ, VT and XL goats (17.3˚C,

17.5˚C and 18.8˚C) respectively. At 6 hours post-mortem, SM temperatures of NCS and XL were similar (17.5˚C and 17.8˚C respectively) but remained higher in SM of SAB goats (17.8˚C) than that of MBZ goats (16.5˚C) and VTV goats (14.6˚C) respectively (p<0.001) (Table 4.7).

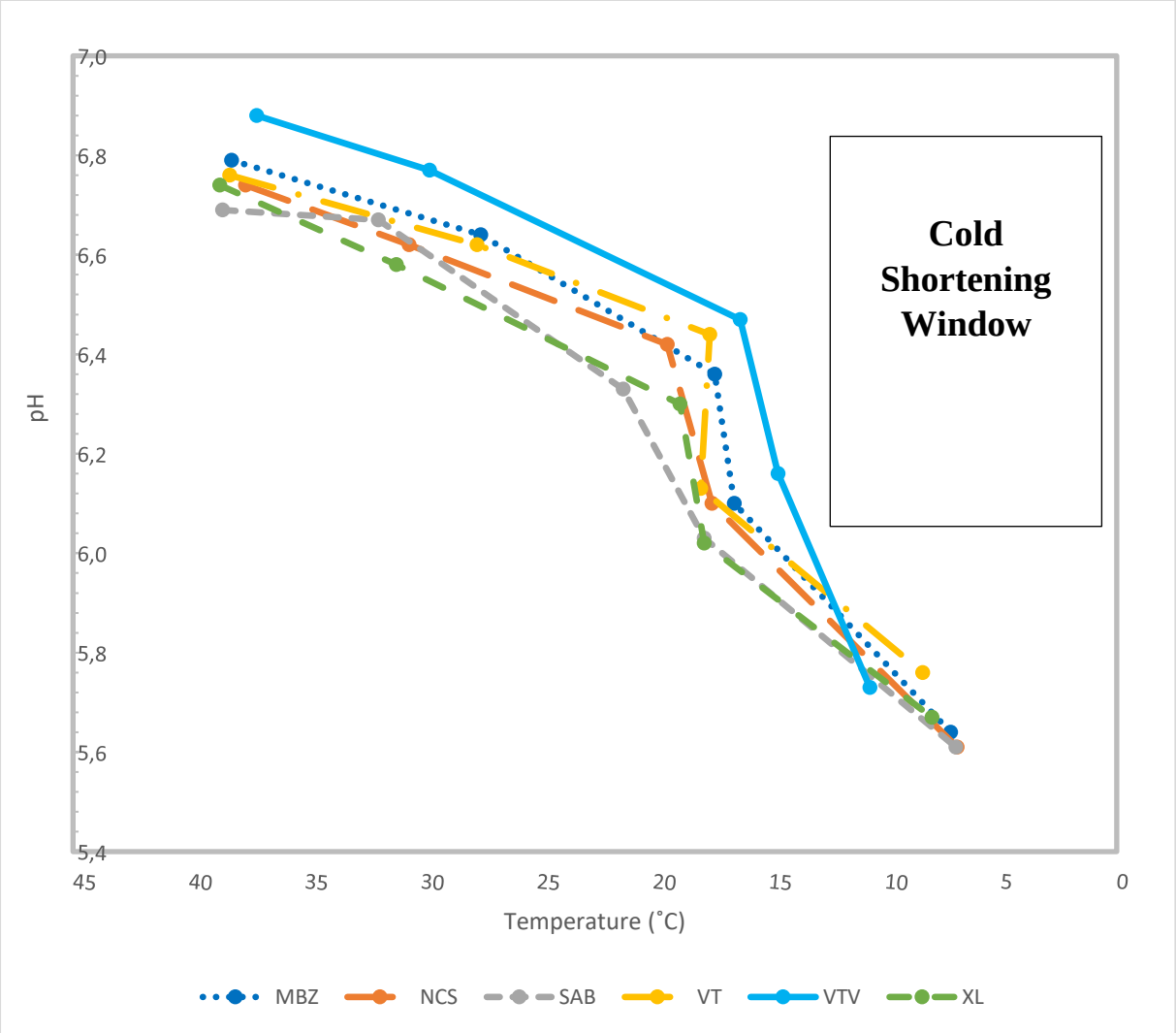


Figure 4.2 pH/temperature decline measured at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem in the m. semimembranosus of MBZ, NCS, SAB, VT, VTV and XL goats. Cold shortening window according to Pearson and Young (1989) and as discussed in the review of Thompson (2002) were used to show that none of the goat carcasses experienced cold shortening.

The SM (Figure 4.2) showed an even greater difference in the pH/temperatures decline of VTV goats in comparison to VT, MBZ, NCS, XL and SAB goats. This suggests that SM

muscle was more affected by the pre-slaughter procedures than LD muscle. Overall the pH and temperature profile for goat ecotypes were all below the risk of cold shortening (Figures 4.1 & 4.2).

4.2.3 Effects of sex on muscle pH and temperature

Table 4.8 Mean pH and temperature values (± SD) measured in the *m. longissimus dorsi* for the effects of sex for goat ecotypes

	Sex		Significance *p*-value ($p<F$)
	Does	Bucks	
pH × Time post-mortem			
15 min pm	6.69^{a}± 0.14	6.76^{b} ± 0.12	0.017
1 hr pm	6.56^{a} ± 0.15	6.63^{b} ± 0.15	0.057
3 hrs pm	6.35^{a}± 0.14	6.44^{b}± 0.16	0.012
6 hrs pm	6.00^{a}± 0.18	6.13^{b}± 0.20	0.005
24 hrs pm	5.60^{a}± 0.14	5.71^{b}± 0.19	0.005
Temperature × Time post-mortem			
15 min pm	38.88^{a} ± 0.81	38.13^{b} ± 1.56	0.010
1 hr pm	28.09 ± 3.54	27.00 ± 3.62	0.172
3 hrs pm	18.40^{a}± 2.35	17.48^{b}± 1.53	0.011
6 hrs pm	17.70 ± 1.92	17.21 ± 2.03	0.158
24 hrs pm	8.31 ± 3.43	8.66 ± 3.56	0.690

Means in the same row with different superscripts are significantly different ($p<0.05$)

The effects of sex on the pH and temperature on the LD are presented in Table 4.8 and Figure 4.3. There were significant differences in pH measured in the LD of does and bucks (Table 4.8). *Longissimus* muscle of bucks had significantly higher pH mean values throughout pH profile and dropped from pH 6.8 to 5.7 as compared to LD of does from pH 6.7 to 5.6 from 15 minutes to 24 hours post-mortem. The sex differences with time post-mortem was caused by the interaction effect as observed in Table 4.4 that occurred in the sexes of MBZ, VT and VTV. On the other hand, the high pHu recorded in LD of does from VTV goats caused the sex differences (Table 4.4).

Longissimus temperature of sex differed ($p<0.01$) but not at 1 hour, 6 hours and 24 hours post-mortem. Does had higher ($p<0.01$) temperature values than LD temperatures of bucks (38.9˚C *vs* 38.1˚C) and (18.4˚C *vs* 17.5˚C) at 1 hour and 3 hours post-mortem

respectively (Table 4.8). However, the LD showed an even greater difference in the pH and temperatures decline between bucks and does, with higher pH values and this can be concluded that bucks were more prone to preslaughter conditions as compared to does (Figure 4.3).

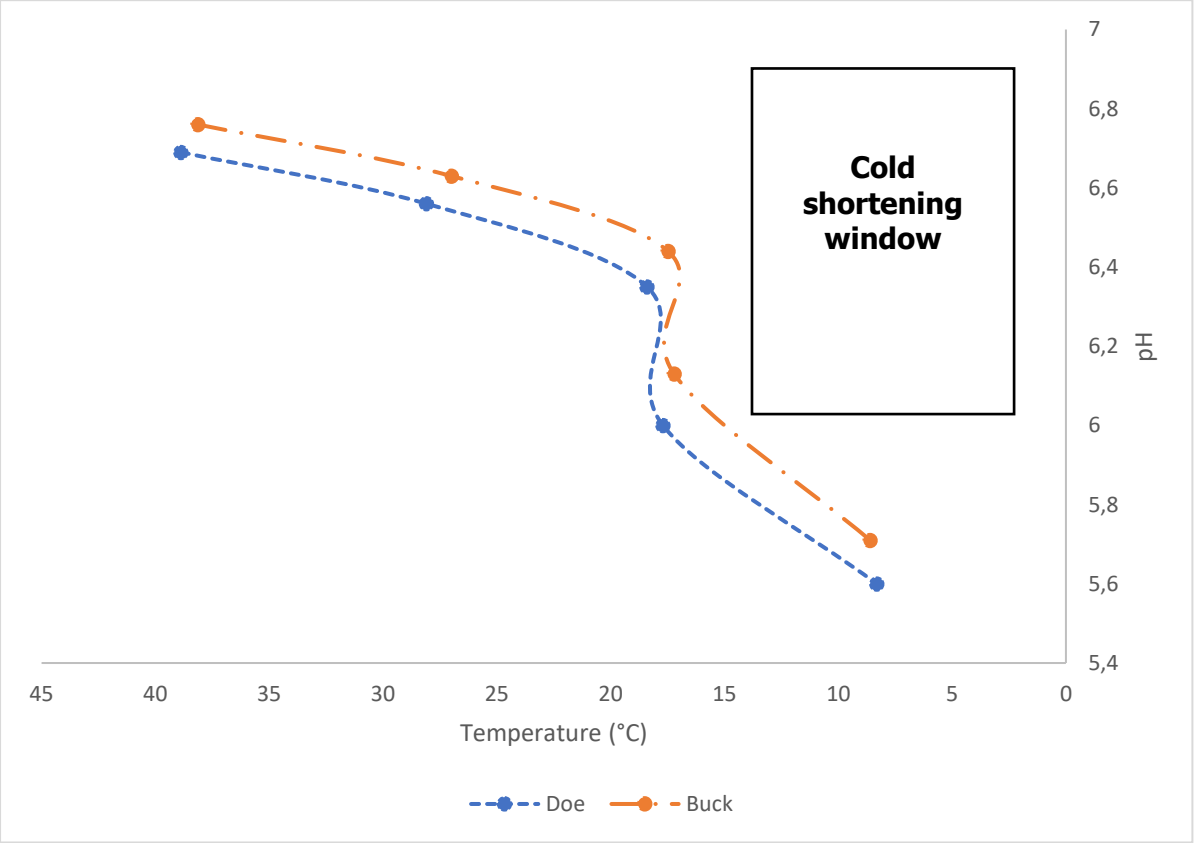


Figure 4.3 pH/temperature decline measured at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem in the *m. longissimus dorsi* of bucks and does. Cold shortening window according to Pearson and Young (1989) and as discussed in the review of Thompson (2002) were used to show that none of the goat carcasses experienced cold shortening.

Table 4.9 Mean pH and temperature values (± SD) measured in the *m. semimembranosus* for the effects of sex for goat ecotypes

	Sex		Significance *p*-value (p<F)
	Does	Bucks	
pH × Time post-mortem			
15 min pm	6.75 ± 0.193	6.77 ± 0.13	0.596
1 hr pm	6.62^{a} ± 0.127	6.68^{b} ± 0.15	0.043
3 hrs pm	6.35^{a}± 0.144	6.43^{b}± 0.17	0.011
6 hrs pm	6.05^{a}± 0.157	6.13^{b}± 0.15	0.028
24 hrs pm	5.64 ± 0.134	5.70 ± 0.19	0.088
Temperature × Time post-mortem			
15 min pm	38.16 ± 2.01	38.03 ± 1.30	0.694
1 hr pm	29.64 ± 3.23	30.10 ± 3.22	0.627
3 hrs pm	18.60 ± 2.50	18.68 ± 2.01	0.996
6 hrs pm	17.16 ± 1.80	17.10 ± 1.77	0.667
24 hrs pm	7.78 ± 4.15	7.88 ± 4.07	0.906

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on the pH and temperature on the LD and SM are presented in Table 4.9 and Figure 4.4. Unlike the LD pH, SM pH did not differ (p>0.05) between sex at 15 minutes and 24 hours post-mortem (Table 4.9). Bucks had higher (p<0.05) pH values than does (pH 6.7 *vs* 6.6) at 1 hour post-mortem. Bucks had significantly higher pH than does (pH 6.43 *vs* 6.35) and (pH 6.13 *vs* 6.05) at 3 hours and 6 hours post-mortem respectively. If it was not for the differences for the interaction effects of MBZ and its sexes there would have been no sex differences (Table 4.5).

Bucks and does did not differ (p>0.05) with a drop-in SM temperature values from 15 minutes to 24 hours post-mortem (38.0˚C to 7.9˚C) and (38.2˚C to 7.78˚C) respectively. In the SM, the differences between bucks and does were not pronounced as in LD muscle, however the bucks had slightly higher pH/temperature decline as compared to the does (Figure 4.4).

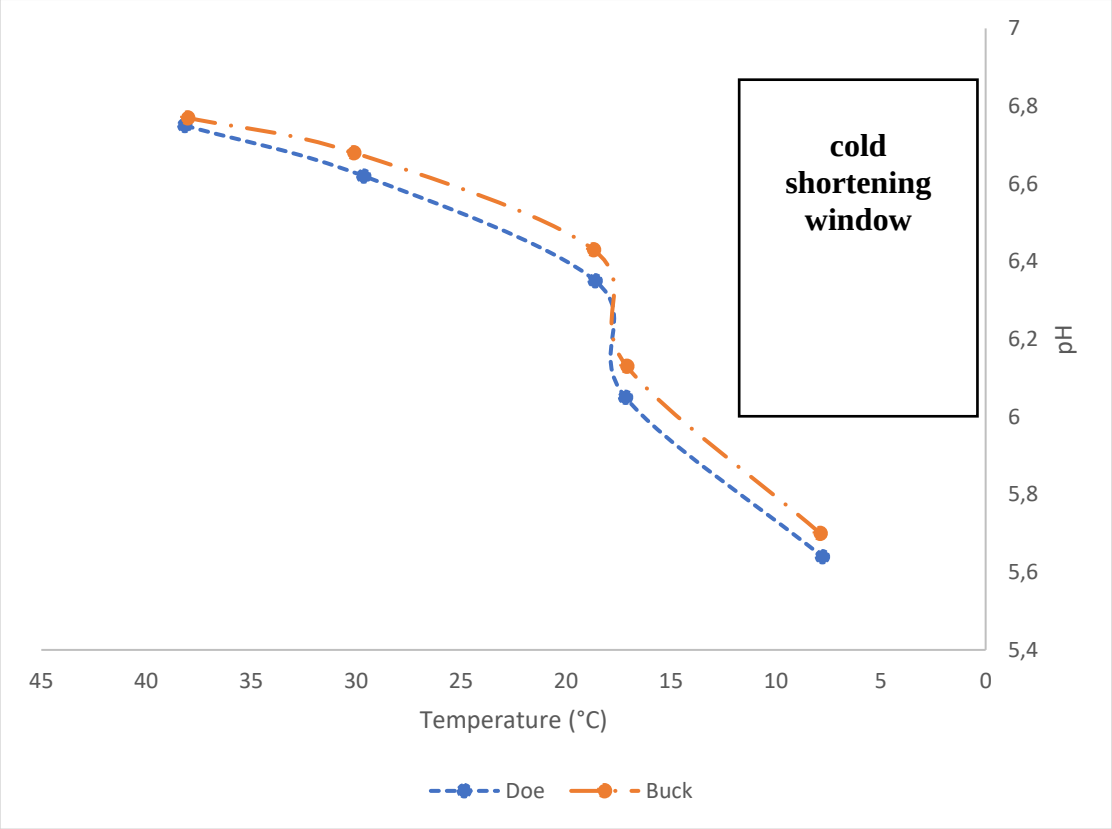


Figure 4.4 pH/temperature decline measured at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem in the *m. semimembranosus* of bucks and does. Cold shortening window according to Pearson and Young (1989) and as discussed in the review of Thompson (2002) were used to show that none of the goat carcasses experienced cold shortening.

4.3 The biochemical muscle energy changes early post-mortem in *m. longissimus dorsi* (LD) and *m. semimembranosus* (SM) of goat ecotypes

4.3.1 The effects of interaction between goat ecotype and sex on muscle energy changes early post-mortem

Table 4.10 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on glycogen concentration (µmol/g) measured in the *m. longissimus dorsi*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	38.42 ±8.78	39.34 ±13.14	36.86 ±13.98	36.91 ±5.97	34.94 ±6.89	34.36 ±8.19	40.28 ±16.4	21.61 ±9.25	21.66 ±9.27	22.11 ±2.16	35.20 ±6.70	26.58 ±6.08	0.192
1 hr pm	28.33 ±4.90	28.58 ±10.41	25.62 ±6.11	23.59 ±4.16	26.10 ±3.48	25.42 ±6.80	22.33 ±8.05	17.34 ±1.98	13.71 ±4.18	18.58 ±6.19	25.16 ±6.32	22.88 ±6.14	0.670
3 hrs pm	26.46 ±5.86	22.79 ±7.27	19.66 ±7.17	20.34 ±3.55	22.16 ±3.92	21.31 ±6.46	18.44 ±4.88	15.04 ±2.01	12.43 ±3.62	15.59 ±4.60	17.40 ±4.54	19.07 ±6.18	0.678
6 hrs pm	19.81 ±6.57	15.69 ±3.56	16.63± 6.53	14.03 ±3.28	14.05 ±2.96	18.31 ±6.56	13.09 ±2.24	14.21 ±1.51	10.67 ±2.77	13.89 ±3.37	10.94 ±3.13	12.18 ±6.91	0.304
24 hrs pm	14.26^{a} ±6.97	10.42^{ab} ^{c} ±3.11	8.66^{bc} ± 2.74	3.95^{d} ±1.97	9.45^{b} ±4.54	14.45^{a}± 2.93	8.90^{bc} ±3.16	12.69^{a} ^{b}±1.29	7.56^{cd} ±2.02	8.03^{cd}± 2.20	6.32^{cd} ±2.22	7.40^{cd} ±3.57	0.014

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.11 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post mortem) on glycogen concentration (µmol/g) for the *m. semimembranosus*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	37.29± 10.49	38.42± 5.39	31.84 ±18.91	32.20± 4.88	31.05 ±7.90	30.50± 2.92	27.00 ±6.42	32.51 ±13.37	34.95± 8.06	32.95 ± 9.49	34.40 ±12.06	44.02± 10.96	0.797
1 hr pm	31.15 ± 5.95	32.16± 6.03	25.11 ±7.27	29.26± 5.99	24.68± 3.66	24.64± 5.47	20.73 ±3.94	24.10 ±12.56	28.32± 5.60	22.75 ±4.47	26.44± 5.79	30.65± 8.24	0.606
3 hrs pm	22.03 ± 5.85	25.65 ±3.15	21.14 ±7.04	23.95± 3.88	19.17± 2.75	23.17± 5.03	17.59± 2.35	15.99 ±5.48	21.18± 5.21	16.16± 3.73	20.52 ±2.84	23.61± 7.26	0.344
6 hrs pm	16.34± 5.63	18.23± 4.91	17.68 ± 5.34	17.42± 3.91	14.00± 2.15	16.19± 4.75	12.88 ±2.05	9.24± 3.59	15.16± 2.92	14.34± 2.11	14.49± 3.52	15.08 ± 4.64	0.797
24 hrs pm	9.42^{abc} ±5.87	9.97^{ab} ±6.34	12.87^{a} ± 2.26	6.93^{bc}± 2.26	7.84^{bc} ±3.67	11.53^{ab} ±4.78	5.08^{c} ±1.65	8.18^{abc} ± 0.71	8.65^{abc} ±0.79	9.85^{abc} ±5.96	6.98^{bc} ±3.72	9.75^{abc} ±2.45	0.048

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.12 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on glucose concentration (µmol/g) for the *m. longissimus dorsi*

Time post-mortem	Ecotypes × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	1.22± 0.41	2.35 ±2.79	1.29 ±0.55	0.71± 0.45	1.26 ±0.85	1.27± 0.47	0.83 ±0.44	1.60 ±0.30	1.61 ±0.84	1.12 ±0.24	1.11 ±0.18	1.03± 0.54	0.169
1 hr pm	1.43± 0.42	0.89 ±0.92	1.68 ±1.25	1.28± 0.86	1.44 ±0.59	1.38± 1.10	1.53 ±0.66	0.75 ±0.57	1.06 ±0.52	1.12 ±1.03	1.39± 0.65	1.44± 0.80	0.806
3 hrs pm	1.81± 0.79	1.27 ±0.87	1.04 ±0.86	1.16± 0.46	1.38 ±0.71	1.07± 0.54	0.96 ±0.23	1.68 ±1.18	1.10 ±1.04	1.31± 0.36	1.53± 0.72	1.32± 0.42	0.483
6 hrs pm	1.53± 0.38	1.49 ±0.59	1.58 ±1.26	2.12± 0.57	1.71 ±0.66	1.34± 0.52	1.41 ±0.52	1.84± 0.72	1.51 ±0.75	1.44 ±0.61	1.66 ±0.85	1.57± 0.89	0.720
24 hrs pm	2.41± 1.26	2.93± 1.51	3.53± 4.35	2.82± 0.71	2.82 ±0.31	2.48± 0.19	2.69 ±1.14	1.79± 0.84	1.83 ±0.29	2.00 ±1.01	2.00 ±1.21	1.60± 1.31	0.948

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.13 Mean values and (± SD) for interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on glucose concentration (µmol/g) for the *m. semimembranosus*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	1.35 ±0.92	0.98 ±0.36	0.80 ±0.17	0.84 ±0.54	1.45 ±0.51	1.13 ±0.93	0.83 ±0.24	1.22 ±0.90	0.72 ±0.34	1.42 ±1.01	0.83 ±0.41	1.378 ± 0.522	0.240
1 hr pm	1.51^{abc} ±0.63	0.73^{d} ±0.16	1.52^{abc} ±0.78	0.75^{bcd} ±0.41	1.53^{ab} ±0.52	0.74^{cd} ±0.57	1.14^{abcd}± 0.34	1.24^{abcd} ±0.55	0.94^{abcd} ±0.63	0.64^{d} ±0.19	0.88^{bcd} ±0.34	1.70^{a} ±1.17	0.011
3 hrs pm	1.85 ±1.18	1.76 ±0.94	1.08 ±0.66	0.82 ±0.67	1.08 ±0.58	1.00 ±0.64	0.99 ±0.38	1.22 ±1.18	0.85 ±0.42	1.16 ±0.44	1.63 ±1.20	1.13 ±0.53	0.881
6 hrs pm	1.54 ±0.39	1.38 ±0.73	1.34± 0.61	1.29 ±0.37	1.32 ±0.64	1.30 ±0.61	1.84 ±0.94	1.71 ±0.11	1.78 ±0.96	1.77 ±0.68	1.40 ±0.64	2.41 ±1.56	0.424
24 hrs pm	2.60 ±1.26	2.48 ±1.39	1.90± 1.18	2.44 ±1.00	1.80 ±0.81	1.43 ±0.76	1.86 ±0.84	1.52 ±0.77	1.95 ±2.30	1.89 ±0.97	2.61 ±0.75	2.10 ±1.33	0.911

Means in the same row with different superscripts are significantly different ($p<0.05$)

Table 4.14 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours of post-mortem) on glucose-6-Phosphate concentration (µmol/g) in the *m. longissimus dorsi*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	1.42± 1.02	0.57 ±0.38	1.81 ±1.16	0.70 ± 0.56	1.80 ±1.09	0.98 ±0.69	2.28± 1.75	1.09± 1.22	1.46± 1.05	1.29± 0.68	1.72± 0.88	1.15± 0.74	0.905
1 hr pm	0.82± 0.67	1.04± 0.90	1.10± 0.57	0.79± 0.65	0.99± 0.34	0.65 ±0.58	0.95± 0.72	0.36± 0.39	0.62± 0.55	0.93± 0.38	1.06± 0.72	0.81± 0.62	0.624
3 hrs pm	0.81± 0.38	1.36± 1.72	0.95± 0.52	1.04± 0.68	0.80± 0.56	0.46± 0.25	0.75± 0.52	0.71± 0.62	0.76± 0.32	1.06± 1.02	1.25 ±0.59	0.57± 0.63	0.327
6 hrs pm	0.85± 0.39	0.92± 0.89	1.63± 1.15	1.05± 0.84	1.08± 0.65	0.78± 0.79	1.31± 0.95	1.07± 0.92	1.29± 0.87	1.21± 0.34	2.03± 1.12	1.16± 0.85	0.817
24 hrs pm	3.17^{ab} ±1.92	2.28^{abc} ±2.03	1.81^{bc} ±1.24	1.83^{bc} ±1.88	3.98^{a} ±1.36	1.86^{bc} ±1.68	1.39^{bc} ±1.88	1.14^{bc} ±1.73	0.70^{c} ± 0.66	2.58^{abc} ±1.02	0.75^{c} ±0.64	2.57^{ab} ^{c}±2.41	0.041

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.15 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on glucose-6-Phosphate concentration (µmol/g) for the *m. semimembranosus*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
15 min pm	1.94± 1.12	1.82± 1.31	1.14± 1.01	1.45± 1.10	0.69± 0.63	1.15± 1.42	1.28± 1.30	1.47± 0.85	0.58± 0.69	0.59± 0.20	1.46± 1.53	1.69± 1.15	0.993
1 hr pm	0.89± 0.56	0.59± 0.66	1.06± 0.87	0.62± 0.45	1.09± 0.75	0.80± 0.89	0.98 ± 0.68	1.14± 1.46	0.58± 0.35	0.97± 0.64	0.96± 0.76	0.83± 0.81	0.859
3 hrs pm	1.14± 0.67	0.77± 0.40	1.17 ± 1.034	0.82± 0.93	1.52± 2.00	0.58± 0.16	0.68 ±0.37	0.53± 0.86	0.21 ±0.06	1.11± 0.87	1.61± 1.99	0.87± 0.27	0.604
6 hrs pm	1.29 ±0.20	1.27± 1.15	0.86± 0.87	0.69± 0.88	1.22± 1.04	0.77± 0.82	0.76 ± 0.84	1.04± 1.20	0.41± 0.35	0.71± 0.26	1.87± 1.07	1.32± 0.74	0.813
24 hrs pm	1.21± 1.77	1.90± 1.61	2.42± 2.08	1.71± 1.97	4.74 ± 2.15	3.36± 2.80	1.51 ±1.96	1.35± 1.45	1.07 ±0.67	3.14 ±1.92	2.40± 1.82	1.24± 1.40	0.375

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.16 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on lactate concentration (µmol/g) for the *m. longissimus dorsi*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	28.44± 4.11	15.97± 8.62	24.59± 9.87	22.38± 10.75	21.45± 5.48	17.05± 2.02	23.64± 10.69	18.20± 3.53	18.18 ±4.58	18.67± 4.10	24.40± 5.38	21.42± 4.61	0.424
1 hr pm	32.54± 4.45	21.44± 5.58	31.97± 8.39	27.84± 11.47	29.43± 6.17	29.87± 3.20	33.67± 8.25	24.11 ±1.60	26.73 ±7.81	23.07± 3.81	32.45± 3.29	30.22± 5.63	0.307
3 hrs pm	39.86± 8.75	28.18± 6.68	40.83± 10.36	39.55± 12.15	39.51± 9.08	40.18± 2.92	41.06± 11.78	32.59± 4.29	33.70± 11.40	29.63± 3.84	38.92± 5.67	38.96± 9.66	0.527
6 hrs pm	50.90± 7.69	42.15± 11.84	52.45± 4.97	52.03± 12.38	53.75± 11.29	46.87± 5.99	50.86± 11.49	43.42± 9.55	40.38± 14.01	49.01± 6.35	51.32± 13.75	46.63± 10.04	0.560
24 hrs pm	76.08^{abc} ±12.34	75.45^{abc} ±10.29	72.95^{abc} ±12.61	59.86^{cd} ±17.84	81.67^{a} ±14.12	63.92^{bc} ^{d}±9.39	65.87^{ab} ^{cd}±19.65	67.210^{ab} ^{cd}±5.90	53.45^{d} ±13.44	71.64^{ab} ±6.37	76.95^{ab}± 11.99	62.65^{bcd} ±11.84	0.047

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.17 Mean values and (± SD) for the interaction effect of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on lactate concentration (µmol/g) for the *m. semimembranosus*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
15 min pm	18.34± 5.12	15.28± 5.53	17.15± 6.21	14.29± 5.00	15.64 ±3.87	16.60 ± 4.17	18.84± 7.17	16.45± 3.86	20.32± 6.02	29.19± 5.76	20.49± 7.07	17.66 ± 5.78	0.329
1 hr pm	28.42± 6.37	19.53± 6.26	25.64± 8.51	22.00± 6.30	27.85 ±4.81	21.87± 4.95	26.58 ±5.99	25.08 ±8.39	27.85± 15.59	21.72± 4.41	24.82± 12.21	25.02± 7.33	0.846
3 hrs pm	40.92± 4.21	24.31 ±13.96	33.24± 10.92	31.01± 8.81	40.23± 9.86	32.35± 10.26	32.17 ±9.88	31.79± 6.64	36.72± 20.16	38.27± 4.34	34.72± 10.12	32.74± 6.72	0.421
6 hrs pm	54.97± 10.92	39.53± 20.23	46.75± 10.87	37.35± 8.65	61.17± 12.62	47.23± 16.85	47.07 ±12.97	40.48 ± 13.17	57.49± 18.88	41.14± 13.07	49.88± 7.85	49.86± 14.47	0.691
24 hrs pm	74.27± 13.32	83.43± 10.67	63.00± 15.56	67.12± 16.87	83.26± 16.12	62.77 ±16.96	67.42± 14.00	67.53± 19.07	77.52± 15.52	80.92± 8.68	69.67± 18.31	67.45± 21.38	0.358

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.18 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on glycolytic potential (µmol/g) for the *m. longissimus dorsi*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	110.55 ±19.12	100.47 ±31.78	104.50 ±26.21	99.03 ±20.85	91.97± 7.01	90.27± 18.57	110.42± 33.18	66.79 ± 21.64	67.65± 13.88	67.70± 7.32	100.45± 16.65	78.93 ± 15.17	0.211
1 hr pm	93.71 ± 10.16	82.46 ±22.24	88.78± 9.82	79.15 ±20.95	86.46 ± 3.64	84.97± 14.57	83.29± 17.63	60.99 ± 4.92	60.60± 10.55	64.33 ± 6.36	87.68 ± 14.48	80.48 ± 16.26	0.489
3 hrs pm	98.02 ±15.37	79.01 ±17.88	84.15 ±14.21	84.62 ±19.69	88.20 ± 10.14	85.86± 11.47	81.39± 15.23	67.43 ± 3.05	62.27± 13.66	65.56± 13.18	79.26± 13.73	80.87± 18.84	0.429
6 hrs pm	94.77 ± 6.73	76.72 ±10.23	92.12± 11.78	86.42 ±15.18	87.45± 10.05	87.74± 11.68	82.47± 13.42	77.67 ± 7.01	67.34± 8.94	82.09± 12.14	80.59± 20.61	76.45 ± 22.85	0.355
24 hrs pm	115.75 ±20.95	106.70 ±17.36	100.93 ±14.82	77.05± 19.27	114.18 ± 17.58	101.52± 10.00	91.84± 25.94	98.44 ± 10.28	73.62± 12.01	96.85± 6.05	95.08 ± 12.44	85.79 ± 21.28	0.078

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.19 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on glycolytic potential (µmol/g) for the *m. semimembranosus*

Time post-mortem	Ecotype Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
15min pm	99.51 ±24.31	97.73 ± 4.60	84.71 ±35.30	83.28 ±14.69	82.00± 15.40	82.16 ±6.13	77.07 ±10.73	86.84 ±23.59	92.81 ±17.85	106.92 ±8.81	93.87 ±28.43	111.84 ±17.70	0.814
1 hr pm	95.91 ±8.31	81.78 ±12.30	81.02 ±10.36	83.28 ±15.23	82.42± 9.36	74.23 ±8.65	72.27 ±7.39	78.02 ±31.85	87.52 ±19.79	70.46 ±4.48	81.37 ±15.26	91.37 ±17.05	0.238
3 hrs pm	90.97± 8.69	80.66 ±17.81	80.02 ±15.98	82.19 ±17.16	83.76 ±14.01	82.22 ±9.16	70.70 ±10.14	67.27 ±19.66	81.21 ±28.77	75.15 ±12.22	82.25 ±14.20	83.97 ±16.44	0.943
6 hrs pm	93.28 ±12.77	81.28± 14.50	86.49 ±17.70	76.14 ±15.40	94.24 ±11.65	83.76 ±23.64	78.03± 17.17	64.46 ±17.60	92.19 ±22.12	74.79 ±10.86	85.41 ±6.66	87.49 ±13.57	0.777
24 hrs pm	100.73± 16.53	112.13 ±5.38	97.76 ±19.38	89.28 ±21.76	112.04 ±22.74	95.40 ±22.12	84.31 ±18.36	89.62 ±21.77	100.86 ±14.55	110.68 ±20.74	93.67 ±24.34	93.63 ±22.19	0.572

Means in the same row with different superscripts are significantly different (p<0.05)

The interaction effects of goat ecotype and sex on glucose concentration in the LD and SM muscles are presented in Tables 4.10 & 4.11**.** Interactions of goat ecotype and sex had no effects on glycogen concentration with time post-mortem except at 24 hours post-mortem (Table 4.10). The LD of bucks from SAB had higher (p<0.001) glycogen concentration than does (14.45 µmol/g *vs* 9.45 µmol/g). The LD of bucks from NCS goats had lower (p<0.001) glycogen concentration than does (3.95 µmol/g *vs* 8.66 µmol/g). On the other hand, LD of does and bucks for MBZ, VT, VTV and XL goats did not differ on average (Table 4.10).

Similarly, with SM there were no significant interactions of goat ecotype and sex on glycogen concentration with time post-mortem except at 24 hours post-mortem. The LD of does from NCS goats had a higher (p<0.05) glycogen concentration than bucks (12.87 µmol/g *vs* 6.93 µmol/g). Bucks and does of MBZ, SAB, VT, VTV and XL goats had similar glycogen concentration on average (Table 4.11).

The interaction effects of goat ecotype and sex on glucose concentration in the LD and SM muscles are presented in Tables 4.12 & 4.13. There were no interaction effects of goat ecotype and sex in LD glucose concentration with time post-mortem (Table 4.12). There were no interaction effects of goat ecotype and sex in SM glucose concentration with time post-mortem except at 1 hour post-mortem (Table 4.13). The SM of does for MBZ and SAB goats had higher (p<0.01) glucose concentration than that recorded in bucks (~1.5 µmol/g *vs* ~0.7 µmol/g). The SM of bucks for XL goats that had a higher (p<0.01) glucose concentration than that recorded in SM of does (1.7 µmol/g *vs* 0.9 µmol/g). The bucks and does for SM of VT, VTV and NCS goats had similar glucose concentration at 1 hour post-mortem (Table 4.13).

The interaction effects of goat ecotype and sex on glucose-6-phosphate (G-6-P) concentration in the LD and SM muscles are presented in Tables 4.14 & 4.15. There were no significant interaction effects of goat ecotype and sex in LD G-6-P concentration with time post-mortem except at 24 hours post-mortem (Table 4.14). The LD of does from SAB goats had the highest (p<0.05) G-6-P concentration than that recorded in bucks (3.98 µmol/g *vs* 1.86 µmol/g). A similar trend was recorded in LD of VTV and XL goats e.g. does had higher (p<0.05) G-6-P concentration than that recorded in bucks (~0.7 µmol/g *vs* ~2.6 µmol/g). On average, LD of bucks and does from NCS, VT and MBZ goats had similar G-6-P concentration. There were no significant interaction effects of goat ecotype and sex in SM G-6-P with time post-mortem (Table 4.15).

The interaction effects of goat ecotype and sex on lactate concentration in the LD and SM muscles are presented in Tables 4.16 & 4.17. Lactate concentration increased with time post-mortem but there were no interaction effects of goat ecotype and sex in LD lactate concentration at 15 minutes, 1 hour, 3 hours and 6 hours post-mortem (Table 4.16). On the other hand, at 24 hours post-mortem, LD of does from SAB goats had higher (p<0.05) lactate concentration than that recorded in bucks (81.67 µmol/g *vs* 63.92 µmol/g). The LD of bucks from VTV goats had higher (p<0.05) lactate concentration than that bucks (71.64 µmol/g *vs* 53.45 µmol/g). On average, LD of bucks and does for VT, MBZ, NCS and XL goats were similar (Table 4.16). There were no interaction effects of goat ecotype and sex in SM lactate concentration with time post-mortem (Table 4.17).

The interaction effects of goat ecotype and sex on glycolytic potential for the LD and SM muscles are presented in Tables 4.18 & 4.19. There were no interaction effects of goat ecotype and sex differences (p>0.05) in both muscles (LD and SM) for the calculated glycolytic potential with time post-mortem (Tables 4.18 & 4.19).

The interaction effects of goat ecotype and sex on creatine phosphate (CP) concentration in the LD and SM muscles are presented in Tables 4.20 & 4.21. There were no interaction effects of goat ecotype and sex in LD creatine phosphate with time post-mortem except at 3 hours post-mortem (Table 4.20). The LD of does for SAB, VT and VTV goats had higher (p<0.01) creatine phosphate than LD of bucks (3.65 µmol/g *vs* 3.54 µmol/g), (4.08 µmol/g *vs* 2.86 µmol/g) and (4.25 µmol/g *vs* 2.79 µmol/g) respectively. The bucks and does LD of MBZ and NSC goats did not differ in creatine phosphate concentration. On average, LD of bucks and does for XL goats had similar creatine phosphate concentration. There were no differences (p>0.05) on interaction effects of goat ecotype and sex in SM creatine phosphate with time post-mortem (Table 4.21).

The interaction effects of goat ecotype and sex on ATP concentration for the LD and SM muscles are presented in Tables 4.22 & 4.23. There were no interaction effects of goat ecotype and sex in LD ATP content (p>0.05) with time post-mortem except at 6 hours post-mortem (Table 4.22). The LD of does of NCS goats had higher (p<0.01) ATP content than that recorded in bucks (8.17 µmol/g *vs* 4.26 µmol/g). The LD of bucks and does from MBZ, SAB, VT and XL had similar ATP content on average and sexes of VTV goats did not differ. Unlike the LD, interaction effects of ecotypes and sex in SM did not differ in ATP content with time post-mortem (Table 4.23).

Table 4.20 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours of post-mortem) on creatine phosphate concentration (µmol/g) for the *m. longissimus dorsi*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
15 min pm	3.46 ± 0.86	5.28± 1.88	4.17 ± 1.65	3.94± 1.33	4.03 ± 1.43	3.69 ± 2.07	4.62 ± 1.75	5.37± 2.80	5.60± 1.64	4.92± 0.33	2.98± 1.82	3.79± 0.96	0.541
1 hr pm	3.52 ± 0.98	3.62± 0.74	3.99± 0.91	3.70± 2.21	3.45± 1.23	3.22± 1.98	3.81± 1.09	3.17± 0.51	4.22 ± 2.24	4.29± 0.33	3.94± 0.58	3.36± 0.72	0.980
3 hrs pm	4.21^{a} ± 0.581	4.07^{a} ± 0.26	2.81^{abc}± 0.40	3.85^{abc} ±0.51	3.65^{c} ± 0.69	3.54^{ab}± 0.41	4.08^{a} ± 1.12	2.86^{bc} ±0.25	4.25^{a} ± 0.88	2.79^{c}± 0.71	4.32^{a} ±1.20	3.34^{abc} ± 1.29	0.010
6 hrs pm	3.70± 0.65	3.33± 0.31	3.37 ± 1.32	3.96± 0.72	3.54± 0.51	4.14± 1.04	2.99± 1.06	3.24± 1.21	2.75± 1.02	3.09± 1.17	3.59± 0.56	3.88± 1.12	0.852
24 hrs pm	3.34± 0.91	3.47± 0.36	2.91± 1.49	3.63± 1.01	3.03± 0.42	3.31± 0.38	4.35± 1.19	4.11± 2.90	3.48 ± 1.23	2.41± 2.33	3.87± 1.76	3.55± 0.64	0.772

Means in the same row with different superscripts are significantly different (p<0.05).

Table 4.21 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours of post-mortem) on creatine phosphate (µmol/g) for the *m. semimembranosus*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	5.53 ± 2.02	4.45 ± 1.65	5.67± 0.96	4.96± 1.94	6.02± 1.65	5.29± 1.17	5.25± 1.78	3.69± 2.69	4.72± 2.19	3.84± 2.56	5.11± 1.19	4.76 ±2.43	0.984
1 hr pm	4.67 ± 1.14	4.79± 2.11	4.38 ± 1.27	4.70 ± 0.63	4.27 ± 1.43	3.28± 0.78	3.79± 1.20	4.74± 1.44	4.84± 1.66	4.07± 1.89	4.23± 0.87	3.74± 1.01	0.543
3 hrs pm	3.34± 0.43	4.47± 2.012	3.68± 1.00	3.64± 1.25	3.60 ± 0.70	3.28± 0.79	3.45± 0.92	3.29± 0.45	3.94± 1.13	4.23± 1.15	3.43± 1.72	3.17± 1.22	0.695
6 hrs pm	3.98 ± 0.58	3.04± 0.64	3.35± 0.55	4.05± 0.74	3.90 ± 0.68	3.40± 0.93	3.09± 0.81	3.35± 0.27	3.50± 1.09	3.33± 0.65	3.00± 0.84	3.50± 0.64	0.090
24 hrs pm	3.54 ± 0.92	3.00 ± 0.48	3.53± 1.31	3.61± 1.21	3.51 ± 0.88	5.29± 2.98	3.83± 1.29	4.09± 1.39	3.92± 1.74	3.82± 1.81	3.38± 1.15	4.68± 1.67	0.424

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.22 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours of post-mortem) on ATP concentration (µmol/g) for the *m. longissimus dorsi*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
15 min pm	8.88± 1.64	7.58 ± 0.45	7.62± 1.60	7.45± 0.49	7.55± 2.10	7.16± 2.11	7.49± 0.53	7.66± 1.75	9.00± 1.31	8.68± 1.60	7.33± 1.76	8.12± 2.26	0.778
1 hr pm	7.73± 1.84	6.02± 0.79	7.23 ± 1.45	6.03± 1.17	7.23± 0.79	6.86 ± 2.06	5.44± 0.61	5.14± 1.00	8.60± 1.70	8.56± 1.83	9.14± 2.40	7.11± 1.70	0.623
3 hrs pm	7.81± 1.57	8.61± 1.45	5.91± 2.09	5.32± 2.02	7.51± 1.40	6.45± 2.07	5.34± 1.34	6.19± 1.55	9.32± 3.29	9.79± 3.33	8.18± 0.97	6.84± 1.18	0.613
6 hrs pm	6.02^{abc}± 1.46	7.07^{ab} ± 0.95	8.17^{a} ± 1.65	4.26^{cd} ± 0.81	6.55^{ab}± 1.66	6.44^{abc}± 1.52	4.13^{d}± 1.59	5.76^{bcd} ± 1.37	6.92^{ab} ± 3.80	6.71^{ab} ± 1.91	6.21^{abcd} ± 1.52	6.72^{ab} ±1.73	0.011
24 hrs pm	4.73± 1.22	5.36± 1.63	4.54± 1.43	3.78± 2.13	4.85± 1.52	4.64± 1.46	4.14± 1.60	5.15± 2.65	6.33± 1.78	6.54± 1.98	5.34± 2.46	4.53± 2.06	0.829

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.23 Mean values and (± SD) for the interaction effects of goat ecotype, sex and time intervals (15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem) on the ATP concentration (µmol/g) for the *m. semimembranosus*

Time post-mortem	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
15 min pm	8.95± 1.97	7.91 ± 2.03	8.66 ± 1.97	7.47± 2.48	8.75 ± 0.96	8.42± 1.09	8.01± 2.19	6.22± 2.44	8.54 ± 1.07	7.98± 1.35	6.77± 0.60	7.54 ±1.15	0.574
1 hr pm	8.40± 1.10	8.34 ± 2.27	7.74 ± 1.24	8.11± 0.81	8.19 ± 1.86	6.55± 0.97	7.40± 1.58	7.23± 1.62	8.80± 1.28	8.23± 1.89	8.02± 1.33	6.74± 1.35	0.543
3 hrs pm	7.69± 1.73	7.46 ± 2.46	6.95± 1.36	6.78 ± 1.49	6.69 ± 1.92	6.09± 1.55	7.15± 1.35	6.58± 2.69	6.75± 0.48	7.26± 1.57	5.69± 1.61	7.12± 1.57	0.679
6 hrs pm	6.24± 1.40	6.14 ± 2.20	6.22± 1.58	5.68± 0.89	6.92 ± 2.02	7.29± 1.30	5.49± 1.50	5.00± 1.69	6.37± 1.827	7.94± 0.66	5.51± 2.95	4.64± 1.03	0.729
24 hrs pm	5.25± 2.27	3.58 ± 0.55	5.84± 3.30	6.82± 2.11	5.42 ± 1.47	6.82± 2.04	4.44± 1.19	4.77± 1.26	5.88± 2.36	6.93± 3.34	5.60± 2.33	6.30± 3.76	0.740

Means in the same row with different superscripts are significantly different (p<0.05)

4.3.2 The effects of goat ecotypes on muscle energy changes early post-mortem

Table 4.24 Mean values and (± SD) for the effects of goat ecotypes on glycogen concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15min pm	38.75^{a} ± 9.91	36.88^{a}± 10.93	34.70^{a}± 7.10	31.98^{a}± 16.23	21.83^{b}± 7.11	31.22^{a}± 7.61	0.01
1 hr pm	28.42^{a} ±6.85	24.78^{ab}± 5.27	25.81^{a}± 4.85	20.11^{bc}± 6.39	15.54^{c}± 5.22	24.11^{ab}± 6.09	0.001
3 hr pm	25.13^{a} ±6.32	19.94^{bc}± 5.72	21.81^{ab}± 4.87	16.93^{cd}± 4.08	13.62^{d}± 4.03	18.17^{bcd}± 5.19	0.001
6 hrs pm	18.31^{a} ± 5.83	15.54^{abc}± 5.38	15.83^{ab}± 5.02	13.59^{bc}± 1.93	11.88^{bc}± 3.23	11.51^{c}± 5.02	0.011
24 hrs pm	12.86^{a} ± 5.99	6.69^{c}± 3.37	11.53^{a}± 4.58	10.58^{b}± 3.09	7.73^{bc}± 1.94	6.82^{c}± 2.84	0.001

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of goat ecotypes on glycogen concentration in the LD are presented in Table 4.24 and Figure 4.5. The glycogen concentration dropped by about 67–82% in LD of goat ecotypes because it was being used up and goat ecotype differed with time post-mortem (Table 4.24). The LD of MBZ goats had the highest glycogen concentration at all the times post-mortem due to their small weight loss and the fact that they were not sensitive to preslaughter stress, followed by SAB goats but not at 15 minutes post-mortem. The LD of VTV goats had the lowest glycogen concentration from 15 minutes to 6 hours post-mortem. The LD of VT goats were second lowest due to the preslaughter stress, followed by LD of XL and NCS goats at 1 hour and 3 hours post-mortem. On the other hand, at 24 hours post-mortem, LD of XL and NCS goats had the lowest glycogen concentration, followed by VTV goats and then VT goats (Figure 4.5).

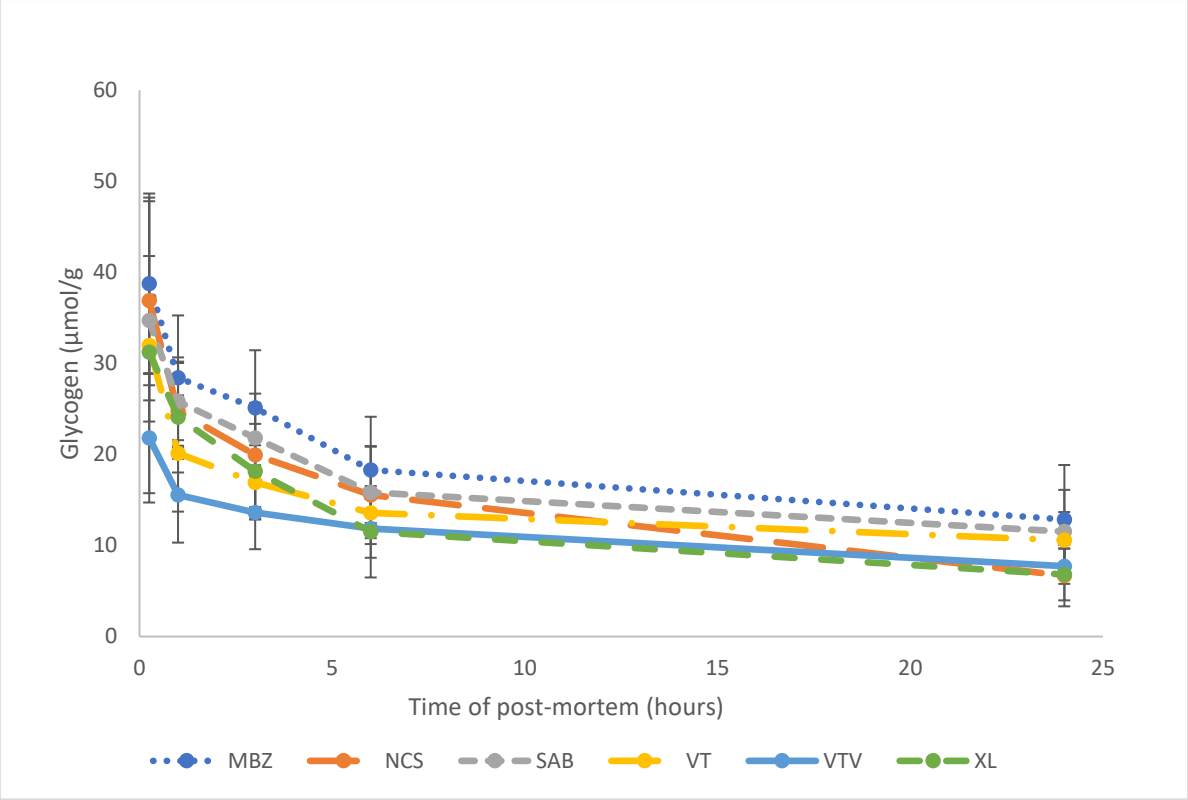


Figure 4.5 Glycogen concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Table 4.25 Mean values and (± SD) for the effects of goat ecotypes on glycogen concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	37.70± 8.66	31.99± 14.28	30.82 ± 6.10	29.45± 9.80	34.20± 7.99	38.84± 12.15	0.228
1 hr pm	31.55^{a} ±5.66	26.84^{abc}± 6.82	24.66^{bc}± 4.27	22.22^{c}± 8.37	26.23^{abc}± 5.65	28.38^{ab}± 7.06	0.049
3 hr pm	23.35± 5.18	22.31± 5.88	20.62± 4.02	16.88± 3.84	19.30± 5.12	21.95± 5.34	0.067
6 hrs pm	17.02^{a}± 5.21	17.57^{a} ± 4.60	14.91^{ab}± 3.46	11.26^{b}± 3.26	14.85^{ab}± 2.52	14.76^{ab}± 3.91	0.020
24 hrs pm	9.62± 5.73	10.17± 3.77	9.38± 4.39	6.46± 2.05	9.10± 3.30	8.26± 3.39	0.325

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of goat ecotypes on glycogen concentration in the SM are presented in Table 4.25 and Figure 4.6. The SM of goat ecotypes did not differ (p>0.05) with glycogen concentration at 15 minutes, 3 hour and 24 hours post-mortem but differences were observed at 1 hour and 6 hours post-mortem (Table 4.25).

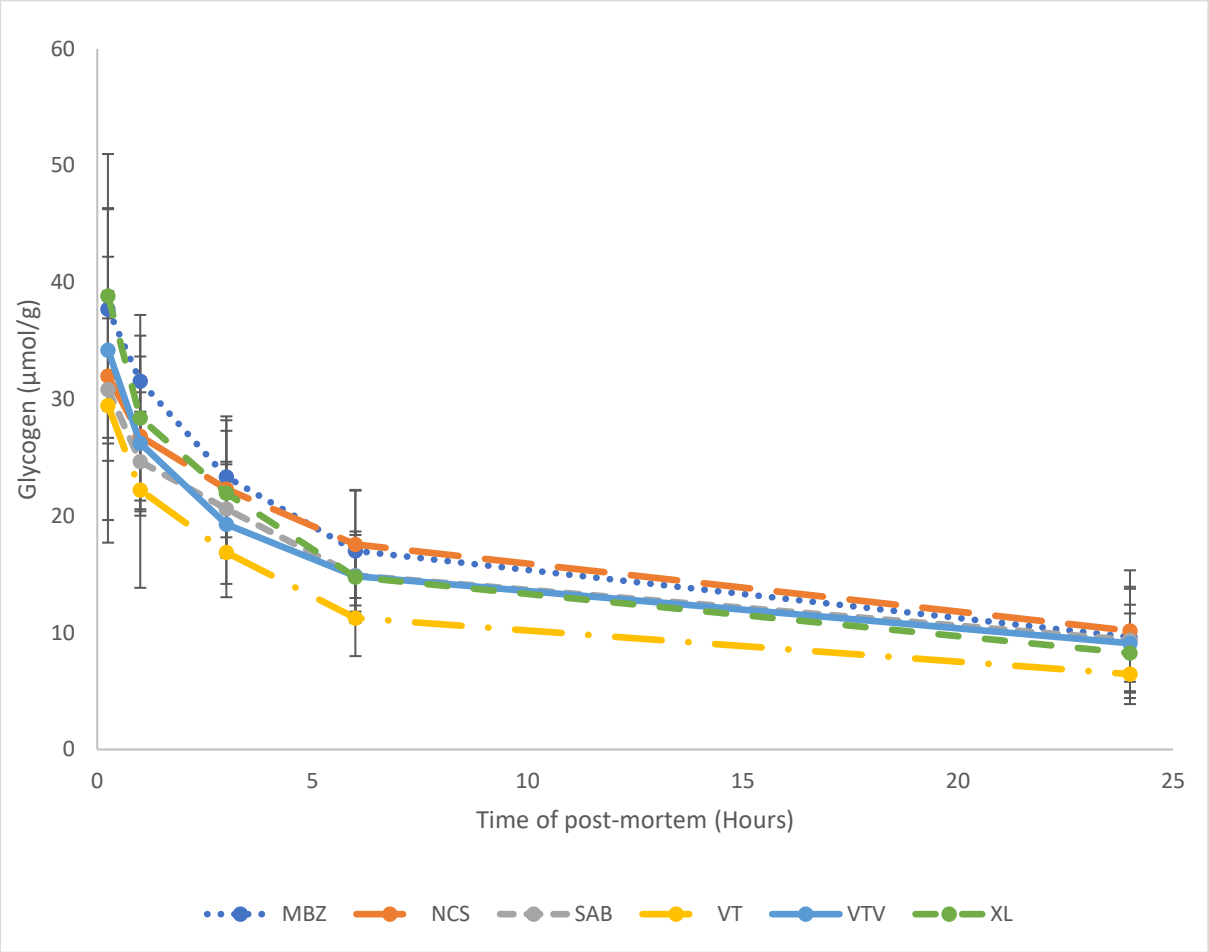


Figure 4.6 Glycogen concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

As expected glycogen concentration decreased with time post-mortem (Figure 4.6) that decreased by about 68-79% as compared to the LD of goat ecotypes. The SM of VT goats had the lowest glycogen concentration at all times post-mortem. Followed by SM of SAB goats and then NCS, VTV goats but only at 15 minutes and 1 hour post-mortem. At 3 hours post-mortem, SM of MBZ goats remained higher, followed by SM of NCS, XL, SAB and then VTV goats. While at 6 to 24 hours post-mortem, SM of NCS and MBZ goats had the highest glycogen concentration, followed by SM of VTV and XL goats.

Table 4.26 Mean values and (± SD) for the goat ecotypes on glucose concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	1.63± 1.66	1.04± 0.57	1.26± 0.69	1.17± 0.57	1.43± 0.69	1.07± 0.37	0.563
1 hr pm	1.23± 0.66	1.51± 1.08	1.41± 0.79	1.18± 0.71	1.08± 0.68	1.42± 0.69	0.831
3 hrs pm	1.61± 0.82	1.09± 0.70	1.25± 0.64	1.28± 0.83	1.18± 0.81	1.44± 0.59	0.608
6 hrs pm	1.51± 0.44	1.80± 1.03	1.56± 0.61	1.60± 0.62	1.49± 0.65	1.62± 0.83	0.939
24 hrs pm	2.60± 1.31	3.23± 3.26	2.68± 0.31	2.29± 1.07	1.89± 0.59	1.82± 1.22	0.386

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.27 Mean values and (± SD) for the effects of goat ecotypes on glucose concentration (µmol/g) on the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	1.22± 0.76	0.82± 0.35	1.32± 0.69	1.00± 0.61	0.98± 0.70	1.09± 0.53	0.425
1 hr pm	1.22± 0.63	1.20± 0.74	1.20± 0.65	1.19± 0.42	0.83± 0.51	1.26± 0.90	0.722
3 hrs pm	1.81± 1.05	0.97± 0.65	1.05± 0.58	1.09± 0.78	0.97± 0.43	1.40± 0.95	0.121
6 hrs pm	1.48± 0.51	1.32± 0.51	1.31± 0.60	1.79± 0.67	1.78± 0.81	1.87± 1.22	0.329
24 hrs pm	2.56± 1.24	2.13± 1.10	1.65± 0.78	1.71± 0.78	1.93± 1.82	2.38± 1.05	0.393

Means in the same row with different superscripts are significantly different (p<0.05)

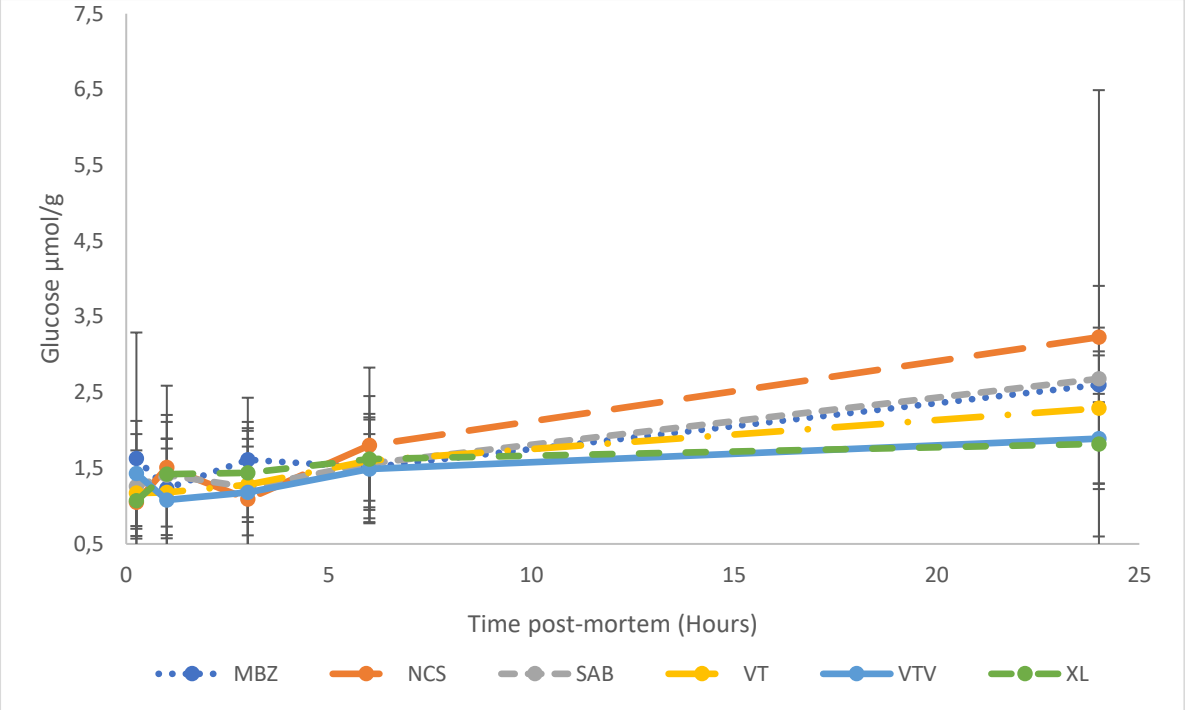


Figure 4.7 Glucose concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

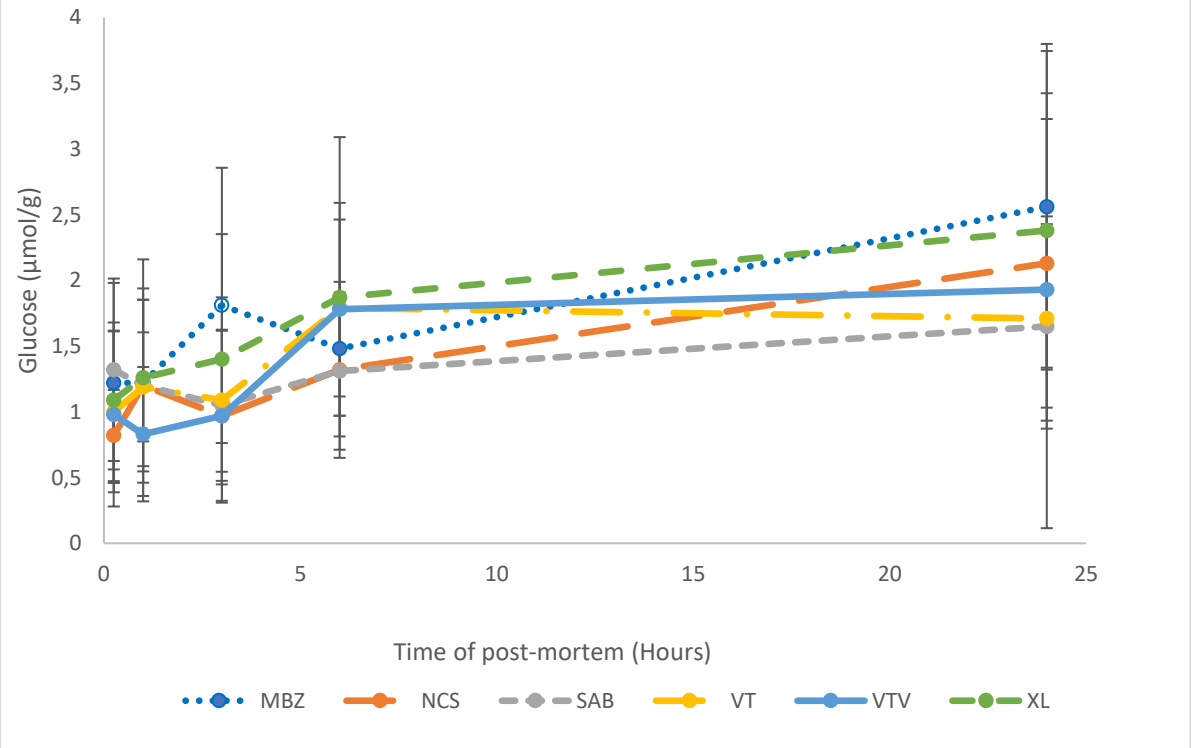


Figure 4.8 Glucose concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

The effects of goat ecotypes on glucose concentration in the LD and SM are presented in Tables 4.26 & 4.27 and Figures 4.7 & 4.8. The goat ecotypes did not differ (p>0.05) in LD and SM glucose concentration with time post-mortem (Tables 4.26 & 4.27). For all the goat ecotypes glucose concentration showed a tendency to increase over the early post-mortem period tested (Figures 4.7 & 4.8).

Table 4.28 Mean values and (± SD) for the effects of goat ecotypes on glucose-6-phosphate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	p- value (p<F)
15 min pm	1.11± 0.99	1.35± 1.09	1.42± 0.99	1.75± 1.58	1.40± 0.53	1.46± 0.84	0.825
1 hr pm	0.90± 0.73	0.97± 0.60	0.87± 0.45	0.69± 0.64	0.75± 0.48	0.95± 0.66	0.899
3 hrs pm	1.01± 1.02	0.99± 0.56	0.66± 0.47	0.73± 0.53	0.87± 0.62	0.93± 0.68	0.770
6 hrs pm	0.87± 0.58	1.39± 1.03	0.96± 0.70	1.20± 0.88	1.26± 0.68	1.63± 1.06	0.293
24 hrs pm	2.84^{a}± 1.91	1.82^{ab}± 1.46	3.10^{a}± 1.80	1.28^{b}± 1.70	1.40^{b}± 1.22	1.59^{ab}± 1.88	0.044

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of goat ecotypes on glucose-6-phosphate concentration in the LD are presented in Table 4.28 and Figure 4.9. The goat ecotypes did not differ (p>0.05) in LD glucose-6-phospahte concentration with time post-mortem except at 24 hours post-mortem (Table 4.28). Example, LD of SAB and MBZ goats had the highest (p<0.05) glucose-6-phosphate concentration (2.84 µmol/g and 3.10 µmol/g) than that recorded in VT and VTV goats (1.28 µmol/g and 1.40 µmol/g) respectively. But on average, the NCS and XL goats did not differ from the rest of the goat ecotypes (p<0.05) (Figure 4.9).

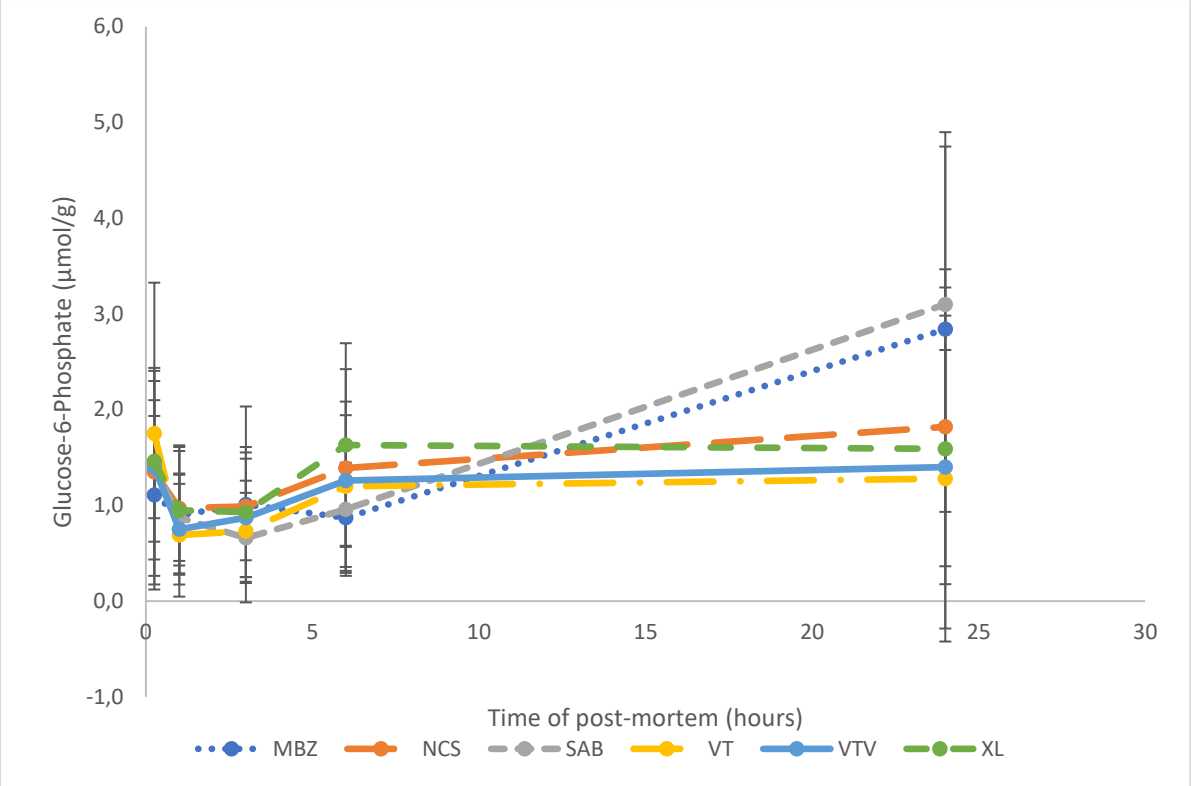


Figure 4.9 Glucose-6-phosphate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Table 4.29 Mean values and (± SD) for the effects of goat ecotypes on glucose-6-phosphate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	1.90± 1.13	1.27± 1.01	0.88± 1.00	1.36± 1.06	0.58± 0.54	1.56± 1.32	0.128
1 hr pm	0.78± 0.59	0.88± 0.73	0.97± 0.79	1.05± 1.02	0.73± 0.48	0.90± 0.76	0.953
3 hrs pm	1.01± 0.59	1.03± 0.97	1.13± 1.56	0.62± 0.59	0.55± 0.66	1.27± 1.47	0.657
6 hrs pm	1.28± 0.65	0.79± 0.84	1.03± 0.94	0.88± 0.96	0.52± 0.34	1.62± 0.94	0.064
24 hrs pm	1.46^{b}± 1.67	2.12^{b}± 1.98	4.17^{a}± 2.42	1.44^{b}± 1.65	1.85^{b}± 1.57	1.87^{b}± 1.69	0.010

Means in the same row with different superscripts are significantly different (p<0.05).

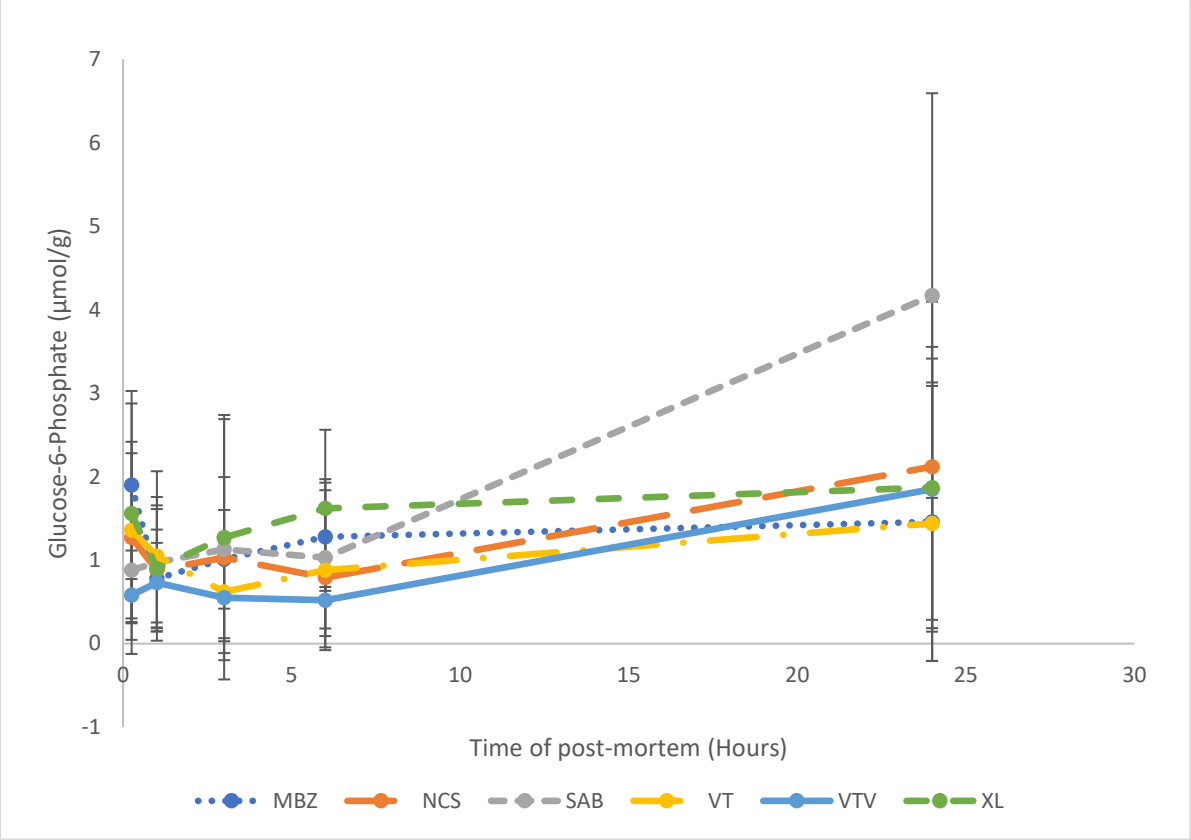


Figure 4.10 Glucose-6-phosphate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

The effects of goat ecotypes on glucose-6-phosphate concentration in the SM are presented in Table 4.29 and Figure 4.10. There were no goat ecotype differences ($p>0.05$) in SM glucose-6-phosphate with time post-mortem except at 24 hours post-mortem (Table 4.29). At 24 hours post-mortem, SM of SAB goat had higher ($p<0.01$) glucose-6-phosphate concentration (4.17 µmol/g) than that recorded in SM of MBZ, NCS, VT, VTV and XL goats 1.46-4.17 µmol/g (Figure 4.10).

The effects of goat ecotypes on lactate concentration in the LD are presented in Table 4.30 and Figure 4.11. There were no goat ecotype differences ($p>0.05$) in LD lactate concentration at any specific time post-mortem (Table 4.30). As expected there was an increase in lactate concentration in LD with time post-mortem, but LD of VTV goats had the tendency to have the lowest overall lactate concentration at all times post-mortem (Figure 4.11). The LD of MBZ, NCS, SAB, VT and XL goats had similar lactate concentration increase ranging between 65–73%.

Table 4.30 Mean values and (± SD) of goat ecotypes on lactate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	23.91± 8.48	23.67± 9.82	19.61± 4.80	21.22± 8.37	18.36± 4.10	23.02± 5.07	0.350
1 hr pm	28.51± 7.25	30.25± 9.53	29.61± 4.96	29.42± 7.77	25.36± 6.53	31.42± 4.47	0.444
3 hrs pm	35.61± 9.70	40.30± 10.61	39.79± 6.95	37.30± 9.81	32.17± 9.11	38.94± 7.42	0.353
6 hrs pm	47.99± 9.55	52.28± 8.32	50.88± 9.75	47.56± 10.75	43.61± 11.98	49.16± 11.93	0.559
24 hrs pm	75.85± 11.10	67.49± 15.75	74.28± 14.98	66.47± 14.38	60.27± 14.26	70.35± 13.61	0.127

Means in the same row with different superscripts are significantly different (p<0.05)

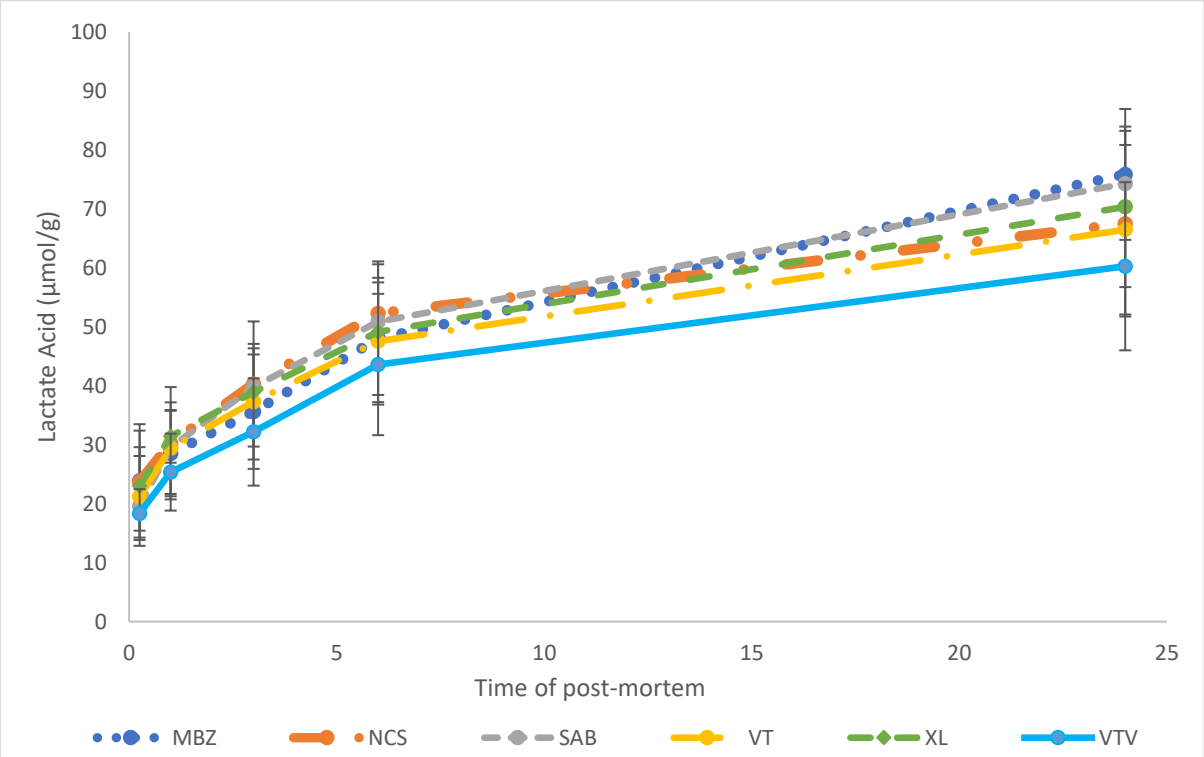


Figure 4.11 Lactate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Table 4.31 Mean values and (± SD) for the effects of goat ecotypes on lactate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	17.23± 5.23	15.96± 5.68	16.04± 3.84	17.78± 5.73	22.85± 6.96	19.19± 6.41	0.126
1 hr pm	25.76± 7.36	24.13± 7.58	25.36± 5.57	25.91± 6.70	25.55± 12.43	24.91± 9.85	0.996
3 hrs pm	34.88± 11.81	32.31± 9.73	36.95± 10.38	32.00± 8.09	37.30± 15.44	33.81± 8.43	0.794
6 hrs pm	49.36± 15.97	42.84± 10.73	55.36± 15.55	44.14± 12.70	51.36± 18.00	49.87± 10.87	0.254
24 hrs pm	77.60± 12.73	64.72± 15.49	74.72± 18.92	67.47± 15.31	78.79± 12.74	68.65± 18.96	0.264

Means in the same row with different superscripts are significantly different (*p*<0.05)

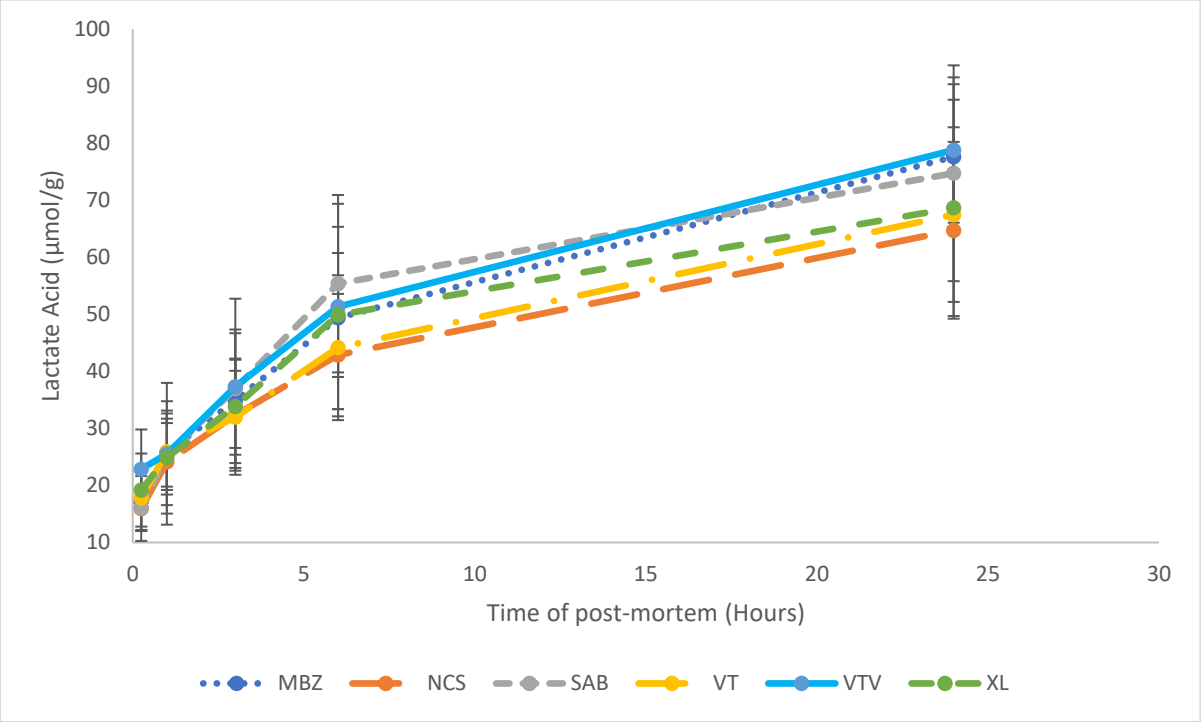


Figure 4.12 Lactate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

The effects of goat ecotypes on lactate concentration in the SM are presented in Table 4.31 and Figure 4.12. There were no goat ecotype differences (p>0.05) in SM lactate concentration with time post-mortem. As expected there was an increase in the lactate concentration mean values in the SM with time post-mortem but unlike the LD of VTV goats, in SM lactate concentrations were higher at 15 minutes, 1 hour and 24 hours post-mortem although there were not significantly different, but to such an extent that it had the highest lactate concentrations overall. This suggested that LD of VTV goats were more sensitive to its stress conditions. The SM of NCS goats had the lowest lactate concentrations on average, followed by VT, XL, MBZ and then SAB goats. The SAB, NCS, VT, XL, MBZ and VTV goats, lactate concentration in SM increased by 71–79 % which were higher than that of LD (Figure 4.12).

Table 4.32 Mean values and (± SD) effects of goat ecotypes on glycolytic potential (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	p-value (p<F)
15 min pm	106.88^{a} ±23.41	102.22^{a} ±23.25	91.19^{a}± 12.78	91.03^{a}± 35.43	67.67^{b}± 11.19	90.52^{a}± 18.95	0.004
1 hr pm	89.62^{a}± 15.57	84.77^{ab}± 15.39	85.92^{a}± 8.50	73.38^{bc}± 17.40	62.20^{c}± 8.55	84.36^{ab}± 15.13	0.001
3 hrs pm	91.11^{a}± 18.16	84.34^{ab}± 15.85	87.23^{ab}± 10.26	75.19^{bc}± 13.17	63.51^{c}± 12.61	80.00^{ab}± 15.58	0.002
6 hrs pm	88.76± 11.66	89.75± 12.97	87.57± 10.23	80.34± 10.72	72.87± 12.08	78.68± 20.84	0.062
24 hrs pm	112.46^{a}± 19.36	90.98^{c}± 20.15	108.90^{ab}± 15.73	94.78^{bc}± 19.70	82.33^{c}± 15.41	90.80^{c}± 17.01	0.001

Means in the same row with different superscripts are significantly different (p<0.05)

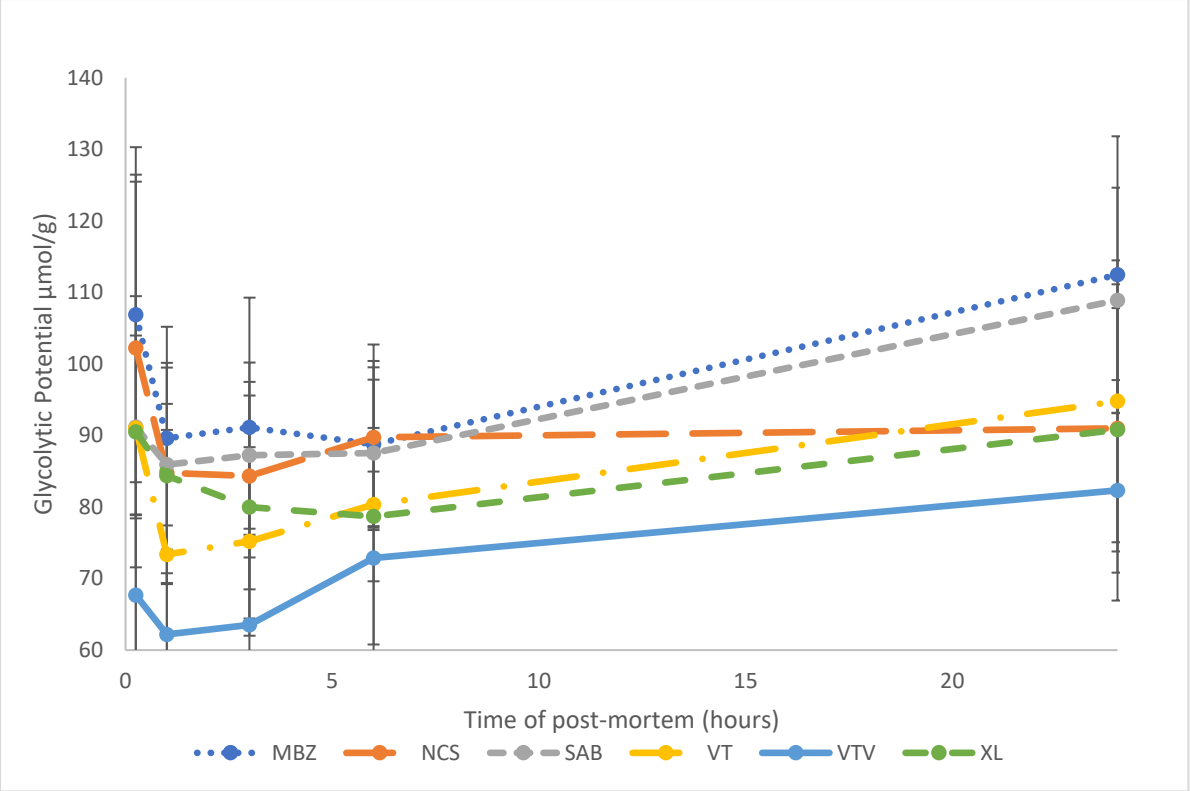


Figure 4.13 Glycolytic potential (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

The effects of goat ecotypes on glycolytic potential (GP) for the LD and SM are presented in Table 4.32 and Figure 4.13. The goat ecotypes differed significantly in LD GP at 15 minutes, 1 hour, 3 hours and 24 hours post-mortem but not at 6 hours post-mortem (Table 4.32). The GP calculated for LD of VTV goats had the lowest glycolytic potential values at all times post-mortem. At 15 minutes post-mortem, GP for LD of MBZ, NCS, SAB, and then in LD of VT, XL goats but lower in the VTV goats. At 1 hour to 3 hours post-mortem, LD of VT, had the second lowest GP after LD of VTV goats, followed by XL, NCS and then SAB goats. At 6 hours post-mortem, LD of NCS goats had the highest glycolytic potential, followed by LD of MBZ, SAB, VT and then XL goats. On the other hand, MBZ goats increased at 24 hours post-mortem, followed by SAB, VT and then dropped in LD of NCS goats (Figure 4.13).

Table 4.33 Mean values and (± SD) for the effects of goat ecotypes effects on glycolytic potential (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	98.86± 19.02	84.11± 27.5	82.07± 11.96	81.41± 17.11	96.84± 16.51	102.16± 24.93	0.071
1 hr pm	91.20± 11.44	81.96± 12.01	79.01 ±9.63	74.82± 20.42	81.13± 17.54	85.99± 16.26	0.221
3 hrs pm	87.22± 12.94	80.92± 15.73	83.20± 11.98	69.17± 14.13	78.94± 22.93	83.04± 14.63	0.229
6 hrs pm	88.91± 14.06	82.18± 16.90	89.87± 17.50	72.00± 17.74	85.67± 19.86	86.37± 10.01	0.149
24 hrs pm	104.88± 14.31	93.90± 19.92	105.11± 23.10	86.67± 18.82	104.54± 16.42	93.65± 22.39	0.203

Means in the same row with different superscripts are significantly different (p<0.05)

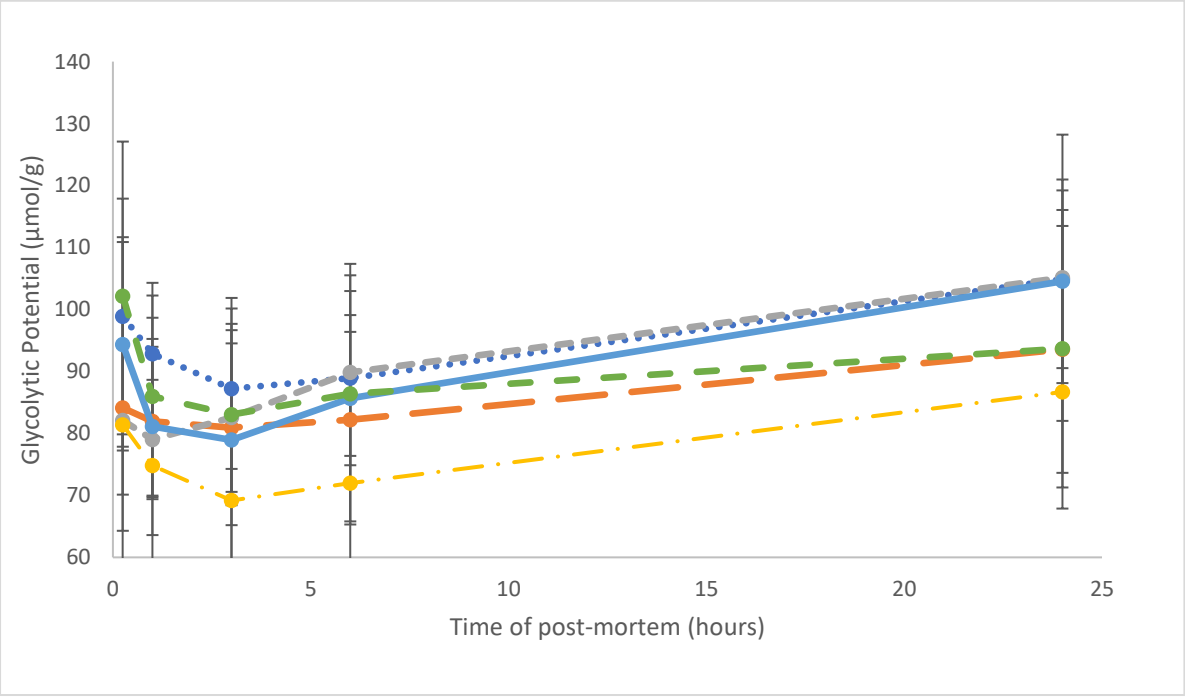


Figure 4.14 Glycolytic potential (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Table 4.34 Mean values and (± SD) for the effects of goat ecotypes on creatine phosphate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	4.12± 1.53	4.08± 1.47	3.89± 1.64	4.96± 2.15	5.34± 1.30	3.32± 1.52	0.096
1 hr pm	3.55± 0.86	3.87± 1.50	3.36± 1.50	3.53± 0.90	4.24± 1.71	3.67± 0.69	0.728
3 hrs pm	4.16± 0.48	3.24± 0.69	3.60± 0.57	3.54± 1.03	3.71± 1.08	3.87± 1.30	0.143
6 hrs pm	3.56± 0.56	3.62± 1.11	3.79± 0.79	3.10± 1.06	2.88± 1.01	3.73± 0.84	0.202
24 hrs pm	3.39± 0.73	3.21± 1.31	3.15± 0.41	4.24± 1.97	3.08± 1.65	3.72± 1.33	0.376

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.35 Mean values and (± SD) for the effects of goat ecotypes effects on creatine phosphate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	5.14± 1.89	5.38± 1.42	5.71± 1.46	4.55± 2.23	4.39± 2.19	4.95± 1.79	0.600
1 hr pm	4.72± 1.45	4.51± 1.02	3.86± 1.26	4.21± 1.32	4.55± 1.66	4.00± 0.93	0.557
3 hrs pm	3.76± 1.28	3.67± 1.05	3.46± 0.72	3.38± 0.71	4.05± 1.06	3.31± 1.46	0.724
6 hrs pm	3.64± 0.74	3.64± 0.70	3.70± 0.80	3.20± 0.61	3.44± 0.90	3.23± 0.77	0.423
24 hrs pm	3.35± 0.81	3.56± 1.21	4.25± 2.12	3.95± 1.26	3.88± 1.64	3.98± 1.51	0.733

Means in the same row with different superscripts are significantly different (p<0.05)

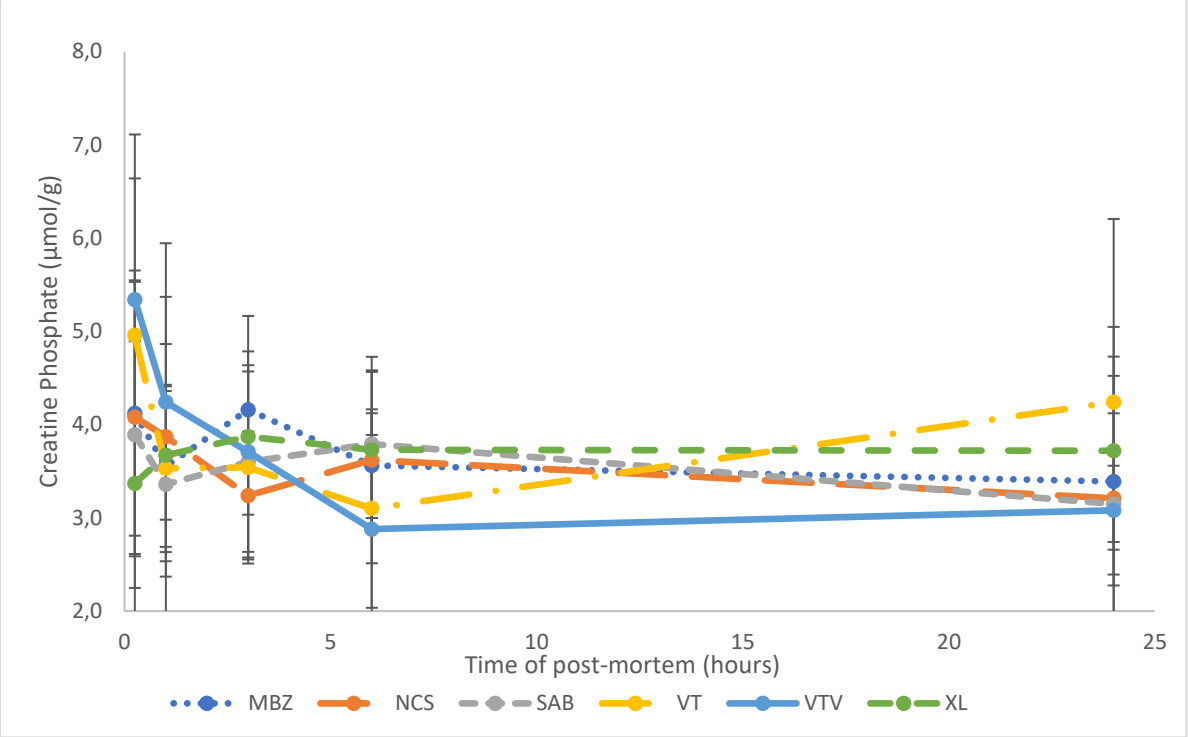


Figure 4.15 Creatine phosphate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

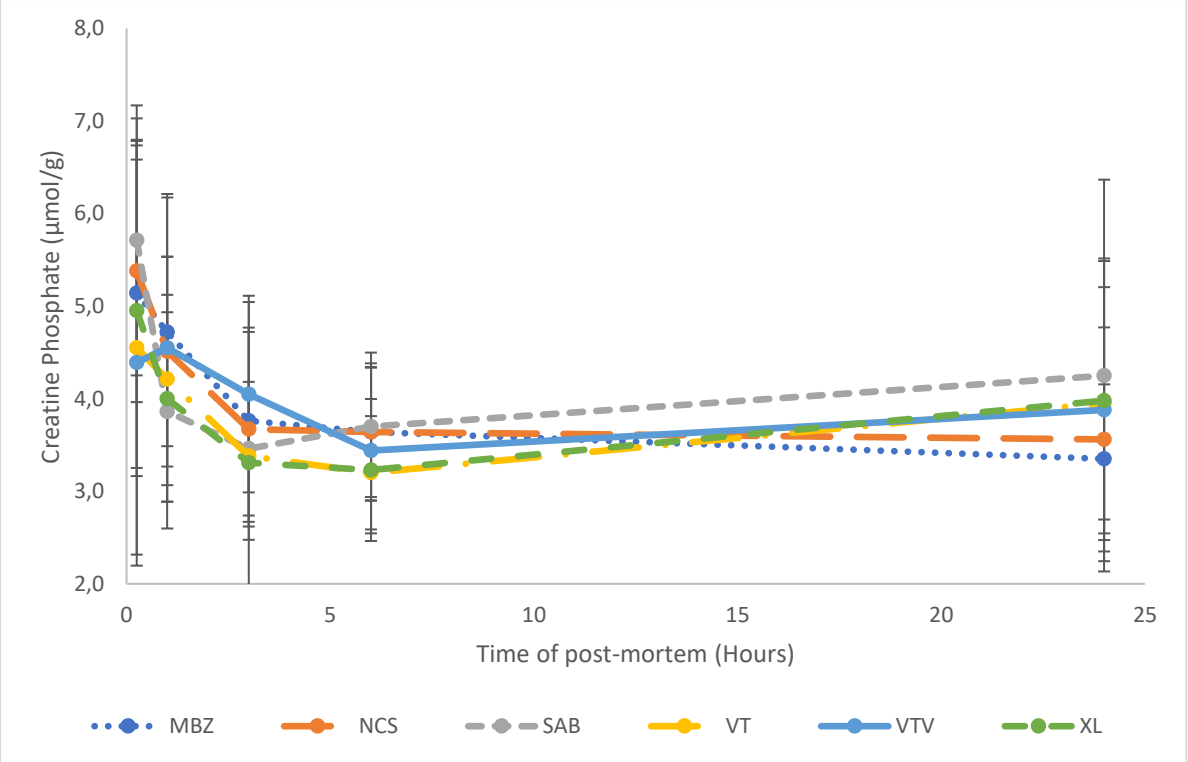


Figure 4.16 Creatine phosphate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

The effects of goat ecotypes on creatine phosphate (CP) concentration for the LD and SM are presented in Tables 4.34 & 4.35 and Figures 4.15 & 4.16. Goat ecotypes did not differ (p>0.05) CP with time post-mortem (p>0.05) in both LD and SM samples (Table 4.34 & 4.35).

The effects of goat ecotypes on ATP concentration for the LD and SM are presented in Tables 4.36 & 4.37 and Figures 4.17 & 4.18. There were no goat ecotype differences (p>0.05) in LD ATP content at 15 minutes, 6 hours and 24 hours post-mortem but rather at 1 hour and 3 hours post-mortem (p<0.001) (Table 4.36). At 1-hour post-mortem, the LD of XL had second highest ATP content, followed by MBZ and SAB goats and lower in the NCS goats. The LD of MBZ and SAB goats did not differ from NCS and XL goats. The LD of VT goats had the lowest ATP content followed by NCS and then SAB goats from 15 minutes to 6 hours post-mortem (Figure 4.17). The goat ecotypes did not differ (p>0.05) in SM ATP content with time post-mortem except at 6 hours post-mortem (Table 4.37). The SM of SAB and VTV goats had higher (p<0.05) ATP content (7.07 µmol/g and 6.69 µmol/g) than that recorded in SM of VT and XL goats (5.27 µmol/g and 5.12 µmol/g respectively). The SM of MBZ and NCS goats did not differ in ATP content and on average they were similar to the rest of goat ecotypes.

Table 4.36 Mean values and (± SD) for the effects of goat ecotypes on ATP concentration (µmol/g) for the m. longissimus dorsi at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	p-value (p<F)
15 min pm	8.40± 1.45	7.55± 1.22	7.39± 2.01	7.57± 1.14	8.88± 1.32	7.69± 1.96	0.311
1 hr pm	7.11^{bc}± 1.72	6.73^{c}± 1.43	7.08^{bc}± 1.38	5.30^{d}± 0.77	8.59^{a}± 1.62	8.20^{ab}± 2.28	0.001
3 hrs pm	8.10^{ab}± 1.51	5.66^{c}± 1.99	7.07^{bc}± 1.71	5.72^{c}± 1.42	9.50^{a}± 3.07	7.56^{b}± 1.23	0.001
6 hrs pm	6.40± 1.35	6.54± 2.41	6.50± 1.53	4.85± 1.65	6.84± 3.05	6.45± 1.57	0.231
24 hrs pm	4.96± 1.34	4.22± 1.71	4.76± 1.43	4.58± 2.05	6.41± 1.72	4.97± 2.23	0.211

Means in the same row with different superscripts are significantly different (p<0.05)

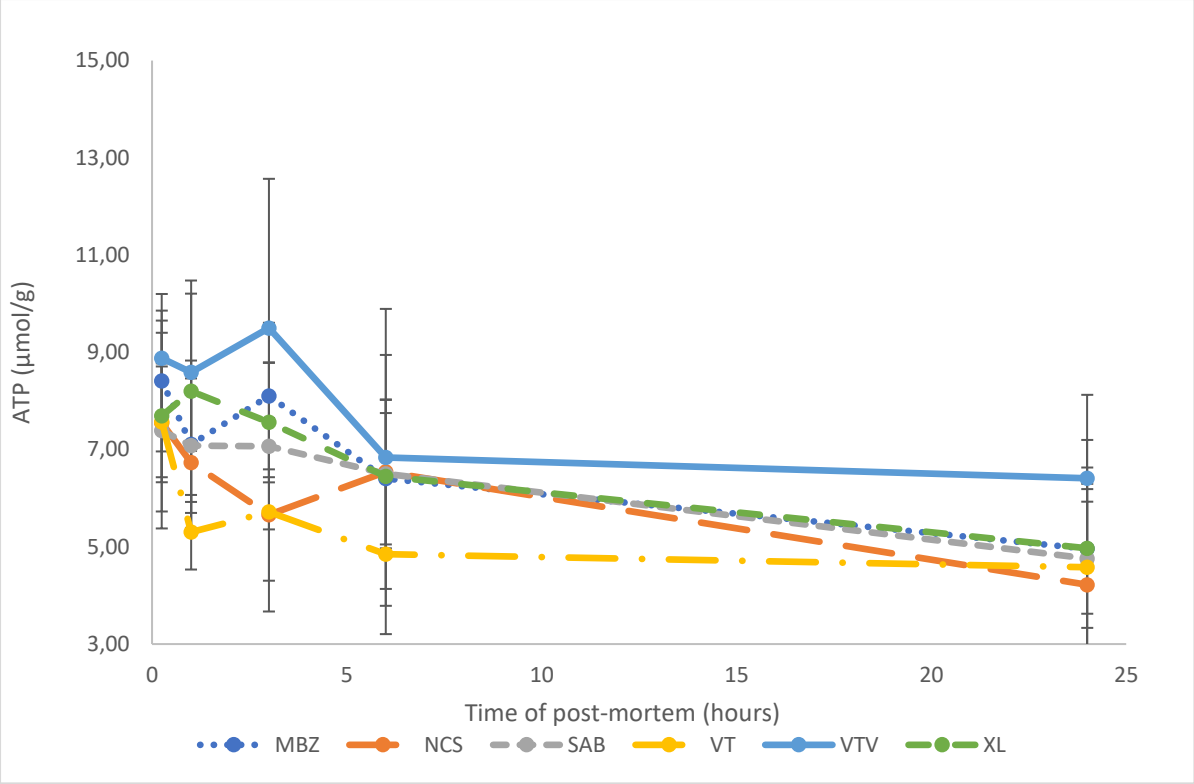


Figure 4.17 ATP concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Table 4.37 Mean values and (± SD) for the effects of goat ecotypes on ATP concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
15 min pm	8.57± 1.96	8.16± 2.17	8.62± 0.98	7.21± 2.35	8.30± 1.13	7.12± 0.94	0.140
1 hr pm	8.38± 1.51	7.90± 1.06	7.51± 1.71	7.33± 1.50	8.59± 1.43	7.43± 1.44	0.279
3 hrs pm	7.61± 1.90	6.88± 1.35	6.44± 1.72	6.90± 1.93	6.94± 0.95	6.35± 1.69	0.544
6 hrs pm	6.21^{ab}± 1.62	6.00^{ab}± 1.32	7.07^{a}± 1.70	5.27^{b}± 1.51	6.96^{a}± 1.64	5.12^{b}± 2.24	0.053
24 hrs pm	4.65± 1.98	6.25± 2.79	6.00± 1.90	4.58± 1.15	6.28± 2.58	5.92± 2.96	0.384

Means in the same row with different superscripts are significantly different (p<0.05)

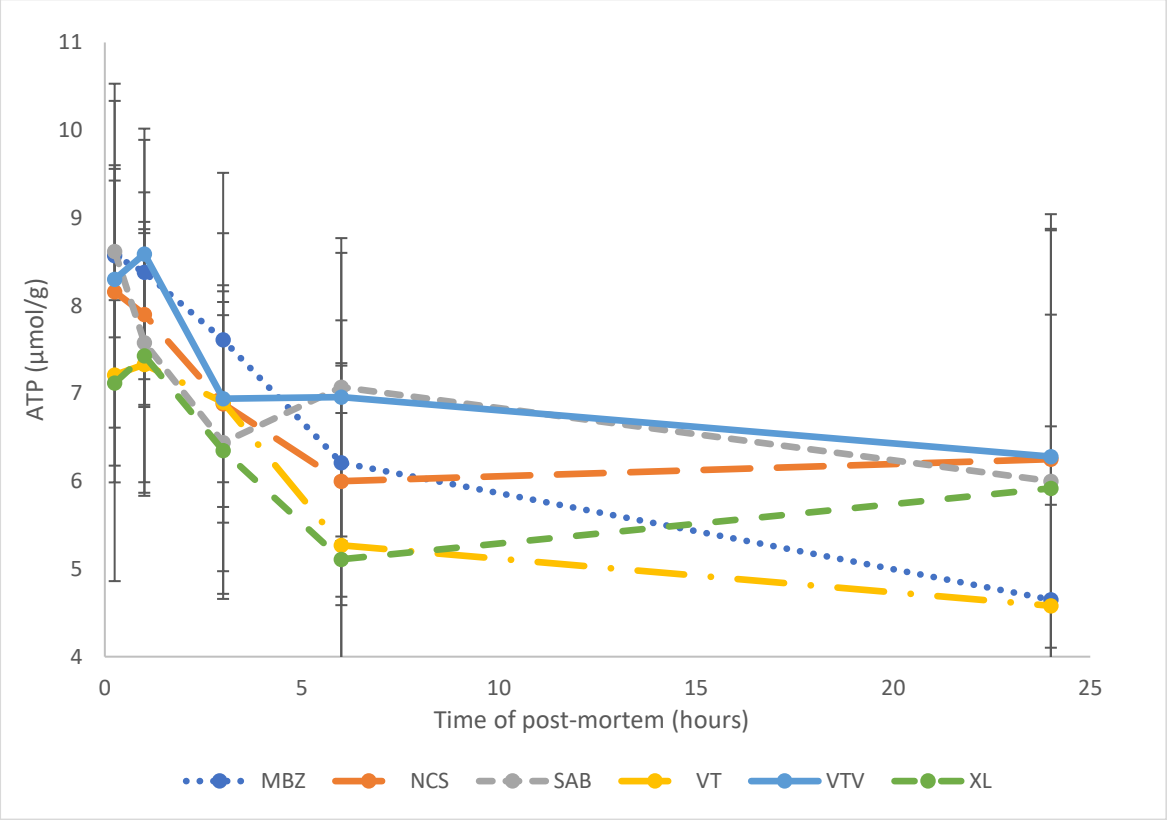


Figure 4.18 ATP concentration for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

4.3.3 The effects of sex on muscle energy changes early post-mortem

Table 4.38 Mean values and (± SD) for the effects of sex on glycogen concentration (µmol/g) for the *m. longissimus dorsi at* 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance *p*-value (*p*<F)
	Does	Bucks	
15 min pm	34.94 ± 11.33	30.59 ± 9.98	0.084
1 hr pm	24.12 ± 6.86	23.03 ± 6.79	0.483
3 hrs pm	19.85 ± 6.47	19.28 ± 5.58	0.771
6 hrs pm	14.44 ± 5.40	14.67 ± 4.94	0.717
24 hrs pm	9.29 ± 4.65	9.37 ± 4.43	0.790

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.39 Mean values and (± SD) for the effects of sex on glycogen concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance *p*-value (p<F)
	Does	Bucks	
15 min pm	32.94 ± 11.45	35.56 ± 9.28	0.325
1 hr pm	26.10 ± 6.03	27.65 ± 7.70	0.331
3 hrs pm	20.37 ± 4.66	21.89 ± 5.96	0.210
6 hrs pm	15.20 ± 4.05	15.24 ± 4.76	0.869
24 hrs pm	8.53 ± 4.11.	9.37 ± 3.91	0.349

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on glycogen concentration in the LD and SM are presented in Tables 4.38 & 4.39. There were no sex differences (p>0.05) in both muscles (LD and SM) glycogen concentration at any time post-mortem (Tables 4.38 & 4.39).

Table 4.40 Mean values and (± SD) for the effects of sex on glucose concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance *p*-value (p<F)
	Does	Bucks	
15 min pm	1.22 ± 0.58	1.31 ± 1.14	0.591
1 hr pm	1.44 ± 0.72	1.18 ± 0.84	0.197
3 hrs pm	1.34 ± 0.77	1.29 ± 0.64	0.820
6 hrs pm	1.58 ± 0.75	1.64 ± 0.67	0.758
24 hrs pm	2.58 ± 2.01	2.26 ± 1.06	0.497

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.41 Mean values and (± SD) for the effects of sex on glucose concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance *p-value* (p<F)
	Does	Bucks	
15 min pm	1.02 ± 0.56	1.15 ± 0.68	0.366
1 hr pm	1.27 ± 0.60	1.02 ± 0.74	0.093
3 hrs pm	1.28 ± 0.87	1.16 ± 0.74	0.586
6 hrs pm	1.51 ± 0.67	1.67 ± 0.92	0.446
24 hrs pm	2.15 ± 1.21	1.99 ± 1.06	0.615

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on glucose concentration in the LD and SM are presented in Tables 4.40 & 4.41. There were no sex differences (p>0.05) in both muscles (LD and SM) glucose concentration with time post-mortem (Tables 4.40 & 4.41).

Table 4.42 Mean values and (± SD) for the effects of sex on glucose-6-phosphate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post mortem	Sex		Significance *p*-value (p<F)
	Does	Bucks	
15 min pm	1.73^{a} ±1.08	0.95^{b} ± 0.72	0.002
1 hr pm	0.95 ± 0.58	0.76 ± 0.60	0.240
3 hrs pm	0.90 ± 0.50	0.83 ± 0.85	0.697
6 hrs pm	1.37 ± 0.92	1.03 ± 0.75	0.091
24 hrs pm	2.06 ± 1.79	2.05 ± 1.80	0.942

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.43 Mean values and (± SD) for the effects of sex on glucose-6-phosphate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	1.21 ± 1.13	1.41 ± 1.08	0.478
1 hr pm	0.94 ± 0.67	0.81 ± 0.80	0.472
3 hrs pm	1.12 ± 1.33	0.77 ± 0.59	0.200
6 hrs pm	1.12 ± 0.89	0.99 ± 0.85	0.479
24 hrs pm	2.33 ± 2.15	2.04 ± 1.93	0.539

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on glucose-6-phosphate concentration in the LD and SM are presented in Tables 4.42 & 4.43. The LD of does had higher (p<0.01) G-6-P concentration (1.73 µmol/g) than that recorded in bucks (0.95 µmol/g) at 15 minutes post-mortem (Table 4.42). There were no sex differences (p>0.05) at 1 hour, 3 hours, 6 hours and 24 hours post-mortem. There were no sex differences (p>0.05) in SM G-6-P concentration with time post-mortem (Tables 4.43).

Table 4.44 Mean values and (± SD) for the effects of sex on lactate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	23.72^{a} ± 7.23	19.20^{b} ± 6.29	0.010
1 hr pm	31.23^{a} ± 6.43	26.71^{b} ± 6.69	0.005
3 hrs pm	39.15 ± 9.09	35.72 ± 8.60	0.106
6 hrs pm	50.39 ± 10.90	46.98 ± 9.29	0.187
24 hrs pm	72.37^{a} ± 15.64	65.94^{b} ± 11.71	0.056

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.45 Mean values and (± SD) for the effects of sex on lactate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	18.34 ± 5.80	17.14 ± 5.85	0.494
1 hr pm	26.82 ± 8.85	22.83 ± 6.16	0.069
3 hrs pm	36.53 ± 10.98	31.57 ± 8.92	0.070
6 hrs pm	52.95^{a} ± 12.69	43.17^{b} ± 14.12	0.005
24 hrs pm	72.53 ± 16.12	70.40 ± 17.09	0.699

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on lactate concentration in the LD and SM are presented in Tables 4.44 & 4.45. At 15 minutes, 1 hour and 24 hours post-mortem, does had higher (p<0.01) lactate concentration than that recorded in LD of bucks (23.72 µmol/g *vs* 19.20 µmol/g, 31.23 µmol/g *vs* 26.71 µmol/g, 72.37 µmol/g *vs* 65.94 µmol/g). The differences in sex could have been caused by the interaction that was observed in SAB and VTV goats but overall the rest did not differ on average (Table 4.16). There were no sex differences in LD lactate concentration observed at 3 hours and 6 hours post-mortem (p>0.05) (Table 4.44).

There were no sex differences (p>0.05) in SM lactate concentration at 15 minutes, 1 hour, 3 hours and 24 hours post-mortem. On the other hand, at 6 hours post-mortem, SM of does had higher (p<0.01) lactate concentration than that recorded in bucks (52.95 µmol/g *vs* 43.17 µmol/g) (Table 4.45).The effects of sex on glycolytic potential in the LD and SM are presented in Tables 4.46 & 4.47. There were sex differences in calculated LD GP with time post-mortem. At 15 minutes, 1 hour and 6 hours post-mortem, LD of does had higher (p<0.05) GP than that calculated in LD of bucks (98.67 µmol/g *vs* 84.90 µmol/g, 85.28 µmol/g *vs* 76.36 µmol/g and 84.83 µmol/g *vs* 81.41 µmol/g) respectively.

Table 4.46 Mean values and (± SD) for the effects of sex on glycolytic potential (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	98.67[a] ± 23.81	84.90[b] ± 22.65	0.011
1 hr pm	85.28[a] ± 14.14	76.36[b] ± 17.11	0.020
3 hrs pm	83.31 ± 16.51	78.52 ± 16.02	0.208
6 hrs pm	84.83[a] ± 14.86	81.41[b] ± 14.59	0.021
24 hrs pm	100.24 ± 21.52	93.28 ± 17.87	0.139

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.47 Mean values and (± SD) for the effects of sex on glycolytic potential (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	88.68 ± 23.95	94.24 ± 18.07	0.273
1 hr pm	83.46 ± 13.35	80.94 ± 17.13	0.568
3 hrs pm	82.07 ± 15.89	79.26 ± 15.54	0.554
6 hrs pm	88.61[a] ± 14.86	78.95[b] ± 16.88	0.021
24 hrs pm	98.85 ± 20.33	97.19 ± 20.34	0.874

Means in the same row with different superscripts are significantly different (p<0.05)

There were no sex differences (p>0.05) in SM GP at 3 hours and 24 hours post-mortem (Table 4.46). There were no sex differences (p>0.05) in SM GP with time post-mortem except at 6 hours post-mortem (Table 4.47). The SM of does had higher (p<0.05) GP than that calculated in bucks (88.61 µmol/g *vs* 78.95 µmol/g).

Table 4.48 Mean values and (± SD) for the effects of sex on creatine phosphate concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	4.04 ± 1.65	4.40 ± 1.74	0.376
1 hr pm	3.80[a] ± 1.16	3.51[b] ± 1.29	0.054
3 hrs pm	3.86 ± 0.96	3.45 ± 0.80	0.386
6 hrs pm	3.37 ± 0.88	3.68 ± 0.96	0.211
24 hrs pm	3.45 ± 1.25	3.46 ± 1.36	0.944

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.49 Mean values and (± SD) for the effects of sex on creatine phosphate concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	5.43 ± 1.58	4.59 ± 1.97	0.075
1 hr pm	4.37 ± 1.22	4.17 ± 1.32	0.615
3 hrs pm	3.56 ± 1.01	3.61 ± 1.21	0.790
6 hrs pm	3.49 ± 0.80	3.47 ± 0.69	0.991
24 hrs pm	3.59 ± 1.14	4.16 ± 1.79	0.146

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on creatine phosphate in the LD and SM are presented in Tables 4.48 & 4.49. There were no sex differences (p>0.05) in LD creatine phosphate with time post-mortem except at 1 hour post-mortem. The LD of does had higher CP concentration than that recorded in bucks (3.80 µmol/g *vs* 3.51 µmol/g) (Table 4.48). There were no sex differences (p>0.05) in SM CP concentration time post-mortem (Table 4.49).

Table 4.50 Mean values and (± SD) for the effects of sex on ATP concentration (µmol/g) for the *m. longissimus dorsi* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	7.95 ± 1.66	7.73 ± 1.58	0.687
1 hr pm	7.62^{a} ± 1.88	6.57^{b} ± 1.68	0.012
3 hrs pm	7.35 ± 2.14	6.98 ± 2.22	0.560
6 hrs pm	6.44 ± 2.19	6.12 ± 1.61	0.557
24 hrs pm	4.96 ± 1.72	4.85 ± 1.97	0.870

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.51 Mean values and (± SD) for the effects of sex on ATP concentration (µmol/g) for the *m. semimembranosus* at 15 minutes, 1 hour, 3 hours, 6 hours and 24 hours post-mortem

Time post-mortem	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
15 min pm	8.27 ± 1.66	7.60 ± 1.77	0.156
1 hr pm	8.09 ± 1.38	7.44 ± 1.52	0.105
3 hrs pm	6.81 ± 1.56	6.85 ± 1.77	0.826
6 hrs pm	6.15 ± 1.91	5.97 ± 1.69	0.809
24 hrs pm	5.43 ± 2.21	5.93 ± 2.57	0.428

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on ATP concentration in the LD and SM are presented in Tables 4.50 & 4.51. There were no sex differences (p>0.05) in LD ATP content with time post-mortem except at 1 hour post-mortem. Does had higher (p<0.01) ATP content than that recorded in bucks (7.62 µmol/g *vs* 6.57 µmol/g) (Table 4.50). In the SM, does equally had high ATP content than that recorded in bucks (6.94 µmol/g *vs* 6.76 µmol/g) and no sex differences were observed with time post-mortem (Table 4.51).

4.4 Meat quality characteristics

Table 4.52 Mean values and (± SD) for interaction effects of goat ecotype and sex on water holding capacity, drip loss, thawing loss and cooking loss for *m. longissimus dorsi*

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
Water holding capacity (WHC)													
Post-mortem aging													
1 day pm	0.40 ±0.04	0.38 ±0.09	0.38 ±0.05	0.35 ±0.04	0.41 ±0.05	0.36 ±0.02	0.34± 0.03	0.35 ±0.06	0.46 ±0.07	0.47 ±0.03	0.40 ±0.02	0.36 ±0.06	0.784
4 days pm	0.35 ±0.06	0.35 ±0.03	0.36 ±0.05	0.33 ±0.02	0.39 ±0.05	0.37 ±0.06	0.36± 0.04	0.39 ±0.05	0.39 ±0.03	0.34 ±0.04	0.36 ±0.06	0.37 ±0.03	0.478
Drip loss %													
4 days pm	2.11 ±0.63	1.36 ±0.53	1.95 ±0.68	1.74 ±1.04	1.97 ±0.83	1.31 ±0.32	1.47± 0.58	1.22 ±0.30	0.51 ±0.77	0.50 ±0.52	2.30 ±1.23	1.36 ±0.54	0.700
Thawing loss %													
4 days pm	3.35 ±1.69	4.22 ±1.35	4.72 ±2.63	2.70 ±0.70	3.69 ±1.21	3.72 ±1.54	3.10 ±1.95	3.30 ±2.63	2.92 ±1.71	4.13 ±2.92	4.26 ±1.54	3.00 ±1.47	0.302
Cooking loss %													
4 days pm	11.8 ±4.8	12.9 ±3.6	14.7 ±5.7	12.6 ±5.2	11.9 ±5.2	13.6 ±5.3	11.4 ± 0.8	13.1 ±4.1	15.2 ±3.3	18.4 ±5.2	12.9 ±5.6	12.6 ±2.7	0.844

Means in the same row with different superscripts are significantly different (p<0.05)

Table 4.53 Mean values and (± SD) for interaction effect of goat ecotype and sex on water holding capacity, drip loss, thawing loss and cooking loss for *m. semimembranosus*

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
Water holding capacity (WHC)													
Post-mortem aging													
1 day pm	0.38 ±0.04	0.37 ±0.04	0.34 ± 0.02	0.328 ±0.07	0.37 ± 0.06	0.29 ±0.04	0.31 ±0.08	0.33 ±0.06	0.38 ±0.03	0.39 ±0.02	0.35 ±0.06	0.35 ±0.04	0.283
4 days pm	0.33 ±0.05	0.34 ±0.10	0.34± 0.08	0.31 ±0.08	0.34 ±0.05	0.37 ±0.05	0.31 ±0.03	0.33 ±0.07	0.38 ±0.03	0.33 ±0.04	0.36 ±0.06	0.34 ±0.04	0.696
Drip loss %													
4 days pm	1.90 ±0.04	1.90 ±0.09	1.88 ± 0.12	1.92 ±0.20	1.86 ±0.12	1.96 ±0.11	1.89 ±0.08	1.93 ±0.12	1.92 ±0.05	1.89 ±0.03	1.86 ±0.10	1.91 ±0.12	0.819
Thawing loss (%)													
4 days pm	9.51 ±1.41	8.04 ±2.52	8.07 ± 1.07	7.05 ±3.46	7.89 ±1.56	4.63 ±2.83	7.40 ±2.46	6.86 ± 0.83	7.06 ±1.32	7.33 ±0.54	6.17 ±1.55	5.76 ±2.41	0.430
Cooking loss (%)													
4 days pm	24.5 ±2.4	25.9 ±2.9	25.2± 2.7	24.1 ±3.9	23.0 ±0.9	22.5 ±8.4	26.9 ±3.4	27.9 ±10.4	25.3 ±4.2	25.5 ±1.8	23.6 ±2.6	24.1 ±7.3	0.992

Means in the same row with different superscripts are significantly different (p<0.05)

4.4.1 The interaction effects of goat ecotype and sex on water holding capacity (WHC), drip loss, thawing loss and cooking loss in the *m. longissimus dorsi* and *m. semimembranosus*

The interaction effects of goat ecotype and sex on moisture characteristics; water holding capacity measured on 1 day and 4 days post-mortem, and drip loss, thawing loss and cooking loss measured at 4 days post-mortem for the LD and SM muscles are presented in Tables 4.52 & 4.53.

Interaction effects of goat ecotype and sex on moisture content parameters did not differ (p>0.05) in both muscles (LD and SM). The overall mean of WHC, drip loss, thawing loss and cooking loss of LD for the interaction effects of goat ecotype and sex ranged between 0.34-0.47%, 0.51-2.30%, 11.42-18.43% and 2.70–4.71% respectively (Table 4.52).

The overall means of drip loss, cooking loss and thawing loss in SM for determining the interaction effects of goat ecotype and sex ranged between 0.31-0.39%, 1.86-1.96%, 22.54-27.86% and 4.63-9.51% respectively (p>0.05) (Table 4.53).

4.4.2 The effects of goat ecotypes on water holding capacity, drip loss, thawing loss and cooking loss in the *m. longissimus dorsi* and *m. semimembranosus*

The effects of goat ecotypes on the water holding capacity, drip loss, thawing loss and cooking loss for the LD are presented in Tables 4.54 & 4.55. At 1 day post-mortem, goat ecotypes WHC differed (p<0.001), e.g. LD of VTV goats had higher (p<0.001) WHC (0.46) in as compared LD of MBZ, NCS, SAB, VT and XL goats (0.35-0.39). There were no interaction effects of goat ecotype measured at 4 days post mortem (Table 4.54). The LD of MBZ, NCS, SAB, VT and XL goats had higher drip loss (1.36-1.86%) than LD of VTV goats (0.51%). Cooking loss and thawing loss in LD of goat ecotypes were not different (p>0.05).

At 1 day post-mortem, SM of VTV and MBZ goats had higher (p<0.05) WHC (0.38) than that recorded in VT goats (0.32). The SM of NCS and SAB goats were similar but on average SM of XL goats did not differ from the rest of goat ecotypes. There were no goat ecotype differences (p>0.05) in SM WCH measured at 4 days post-mortem) and aging effect was significant (See results reported under 4.4.7 and Table 4.64).

Table 4.54 Mean values and (± SD) of the effects of goat ecotypes on water holding capacity, drip loss, thawing loss and cooking loss of *m. longissimus dorsi*

	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (p<F)
Water holding capacity (WHC)							
Post-mortem aging							
1 day pm	0.39^{b}±0.06	0.37^{b}±0.05	0.39^{b}±0.04	0.35^{b}±0.04	0.46^{a}±0.06	0.38^{b}±0.05	0.001
4 days pm	0.35± 0.05	0.35±0.04	0.38±0.05	0.37±0.04	0.37±0.04	0.37±0.05	0.406
Drip loss %							
4 days pm	1.83^{a}±0.68	1.86^{a}±0.81	1.70^{a}±0.73	1.36^{a}±0.47	0.51^{b}±0.65	1.86^{a}±1.05	0.002
Thawing loss %							
4 days pm	3.66 ±1.57	3.88 ±2.24	3.70 ±1.29	3.19 ±2.12	3.39 ±2.13	3.68 ±1.59	0.967
Cooking loss %							
4 days pm	12.2 ± 4.2	13.8 ± 5.4	12.6 ± 5.0	12.2 ± 2.7	16.4 ± 4.1	12.7 ± 4.3	0.373

Means in the same row with different superscripts are significantly different (p<0.05).

Table 4.55 Mean values and (± SD) of the effects of goat ecotypes on water holding capacity, drip loss and cooking loss for *m. semimembranosus*

	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (p<F)
Water holding capacity (WHC)							
Post-mortem aging							
1 day pm	0.38^{a}±0.04	0.34^{bc}±0.04	0.34^{bc}±0.06	0.32^{c}±0.07	0.38^{a}±0.03	0.35^{abc}±0.05	0.045
4 days pm	0.34± 0.07	0.33±0.08	0.35±0.05	0.32± 0.05	0.36± 0.04	0.35±0.05	0.609
Drip loss %							
4 days pm	1.90± 0.06	1.90± 0.15	1.90± 0.12	1.91± 0.10	1.91± 0.04	1.88±0.11	0.994
Thawing loss %							
4 days pm	8.97^{a}±1.91	7.65^{ab}±2.29	6.53^{b}±2.66	7.16^{b}±1.84	7.17^{b}±1.05	5.98^{b}±1.91	0.015
Cooking loss %							
4 days pm	25.0±2.5	24.7±3.1	22.8± 5.1	27.3± 6.9	25.4± 3.4	23.8± 5.1	0.406

Means in the same row with different superscripts are significantly different (p<0.05)

Drip and cooking losses in SM of goat ecotypes did not differ (p>0.05) ranging between 1.88-1.91% and 22.8-27.3% respectively (Table 4.55). The SM of MBZ goats had higher (p>0.01) thawing loss (8.97%) than SM of VTV, VT, SAB, and XL goats (5.98-7.17%) but were all similar to SM of NCS goats (7.65%).

4.4.3 The effects of sex on water holding capacity, drip loss, thawing loss and cooking loss for *m. longissimus dorsi* and *m. semimembranosus*

Table 4.56 Mean values and (± SD) for the effects of sex on water holding capacity, drip loss, thawing loss and cooking loss of *m. longissimus dorsi*

	Sex		Significance
	Does	Bucks	p-value (p<F)
Water holding capacity (WHC)			
Post-mortem aging			
1 day post-mortem	0.39 ± 0.05	0.37 ± 0.06	0.066
4 days post-mortem	0.37 ± 0.05	0.36 ± 0.04	0.344
Drip loss (%)			
4 day post-mortem	1.79^{a} ± 0.95	1.31^{b}± 0.64	0.009
Thawing loss (%)			
4 days post-mortem	3.74 ± 1.83	3.43 ± 1.69	0.499
Cooking loss (%)			
4 days post-mortem	12.9 ± 4.7	13.6 ± 4.3	0.559

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on water holding capacity, drip loss, thawing loss and cooking loss for the LD and SM muscles are presented in Tables 4.56 & 4.57. There were sex no differences in both muscles (LD and SM) moisture characteristics except in LD drip loss and SM thawing loss (Tables 4.56 & 4.57). The LD does had a higher drip loss than that recorded in LD bucks (1.79% *vs* 1.31%) measured at 4 days post mortem. The SM of does had a higher thawing loss than that recorded in SM bucks (7.73% *vs* 6.47%).

Table 4.57 Mean values and (± SD) for the effects of sex on water holding capacity, drip loss, thawing loss and cooking loss of *m. semimembranosus*

	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
Water holding capacity (WHC)			
Post-mortem aging			
1 day post-mortem	0.36 ± 0.05	0.34 ± 0.05	0.137
4 days post-mortem	0.34 ± 0.05	0.34 ± 0.06	0.597
Drip loss (%)			
4 day post-mortem	1.88 ± 0.09	1.92 ± 0.12	0.163
Thawing loss (%)			
4 days post-mortem	7.73^{a} ± 1.81	6.47^{b} ± 2.52	0.024
Cooking loss (%)			
4 days post-mortem	24.6 ± 2.8	24.8 ± 6.3	0.872

Means in the same row with different superscripts are significantly different (*p*<0.05)

4.4.4 The interaction effects of goat ecotype and sex on WBSF, sarcomere length and myofibril fragment length

Table 4.58 Mean values and (± SD) for interaction effects of goat ecotype and sex on WBSF, sarcomere length and myofibril fragment length for *m. longissimus dorsi*

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
WBSF (kg)													
4 days pm	3.08 ±0.66	3.35 ±0.46	3.72 ±1.31	2.87 ±0.32	3.19 ±0.70	3.26 ±0.91	3.11 ± 0.53	3.83 ±1.17	3.71 ±0.77	3.56 ±0.51	3.64 ±0.35	3.08 ±1.09	0.279
Sarcomere length (µm)													
1 day pm	1.90 ±0.04	1.90 ±0.09	1.88 ±0.12	1.92 ±0.20	1.86 ±0.12	1.96 ±0.11	1.89 ±0.08	1.93 ±0.12	1.92 ±0.05	1.89 ±0.03	1.86 ±0.10	1.91 ±0.12	0.819
Myofibril fragment length (µm)													
Post-mortem aging													
1 day pm	30.84 ±4.55	36.61 ±0.33	30.27 ±3.62	29.21 ±3.14	30.49 ±0.67	38.06 ±5.86	32.73 ±4.07	33.28 ±3.12	32.85 ±9.79	33.57 ±4.74	32.40 ±2.77	33.50 ±4.70	0.148
4 days pm	24.78 ±6.40	26.32 ±2.41	25.97 ±4.45	22.92 ±2.67	22.67 ±1.47	27.02 ±4.17	25.27 ±5.42	28.00 ±5.40	28.45 ±5.51	27.75 ±3.95	24.13 ±4.36	27.06 ±2.91	0.379

Means in the same row with different superscripts are significantly different (p<0.05); WBSF– Warner Bratzler Shear Force

Table 4.59 Mean values and (± SD) for interaction effects of goat ecotype and sex on WBSF, sarcomere length and myofibril fragment length for *m. semimembranosus*

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-values
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
WBSF (kg)													
4 days pm	4.76	4.55	5.08	3.97	4.35	4.56	3.84	4.35	5.37	4.56	4.84	4.46	0.712
	±1.21	±1.27	±1.65	±0.87	±0.90	±1.18	±1.19	±1.34	±1.54	±0.46	±1.21	±1.51	
Sarcomere length (µm)													
1 day pm	1.96	2.00	1.91	1.97	1.89	1.93	1.94	1.99	1.96	1.91	1.95	1.98	0.799
	±0.07	±0.10	±0.09	±0.10	±0.07	±0.07	±0.10	±0.09	±0.07	±0.06	±0.11	±0.08	
Myofibril fragment length (µm)													
Post-mortem aging													
1 day pm	34.55	38.85	35.61	36.98	34.50	42.29	37.05	39.37	38.81	40.06	33.96	38.43	0.757
	±3.87	±4.98	±5.52	±8.24	±3.14	±4.35	±5.09	±8.21	±8.55	±8.91	±3.83	±3.93	
4 days pm	24.89	24.58	25.76	23.14	27.91	30.65	25.07	27.72	27.18	26.36	24.44	28.33	0.468
	±2.93	±1.91	±6.52	±2.66	±3.75	±2.30	±3.99	±6.67	±5.07	±4.66	±4.53	±4.85	

Means in the same row with different superscripts are significantly different (p<0.05); WBSF– Warner Bratzler Shear Force

The interaction effects of goat ecotype and sex on WBSF, sarcomere length and myofibril fragment length for the LD and SM muscles are presented in Tables 4.58 & 4.59. There were no interactions of goat ecotype and sex on WBSF and sarcomere length (both LD and SM; $p>0.05$) ranging between 2.87-3.83 kg, 1.86-1.96 µm **(**Table 4.58**)** and 3.84-5.37 kg, 1.89-2.00 µm **(**Table 4.59) respectively. There were no interactions effects ($p>0.05$) of goat ecotype and sex on MFL measured on 1 day and 4 days respectively. MFL shortened with post-mortem aging (29.21-38.06 µm to 22.67-28.45 µm) and (33.96-42.29 µm to 34.50-39.37) µm in LD and SM respectively ($p>0.05$) (Tables 4.58 & 4.59) and aging effect was significant (See results under 4.4.7 and Table 4.6).

4.4.5 The effects of goat ecotypes on WBSF, sarcomere length and myofibril fragment length

Table 4.60 Mean values and (± SD) for the effects of goat ecotypes on WBSF, sarcomere length and myofibril fragment length for *m. longissimus dorsi*

	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value ($p<F$)
WBSF (kg)							
4 days pm	3.18± 0.59	3.37± 1.08	3.22± 0.75	3.43± 0.90	3.65± 0.65	3.38± 0.80	0.843
Sarcomere length (µm)							
1 day pm	1.90± 0.06	1.90± 0.15	1.90± 0.12	1.91± 0.10	1.91± 0.04	1.88± 0.11	0.994
Myofibril fragment length (µm)							
Post-mortem aging							
1 day pm	32.94± 4.57	29.83± 3.32	33.64± 5.29	32.97± 3.47	33.16± 7.46	32.91± 3.66	0.327
4 days pm	25.34± 5.19	24.70± 3.98	24.48± 3.54	26.48± 5.26	28.18± 4.68	25.48± 3.92	0.483

Means in the same row with different superscripts are significantly different ($p<0.05$); WBSF– Warner Bratzler Shear Force

There were no goat ecotype differences ($p>0.05$) in LD WBSF, sarcomere length 3.18-3.65 kg and 1.88-1.91 µm respectively (Table 4.58). The goat ecotype did not differ ($p>0.05$)

in LD MFL with post-mortem aging but become shorter with post-mortem aging 29.83-33.64 µm to 24.48-28.18 µm (1 day to 4 days).

Table 4.61 Mean values and (± SD) for the effects of goat ecotypes and aging on WBSF, sarcomere length and myofibril fragment length for *m. semimembranosus*

	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
WBSF (kg)							
4 days pm	4.66± 1.17	4.62± 1.45	4.44± 0.98	4.07± 1.20	5.07± 1.26	4.67± 1.31	0.707
Sarcomere length (µm)							
1 day pm	1.97± 0.08	1.94± 0.09	1.90± 0.07	1.96± 0.09	1.94± 0.07	1.96± 0.10	0.486
Myofibril fragment length (µm)							
Post-mortem aging							
1 day pm	36.12± 4.60	36.19± 6.47	37.74± 5.33	38.08± 6.30	39.28± 8.06	36.02± 4.37	0.736
4 days pm	24.77± 2.51	24.67± 5.25	29.05± 3.40	26.25± 5.15	26.87± 4.59	26.23± 4.91	0.190

Means in the same row with different superscripts are significantly different (*P*<0.05); WBSF– Warner Bratzler Shear Force

Correspondingly, there were no goat ecotype differences (*p*>0.05) in SM WBSF and sarcomere length 4.07-5.07 kg and 1.90-1.97 µm respectively (Table 4.61). There were no goat ecotype differences (*p*>0.05) for MFL measured at 1 day and 4 days post-mortem but MFL became shorter from 1 day to 4 days post-mortem e.g. 36.02-39.28 µm to 24.67-29.05 µm respectively (Table 4.61) and from results reported below aging effect was significant in both muscles (See results under section 4.4.7 and Table 4.64).

4.4.6 The effects of sex on WBSF, sarcomere length and myofibril fragment length for *m. longissimus dorsi* and *m. semimembranosus*

Table 4.62 Mean values and (± SD) for the effects of sex on WBSF, sarcomere length and myofibril fragment length for *m. longissimus dorsi*

	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
WBSF			
4 days post-mortem	3.41 ± 0.79	3.28 ± 0.82	0.517
Sarcomere length (µm)			
1 day post-mortem	1.88 ± 0.09	1.92 ± 0.12	0.163
Myofibril fragment length (µm)			
1 day post-mortem	31.43^{a} ± 4.24	33.99^{b} ± 4.76	0.023
4 days post-mortem	25.04 ± 4.76	26.39 ± 3.71	0.209

Means in the same row with different superscripts are significantly different (*P*<0.05); WBSF–Warner Bratzler Shear Force

Table 4.63 Mean values and (± SD) for the effects of sex on WBSF, sarcomere length and myofibril fragment length for *m. semimembranosus*

	Sex		Significance
	Does	Bucks	*p*-value (*p*<F)
WBSF			
4 days post-mortem	4.71 ± 1.29	4.40 ± 1.11	0.352
Sarcomere length (µm)			
1 day post-mortem	1.93 ± 0.09	1.96 ± 0.08	0.145
Myofibril fragment length (µm)			
1 day post-mortem	35.52^{a} ± 4.97	39.27^{b} ± 6.01	0.010
4 days post-mortem	25.85 ± 4.48	26.93 ± 4.53	0.351

Means in the same row with different superscripts are significantly different (*P*<0.05); WBSF–Warner Bratzler Shear Force

The effects of sex on WBSF, sarcomere length and myofibril fragment length for the LD and SM muscles are presented in Tables 4.62 & 4.63. There were no sex and post-mortem

aging differences (p>0.05) in both muscles (LD and SM) WBSF and sarcomere length with mean values of (3.41 kg *vs* 3.28 kg and 1.88 µm *vs* 1.92 µm) and (4.71 kg vs 4.40 kg and 1.93 µm vs 1.96 µm) respectively. The MFL in LD of does was shorter to that of bucks at 1 day post-mortem (31.43 *vs* 33.99 µm; p<0.05) and decreased in length at 4 days post-mortem (p>0.05) in both sexes. In the SM, does similarly had shorter MFL than that of bucks (35.52 vs 39.27 µm; p<0.01). At 4 days post-mortem, there were no sex differences (p>0.05) for MFL but became shorter with post-mortem aging (Table 4.63).

4.4.7 The effects of post-mortem aging on water holding capacity and myofibril fragment length for *m. longissimus dorsi* and *m. semimembranosus*

Table 4.64 Mean values and (± SD) for the effects of post-mortem aging on water holding capacity and myofibril fragment length for *m. longissimus dorsi* and *m. semimembranosus*

Muscles		Post-mortem aging		Significance
		1 day pm	4 days pm	*p*-value (*p*<F)
Longissimus dorsi	WHC	0.39^{a}± 0.06	0.37^{b} ± 0.05	0.005
	MFL (µm)	32.51^{a}± 4.61	25.60^{b} ±4.38	<0.001
Semimembranosus	WHC	0.35 ± 0.05	0.34 ± 0.06	0.347
	MFL (µm)	37.07^{a} ± 5.69	26.30^{b} ± 4.50	<0.001

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of post-mortem aging on water holding capacity and myofibril fragment length for the LD and SM muscles are presented in Table 4.64. Post-mortem aging of LD in water holding capacity differed (p<0.01) and slightly dropped (0.022) from day 1 to 4 days post-mortem. Myofibril fragment length of LD samples became shorter (p<0.001) by 6.91 µm with post-mortem aging from 1 day to 4 days post-mortem (Table 4.64).

There were no differences (p>0.05) of post-mortem aging on water holding capacity in SM. However, water holding capacity dropped from day 1 to 4 days post-mortem (0.008 µm), slightly lower in comparison to LD. The MFL in SM became shorter (p<0.001) by 10.77 µm after post-mortem aging, indicative that SM was slightly tougher compared to LD (Table 4.64).

4.5 Calpain system measured in *m. longissimus dorsi* and *m. semimembranosus*

4.5.1 The effects of goat ecotypes, sex and their interaction on the calpain system in *m. longissimus dorsi* and *m. semimembranosus*

The *p*-values ($p<F$) of goat ecotypes, sex and their interactions on calpain systems for the LD and SM muscles are presented in Tables 4.65 & 4.66. The interactions of goat ecotype and sex had no effects ($p>0.05$) on LD extractable protein, activity of calpastatin inhibitor and specific calpastatin inhibitor (Table 4.65). There were no differences ($p>0.05$) for interaction effects of goat ecotype and sex on LD µ-calpain activity at 15 minutes and 24 hours post-mortem. However, at 1 hour post-mortem, LD of does from XL goats had a higher ($p<0.01$) µ-calpain activity than that recorded in bucks (1.24 U/g *vs* 1.06 U/g). On average, LD of does and bucks from SAB, NCS, VTV, VT and MBZ goats had similar activities of µ-calpain (Table 4.67). There was a decrease in µ-calpain activity that indicated that it was being used up and autolysed with time post-mortem. Interactions of goat ecotype and sex had no effects ($p>0.05$) in LD specific µ-calpain activity, m-calpain activity, calpastatin/µ-calpain ratio and calpastatin/µ+m-calpain ratio with time post-mortem (Table 4.65).

The interactions of goat ecotype and sex had no effects ($p>0.05$) in SM extractable protein at 15 minutes and 24 hours post-mortem (Table 4.66). At 1 hour post-mortem, SM of does from NCS, SAB and XL goats had higher ($p<0.01$) extractable protein than bucks (52.65 g *vs* 45.82 g), (55.10 g *vs* 49.99 g) and (55.37 g *vs* 47.17 g) respectively (Table 4.68). On average, SM of bucks and does from MBZ, VT and VTV goats had similar amount of extractable protein (Table 4.68). The interactions of goat ecotype and sex had no effects ($p>0.05$) on SM calpastatin inhibitor, specific calpastatin inhibitor, µ-calpain activity, specific µ-calpain activity, m-calpain activity, specific m-calpain activity, calpastatin/µ-calpain ratio and calpastatin/µ+m-calpain ratio with time post-mortem (Table 4.66).

Table 4.65 The p-values (p<F) of goat ecotypes, sex and their interactions on calpain systems of the *m. longissimus dorsi* at 15 minutes, 1 hour and 24 hours post-mortem

	Significance *p*-value (*p*<F)		
	Ecotype	Sex	Ecotype x sex
Extractable protein (gram)			
15 min pm	**0.001**	**0.002**	0.445
1 hr pm	**<0.001**	**<0.001**	0.650
24 hrs pm	**0.001**	**<0.001**	0.382
Calpastatin inhibitor (U/g)			
15 min pm	**0.058**	0.133	0.067
1 hr pm	0.167	0.152	0.153
24 hrs pm	0.349	**0.054**	0.527
Specific calpastatin inhibitor (U)			
15 min pm	0.624	0.098	0.275
1 hr pm	0.167	**0.015**	0.163
24 hrs pm	0.657	**0.009**	0.361
µ-calpain activity (U/g)			
15 min pm	0.078	0.281	0.071
1 hr pm	**0.001**	0.994	**0.011**
24 hrs pm	0.767	**0.026**	0.569
Specific µ-calpain activity (U)			
15 min pm	0.583	0.686	0.178
1 hr pm	0.605	**0.042**	0.499
24 hrs pm	**0.047**	**0.002**	0.741
m-calpain activity (U/g)			
15 min pm	0.065	**0.027**	0.714
1 hr pm	**0.025**	0.089	0.432
24 hrs pm	0.168	**0.058**	0.709
Specific m-calpain activity (U)			
15 min pm	0.803	**0.005**	0.790
1 hr pm	0.256	**<0.001**	0.645
24 hrs pm	0.592	**0.001**	0.772
Calpastatin/µ-calpain ratio			
15 min pm	0.227	0.076	0.636
1 hr pm	0.448	0.223	0.154
24 hrs pm	0.473	0.712	0.063
Calpastatin/µ+m-calpain ratio			
15 min pm	0.107	0.296	0.438
1 hr pm	0.165	0.264	0.099
24 hrs pm	0.144	0.235	0.080

Significant (p<0.05) interaction are indicated in bold

Table 4.66 The p-values (p<F) of ecotypes, sex and their interactions on calpain systems of the *m. semimembranosus* at 15 minutes 1 hour and 24 hours post-mortem

	Significance *p*-value (*p*<F)		
	Ecotype	Sex	Ecotype x sex
Extractable protein (gram)			
15 min pm	**0.001**	**<0.001**	0.063
1 hr pm	**<0.001**	**<0.001**	**0.013**
24 hrs pm	**0.001**	**<0.001**	0.131
Calpastatin inhibitor (U/g)			
15 min pm	**0.019**	0.383	0.991
1 hr pm	0.226	0.814	0.882
24 hrs pm	0.237	0.165	0.890
Specific calpastatin inhibitor (U)			
15 min pm	0.185	**0.012**	0.758
1 hr pm	0.119	0.219	0.141
24 hrs pm	0.224	**0.009**	0.965
µ-calpain activity (U/g)			
15 min pm	0.431	0.362	0.361
1 hr pm	0.147	0.300	0.393
24 hrs pm	0.210	0.529	0.468
Specific µ-calpain activity (U)			
15 min pm	0.385	0.110	0.681
1 hr pm	0.832	0.206	0.162
24 hrs pm	0.469	0.084	0.805
m-calpain activity (U/g)			
15 min pm	**0.020**	0.731	0.375
1 hr pm	**0.001**	0.888	0.085
24 hrs pm	**0.058**	0.781	0.736
Specific m-calpain activity (U)			
15 min pm	0.471	**0.004**	0.519
1 hr pm	0.548	**0.001**	0.332
24 hrs pm	0.428	**0.001**	0.637
Calpastatin/µ -calpain ratio			
15 min pm	**0.019**	0.098	0.699
1 hr pm	0.083	0.216	0.671
24 hrs pm	0.439	0.466	0.912
Calpastatin/µ+m-calpain ratio			
15 min pm	**0.031**	0.174	0.825
1 hr pm	0.187	0.316	0.667
24 hrs pm	0.146	0.101	0.729

Significant (p<0.05) interaction are indicated in bold

Table 4.67 Mean values and (± SD) for the interaction effects of goat ecotype and sex on calpain systems in the *m. longissimus dorsi* at 15 minutes 1 hour and 24 hours post-mortem

	Ecotype × Sex											
	MBZ		NCS		SAB		VT		VTV		XL	
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks
Extractable protein (gram)												
15 min pm	56.43±3.02	52.15±3.37	54.42±2.36	50.79±2.55	56.61±2.67	52.12±3.71	50.13±4.13	47.10±6.22	49.93±3.24	51.48±6.07	55.70±1.47	51.64±2.08
1 hr pm	58.20±1.90	52.19±3.40	56.63± 1.61	51.12 ±2.48	57.96 ±4.23	52.91±3.60	51.25±4.55	47.68±6.45	50.03±3.97	49.43±4.87	56.75±2.17	52.91±3.44
24 hrs pm	58.66±4.31	53.44±2.98	58.32± 2.95	54.55±2.45	60.61±3.61	53.64±4.55	54.49±5.98	46.35±5.83	51.83± 6.01	52.49± 7.29	58.62±2.48	53.33± 3.36
Calpastatin inhibitor (U/g)												
15 min pm	1.01±0.16	1.38±0.29	1.13±0.21	0.94±0.30	1.13±0.27	1.21±0.20	0.97±0.18	1.31±0.24	1.07±0.30	1.14±0.11	1.32±0.14	1.33±0.17
1 hr pm	0.93±0.12	1.12±0.20	1.01±0.14	0.79±0.11	0.89 ± 0.17	1.09±0.17	0.81±0.13	1.04±0.24	1.00±0.41	0.96±0.22	1.10±0.26	1.19±0.19
24 hrs pm	0.78±0.15	0.76±0.29	0.65±0.22	0.66±0.17	0.57 ± 0.21	0.88±0.10	0.68±0.23	0.88±0.33	0.69±0.19	0.81±0.13	0.83±0.27	0.89±0.297
Specific calpastatin inhibitor (U)												
15 min pm	0.018±0.003	0.024±0.005	0.021±0.005	0.018±0.005	0.020±0.005	0.022±0.005	0.020±0.005	0.026±0.009	0.022±0.007	0.022±0.004	0.024±0.003	0.026±0.004
1 hr pm	0.016±0.002	0.022±0.003	0.018±0.003	0.017±0.004	0.015±0.004	0.021±0.003	0.017±0.004	0.023±0.009	0.020±0.010	0.020±0.006	0.020±0.005	0.023±0.004
24 hrs pm	0.013±0.002	0.014±0.005	0.011±0.004	0.012±0.003	0.010±0.004	0.017±0.003	0.013±0.006	0.020±0.010	0.013±0.003	0.016±0.003	0.014±0.005	0.017±0.006
µ-calpain activity (U/g)												
15 min pm	1.12±1.00	1.22±0.17	1.18±0.16	1.06±0.09	1.27±0.15	1.07±0.13	1.04±0.17	1.21±0.29	0.99±0.11	0.99±0.08	1.26±0.14	1.13±0.23
1 hr pm	1.02^{cde}±0.08	1.15^{abc}±0.09	1.10^{abcd}±0.11	1.05^{abcd}±0.12	1.18^{ab}±0.13	1.01^{abcd}±.139	0.96^{de}±0.18	1.12^{abcd}±0.19	0.90^{e}±0.14	1.05^{bcde}±0.05	1.24^{a}±0.12	1.06^{bcde}±0.15
24 hrs pm	0.73±0.14	0.81± 0.24	0.869±0.16	0.73±0.13	0.74±0.16	0.75±0.11	0.73±0.19	0.83±0.26	0.79±0.20	0.86±0.13	0.65±0.15	0.91±0.07
Specific µ-calpain activity (U)												

15 min pm	0.020± 0.00	0.023±0.001	0.021±0.004	0.020±0.000	0.021±0.003	0.020±0.000	0.020±0.000	0.025±0.006	0.020±0.000	0.020±0.000	0.023±0.005	0.022±0.006
1 hr pm	0.019±0.004	0.020±0.000	0.020±0.000	0.020±0.000	0.020±0.000	0.020±0.000	0.019±0.004	0.023±0.005	0.018±0.004	0.020±0.008	0.020±0.000	0.022±0.004
24 hrs pm	0.015±0.003	0.018±0.002	0.014±0.003	0.019±0.004	0.012±0.004	0.014±0.005	0.018±0.005	0.018±0.005	0.014±0.005	0.020±0.000	0.013±0.005	0.020±0.001
m-calpain activity (U/g)												
15 min pm	0.77±0.07	0.82±0.06	0.80±0.06	0.89±0.10	0.86±0.10	0.85±0.09	0.79±0.10	0.85±0.06	0.70± 0.13	0.79±0.04	0.78±0.09	0.82±0.06
1 hr pm	0.78±0.07	0.81±0.01	0.81±0.11	0.89±0.10	0.88±0.10	0.87±0.10	0.76±0.05	0.86±0.08	0.71± 0.09	0.80±0.08	0.79±0.06	0.78±0.09
24 hrs pm	0.76±0.08	0.81±0.07	0.82±0.10	0.90±0.09	0.86±0.13	0.86±0.08	0.80±0.06	0.87±0.09	0.72±0.16	0.85±0.02	0.80±0.10	0.81±0.10
Specific m-calpain activity (U)												
15 min pm	0.014±0.002	0.016±0.002	0.015±0.001	0.018±0.003	0.015±0.002	0.016±0.002	0.016±0.002	0.019±0.004	0.014±0.004	0.016±0.003	0.014±0.002	0.016±0.002
1 hr pm	0.013±0.001	0.016±0.001	0.015±0.002	0.017±0.002	0.015±0.002	0.016±0.002	0.015±0.001	0.018±0.003	0.014±0.002	0.016±0.002	0.014±0.002	0.015±0.002
24 hrs pm	0.013±0.002	0.016±0.002	0.014±0.002	0.016±0.002	0.014±0.002	0.016±0.002	0.015±0.002	0.019±0.004	0.014±0.003	0.017±0.002	0.014±0.002	0.015±0.002
Calpastatin/μ-calpain ratio												
15 min pm	0.90± 0.12	1.04±0.16	1.04±0.16	0.96±0.20	0.88±0.24	1.06±0.11	096.±0.27	1.20±0.33	1.07±0.26	1.15±0.16	1.00±0.19	1.20±0.13
1 hr pm	0.92±0.09	0.98±0.11	0.93±0.18	0.82±0.15	0.76±0.17	0.98±0.06	0.93±0.24	0.97±0.40	1.08±0.37	0.91±091	0.88±0.19	1.13±0.20
24 hrs pm	1.06±0.13	0.96± 0.29	0.97±0.28	0.82±0.14	0.76±0.24	1.19±0.20	0.98±0.40	1.09±0.37	0.88±0.11	0.96±0.21	1.17±0.25	0.99±0.35
Calpastatin/μ+m-calpain ratio												
15 min pm	0.53 ± 0.08	0.62±0.10	0.57±0.12	0.48±0.15	0.53 ±0.13	0.59±0.06	0.54±0.14	0.58±0.16	0.63±0.12	0.64±0.07	0.61±0.10	0.69±0.06
1 hr pm	0.52±0.05	0.57±0.08	0.54±0.10	0.44±0.07	0.53 ±0.09	0.55±0.03	0.51±0.12	0.54±0.18	0.60±0.19	0.52±0.10	0.53±0.11	0.65±0.11
24 hrs pm	0.52±0.08	0.47±0.14	0.43±0.13	0.39±0.07	0.35±0.12	0.55±0.05	0.39±0.09	0.51±0.16	0.45±0.06	0.47±0.11	0.54±0.11	0.52±0.18

Means in the same row with different superscripts are significantly different ($p<0.05$)

Table 4.68 Mean values and (± SD) of interaction effects of goat ecotype and sex on calpain systems in the *m. semimembranosus* at 15 minutes, 1 hour and 24 hours post-mortem

	Ecotype × Sex											
	MBZ		NCS		SAB		VT		VTV		XL	
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks
Extractable protein (gram)												
Ecotype ×Sex × Time post-mortem												
15 min pm	52.76±3.54	49.61 ± 5.29	52.65±2.95	45.82±2.93	54.16±3.42	47.11±2.36	45.37±4.25	44.84±3.87	45.36±4.63	45.99±4.85	52.91±4.43	45.11±2.87
1 hr pm	54.65^{ab}±2.12	50.90^{bcd}±3.37	53.54^{abc}±1.76	45.31^{f}±1.38	55.10^{a}±2.26	49.99^{cde}±3.19	47.60^{def}±2.59	46.78^{ef}±4.10	47.51^{def}±5.87	47.81^{def}±4.68	55.37^{a}±3.50	47.17^{def}±2.71
24 hrs pm	56.93±3.32	51.92±3.14	59.61±2.81	49.93±3.78	58.93±4.24	54.33±5.00	50.95 ±2.27	47.67±3.80	51.00±3.95	49.48±2.63	57.39±3.73	48.75±4.52
Calpastatin inhibitor (U/g)												
Ecotype × Sex × Time post-mortem												
15 min pm	1.17± 0.16	1.25±0.34	1.03±0.22	1.04±0.26	1.33±0.16	1.35±0.06	1.13±0.22	1.26±0.11	1.02±0.20	1.07±0.15	1.18±0.22	1.21 ±0.38
1 hr pm	1.10±0.27	1.11±0.21	1.00±0.19	0.93±0.18	1.17±0.19	1.16±0.18	0.96±0.16	1.14±0.04	0.98±0.24	1.02±0.10	1.12± 0.23	1.11±0.26
24 hrs pm	0.89±0.19	0.94±0.12	0.74±0.18	0.79±0.23	0.78±0.18	0.95±0.15	0.79±0.24	0.80±0.10	0.91±0.24	1.14±0.46	0.77±0.26	0.79±0.36
Specific calpastatin inhibitor (U)												
Ecotype × Sex× Time post-mortem												
15 min pm	0.022±0.004	0.025±0.004	0.020±0.004	0.023±0.006	0.025±0.003	0.029±0.002	0.025±0.004	0.028±0.004	0.023±0.006	0.024 ± 0.005	0.022± 0.004	0.027±0.008
1 hr pm	0.020±0.006	0.022±0.003	0.019±0.003	0.021±0.004	0.021±0.004	0.024±0.005	0.020±0.003	0.027±0.006	0.021±0.006	0.022 ± 0.003	0.020±0.004	0.024±0.006
24 hrs pm	0.016±0.004	0.018±0.002	0.012±0.003	0.016±0.005	0.013±0.004	0.018±0.004	0.015±0.004	0.017±0.002	0.018±0.005	0.023±0.009	0.013± 0.005	0.017±008
μ-calpain activity (U/g)												
Ecotype × Sex × Time post-mortem												
15 min pm	1.15±0.15	1.22±0.16	1.12±0.10	1.15±0.10	1.21±0.20	1.08±0.14	1.03±0.25	1.09±0.27	1.05±0.06	1.02±0.09	1.21± 0.12	1.02±0.24
1 hr pm	1.11±0.16	1.12±0.13	1.08±0.10	1.08±0.11	1.13±0.03	1.00± 0.08	0.91±0.08	1.01± 0.28	1.02±0.07	1.01±0.07	1.15±0.12	1.02±0.15
24 hrs pm	0.85±0.15	0.91±0.12	0.81±0.16	0.94±0.19	0.94±0.12	0.91±0.16	0.79±0.09	0.76±0.12	0.89±0.02	1.00±0.19	0.89±0.17	0.81± 0.12

Specific μ-calpain activity (U)												
Ecotype × Sex × Time post-mortem												
15 min pm	0.022±0.003	0.025±0.001	0.021±0.002	0.025±0.003	0.022±0.003	0.023±0.003	0.022±0.004	0.0243±0.006	0.023±0.003	0.022±0.003	0.023±0.002	0.023±0.005
1 hr pm	0.020±0.003	0.022±0.002	0.020±0.002	0.024±0.003	0.020±0.004	0.020±0.002	0.019±0.002	0.022±0.005	0.022±0.003	0.021 ± 0.001	0.021±0.002	0.022±0.003
24 hrs pm	0.015±0.003	0.018±0.002	0.014±0.003	0.019±0.004	0.015±0.003	0.017±0.003	0.015±0.001	0.016 ±0.003	0.018±0.001	0.020 ± 0.003	0.015±0.003	0.017±0.003
m-calpain activity (U/g)												
Ecotype × Sex × Time post-mortem												
15 min pm	0.78±0.09	0.83±0.04	0.79±0.06	0.82± 0.06	0.86±0.09	0.84±0.07	0.80±0.05	0.81±0.06	0.73±0.09	0.79±0.07	0.79±0.09	0.73±0.07
1 hr pm	0.80±0.07	0.82±0.03	0.813±0.11	0.84±0.05	0.91±0.07	0.80±0.05	0.77±0.04	0.82±0.04	0.70±0.09	0.78±0.06	0.78±0.09	0.77±0.05
24 hrs pm	0.83±0.11	0.87±0.02	0.87±0.08	0.91±0.08	0.84±0.07	0.83±0.06	0.80±0.08	0.80±0.10	0.76±0.16	0.81±0.07	0.82±0.09	0.77±0.08
Specific m-calpain activity (U)												
Ecotype × Sex × Time post-mortem												
15 min pm	0.015±0.002	0.017±0.001	0.015±0.002	0.018±0.001	0.016±0.001	0.018±0.002	0.018±0.001	0.018±0.001	0.016±0.003	0.017±0.001	0.015±0.002	0.016±0.001
1 hr pm	0.015±0.002	0.016±0.001	0.015±0.002	0.018±0.002	0.017±0.001	0.016±0.002	0.016±0.002	0.018±0.002	0.015±0.003	0.016±0.001	0.014±0.002	0.016±0.001
24 hrs pm	0.014±0.002	0.017±0.001	0.015±0.001	0.018±0.002	0.014±0.002	0.015±0.002	0.016±0.002	0.017±0.002	0.015±0.003	0.016±0.001	0.014±0.002	0.016±0.002
Calpastatin/μ-calpain												
Ecotype × Sex × Time post-mortem												
15 min pm	1.03±0.18	1.02± 0.15	0.93 ±0.22	0.90±0.19	1.12±0.16	1.27±0.16	1.11±0.09	1.19±0.24	0.98±0.22	1.06±0.24	0.99±0.21	1.18± 0.21
1 hr pm	0.99±0.23	0.99±0.12	0.93 ±0.19	0.86±0.12	1.05±0.22	1.17±0.19	1.06±0.17	1.29±0.31	0.97±0.27	1.02±0.13	0.99±0.22	1.10±0.20
24 hrs pm	1.04±0.17	1.05± 0.19	0.92±0.19	0.834±0.16	0.92±0.29	1.06±0.23	0.99±0.20	1.06±0.12	1.02±0.28	1.11±0.23	0.88±0.27	0.94±0.35
Calpastatin/μ+m-calpain												
Ecotype × Sex × Time post-mortem												
15 min pm	0.61± 0.10	0.60 ± 0.11	0.54±0.11	0.53± 0.13	0.65 ±0.09	0.71±0.06	0.62±0.05	0.67±0.08	0.57± 0.11	0.60±0.13	0.60± 0.12	0.68±0.12
1 hr pm	0.57±0.12	0.57 ±0.09	0.53±0.10	0.48±0.09	0.58±0.11	0.64±0.10	0.57±0.10	0.69±0.11	0.57 ± 0.14	0.58±0.06	0.58± 0.12	0.62±0.11
24 hrs pm	0.53±0.09	0.53±0.08	0.44±0.08	0.43± 0.10	0.46±0.11	0.55±0.11	0.50 ±0.14	0.51 ±0.02	0.54± 0.12	0.62±0.18	0.45±0.13	0.56±0.12

Means in the same row with different superscripts are significantly different ($p<0.05$)

Table 4.69 Mean values and (± SD) for the effects of goat ecotype on calpain systems for the *m. longissimus dorsi*

	Ecotype					
	MBZ	NCS	SAB	VT	VTV	XL
Extractable protein (gram)						
15 min pm	54.87^{a}± 3.68	52.91^{a}± 2.98	54.74^{a}± 3.77	48.78^{c}± 5.06	50.51^{bc}±4.14	53.82^{a}± 2.71
1 hr pm	56.01^{a}± 3.85	54.33^{a}± 3.42	55.86^{a}± 4.61	49.66^{b}±5.43	49.81^{b}± 3.98	54.98^{a}± 3.36
24 hrs pm	56.76^{a}± 4.56	56.75^{a}± 3.27	57.71^{a}± 5.24	50.87^{b}± 7.00	52.08^{b}± 5.99	56.18^{a}± 3.91
Calpastatin inhibitor (U/g)						
15 min pm	1.12^{a}±0.26	1.05^{b}±0.26	1.16^{ab}±0.24	1.10^{b}±0.26	1.09^{b}±0.23	1.33^{a}±0.15
1 hr pm	1.00±0.17	0.93±0.16	0.97±0.19	0.92±0.21	0.98±0.34	1.14±0.22
24 hrs pm	0.77±0.20	0.66±0.19	0.70±0.24	0.77±0.28	0.74±0.17	0.86±0.27
Specific calpastatin inhibitor (U)						
15 min pm	0.020±0.005	0.020±0.005	0.021±0.005	0.022±0.007	0.022±0.006	0.025±0.003
1 hr pm	0.018±0.004	0.018±0.003	0.018±0.004	0.020±0.007	0.020±0.008	0.021±0.005
24 hrs pm	0.014±0.003	0.012±0.003	0.013±0.005	0.016±0.008	0.014±0.003	0.015±0.005
µ-calpain activity (U/g)						
15 min pm	1.16±0.13	1.13±0.14	1.19±0.17	1.11±0.24	0.99±0.09	1.20±0.19
1 hr pm	1.06^{abc}±0.10	1.08^{ab}±0.12	1.15^{a}±0.13	1.03^{bc}±0.19	0.96^{c}±0.14	1.16^{a}±0.16
24 hrs pm	0.76±0.18	0.70±0.15	0.74±0.13	0.77±0.21	0.82±0.18	0.78±0.17
Specific µ-calpain activity (U)						
15 min pm	0.021±0.002	0.021±0.003	0.022±0.002	0.023±0.005	0.020±0.003	0.022±0.004
1 hr pm	0.019±0.003	0.020±0.003	0.021±0.002	0.021±0.004	0.019±0.003	0.021±0.003
24 hrs pm	0.014^{ab}±0.003	0.013^{b}±0.003	0.013^{b}±0.002	0.016^{a}±0.005	0.016^{a}±0.003	0.014^{ab}±0.004
m-calpain activity (U/g)						
15 min pm	0.79± 0.07	0.83±0.09	0.85±0.10	0.82±0.09	0.74±0.11	0.80±0.07
1 hr pm	0.79^{bc}±0.05	0.85^{ab}±0.11	0.87^{a}±0.10	0.81^{abc}±0.08	0.74^{c}±0.09	0.79^{bc}±0.08
24 hrs pm	0.78±0.08	0.86±0.10	0.86±0.11	0.829±0.08	0.77±0.14	0.80±0.09
Specific m-calpain activity (U)						
15 min pm	0.015±0.002	0.016±0.003	0.016±0.002	0.017±0.003	0.015±0.003	0.015±0.002
1 hr pm	0.014 ±0.002	0.016±0.002	0.016 ±0.002	0.016±0.003	0.015±0.002	0.015±0.002
24 hrs pm	0.014±0.002	0.015±0.002	0.015±0.002	0.017±0.004	0.015±0.003	0.014±0.002
Calpastatin/µ-calpain ratio						
15 min pm	0.95±0.15	0.93±0.21	0.96±0.19	0.98±0.28	1.11±0.23	1.09±0.19
1 hr pm	0.94±0.10	0.89±0.17	0.85±0.19	0.95±0.30	1.02±0.31	1.00±0.23
24 hrs pm	1.03±0.20	0.91±0.24	0.94±0.31	1.03±0.37	0.91±0.15	1.09±0.30
Calpastatin/µ+m-calpain ratio						
15 min pm	0.56±0.09	0.54±0.13	0.56±0.11	0.56±0.14	0.63±0.10	0.65±0.09
1 hr pm	0.54±0.07	0.50±0.10	0.48±0.09	0.52±0.14	0.57±0.16	0.59±0.11
24 hrs pm	0.50±0.10	0.41±0.11	0.43±0.14	0.45±0.14	0.46±0.07	0.53±0.14

Means in the same row with different superscripts are significantly different (p<0.05)

4.5.2 The effects of goat ecotypes on calpain systems in the *m. longissimus dorsi* and *m. semimembranosus*

The effects of goat ecotypes on calpain systems for the LD are presented in Table 4.69. The interaction effects of goat ecotype and sex in LD extractable protein are presented in Table 4.69. At 15 minutes post-mortem, LD of MBZ, NCS, SAB, XL goats had higher (p<0.001) extractable gram protein (54.87g, 52.91 g, 54.74 g and 53.82 g respectively) than that recorded in LD of VT and VTV goats (48.78 g and 50.51 g) respectively. The LD of MBZ, NCS, SAB and XL goats had higher (p<0.001) extractable protein (56.01 g, 54.33 g, 55.86 g and 54.98 g) than that recorded in LD of VT and VTV goats (49.66 g, 49.81 g) at 1 hour post-mortem respectively (Table 4.69). Equally at 24 hours post-mortem, LD of MBZ, NCS, SAB and XL goats had higher (p<0.001) extractable protein (56.76 g, 56.75 g, 57.71 g and 56.18 g), than that recorded in LD of VT and VTV goats (50.87 g, 52.08 g) at 1 hour and 24 hours post-mortem respectively (Table 4.69). Overall the extractable protein increased by the range of 3.3-6.8% (Table 4.69).

There were goat ecotype differences (p<0.05) in LD calpastatin inhibitor at 15 minutes post-mortem, but not at 1 hour and 24 hours post-mortem (Table 4.65). The LD of MBZ and XL goats had higher (p<0.05) activity of calpastatin inhibitor (1.12 and 1.33 U/g) than that recorded in LD of NCS, VT, VTV goats (~1.1 U/g). On average, LD of SAB goats did not differ in calpastatin inhibitor from the rest of goat ecotypes (Table 4.69). Overall mean of calpastatin activity decreased with time post-mortem with about (29.8-39.7%). There were no goat ecotype differences (p>0.05) in LD specific calpastatin inhibitor with time post-mortem (Table 4.69).

There were no ecotype differences (p>0.05) in LD µ-calpain activity at 15 minutes and 24 hours post-mortem but differences (p<0.001) were observed at 1 hour post-mortem (Table 4.65). The LD of SAB and XL goats had higher (p<0.001) µ-calpain activity (~1.2 U/g) than that recorded in LD of VTV and VT goats (1.00 U/g) 1.03 U/g). On average, LD of MBZ goats did not differ from the rest of goat ecotypes in terms of µ-calpain activity. There were no goat ecotype differences in LD µ-calpain at 15 minutes and 24 hours post-mortem (Table 4.65). Activities of µ-calpain in LD of goat ecotypes decreased with time post-mortem by about 17.5-37.8% (Table 4.69).

There were no goat ecotype differences (p>0.05) in specific µ-calpain activity at 15 minutes and 1 hour post-mortem (Table 4.65). The LD of VT and VTV goats had higher (p<0.05) specific µ-calpain activity (0.016 U) than that recorded in LD of SAB and NCS goats (0.013 U). On average, LD of XL and MBZ goats did not in specific µ-calpain activity (0.014 U) and were similar to the rest of the goat ecotypes (Table 4.69). There were no goat ecotype differences (p>0.05) in m-calpain activity at 15 minutes and 24 hours post-mortem (Table 4.65). At 1 hour post-mortem, LD of SAB goats had a higher (p<0.05) m-calpain activity (0.87 U/g) than that recorded in VTV goats (0.87 U/g), MBZ and XL goats (0.79 U/g) (Table 4.69). The LD of VT goats did not differ from the rest of goat ecotypes in terms of m-calpain activity and NCS only differed from SAB goats. There were no goat ecotypes in LD specific m-calpain, calpastatin/µ-calpain and calpastatin/µ+m-calpain ratio Table 4.65.

The effects of goat ecotypes on calpain systems for the SM are presented in Table 4.70. The interaction effects of goat ecotypes in SM extractable protein are present in Table 4.70. At 15 minutes post-mortem, SM of MBZ, SAB, NCS and XL goats had higher (p<0.001) extractable protein (51.62 g, 51.22 g, 49.81 g and 49.32 g respectively) than that recorded in SM of VT and VTV goats (~45.5 g). At 1 hour post-mortem, SM of MBZ and SAB goats had higher (p<0.001) extractable protein (53.28 g and 52.97 g) than that recorded in SM of VTV goats (47.24 g). On the other hand, the SM of NCS, VTV and XL goats were similar on average with extractable protein. At 24 hours post-mortem, SM of SAB goats had a higher (p<0.001) extractable gram protein (57.01 g), followed by MBZ and NCS goats (~55.3 g) than that recorded in SM of VT and VTV goats (~50.0 g). On average, MBZ and NCS goats were similar and did not differ from XL goats (53.40 g) Table 4.70. Unlike the extractable protein in LD of goat ecotypes, SM increased more by about 6.3-10.2%.

There were goat ecotype differences (p<0.01) in SM calpastatin activity at 15 minutes post-mortem, but not at 1 hour and 24 hours post-mortem (Table 4.66). The SM of SAB goats had a higher (p<0.01) calpastatin inhibitor (1.34 U/g) than that recorded in SM of NCS and VTV goats (1.03 and 1.04 U/g). Nonetheless those goat ecotypes did not differ on average from SM of MBZ, VT and XL goats (Tables 4.66 & 4.70). There were no goat ecotype differences (p>0.05) in SM activity of specific calpastatin inhibitor, µ-calpain activity and specific µ-calpain (Table 4.66). However, in comparison with LD goat ecotypes µ-calpain had decreased by 10–26% with time post-mortem (Table 4.70).

Table 4.70 Mean values and (± SD) for the effects of goat ecotype on calpain systems for the *m. semimembranosus*

	Ecotype × Sex					
	MBZ	NCS	SAB	VT	VTV	XL
Extractable protein (gram)						
15 min pm	51.62^{a}± 4.29	49.81^{a}± 4.50	51.22^{a}±4.64	45.13^{b}±3.84	45.60^{b}±4.37	49.32^{a}±5.44
1 hr pm	53.28^{a}± 3.11	50.11^{bc}±4.51	52.97^{a}±3.66	47.24^{d}±3.14	47.62^{cd}±5.10	51.58^{ab}±5.22
24 hrs pm	55.11^{ab}±4.00	55.58^{ab}±5.86	57.01^{a}±4.95	49.49^{c}±3.31	50.43^{c}± 3.39	53.40^{b}± 5.97
Calpastatin inhibitor (U/g)						
15 min pm	1.20^{ab}±0.23	1.03^{b}±0.23	1.34^{a}±0.13	1.19^{ab}±0.18	1.04^{b}±0.17	1.20^{ab}±0.29
1 hr pm	1.10± 0.24	0.97±0.18	1.16±0.18	1.03±0.15	1.00±0.19	1.12±0.23
24 hrs pm	0.91±0.16	0.76±0.19	0.85±0.18	0.79±0.18	1.00±0.33	0.78± 0.30
Specific calpastatin inhibitor (U)						
15 min pm	0.023±0.004	0.021±0.005	0.026±0.004	0.027±0.004	0.023±0.005	0.024±0.006
1 hr pm	0.021±0.005	0.020±0.004	0.022±0.004	0.023±0.005	0.021±0.005	0.022±0.005
24 hrs pm	0.017±0.003	0.014±0.004	0.015±0.004	0.016±0.003	0.020±0.007	0.015±0.007
µ-calpain activity (U/g)						
15 min pm	1.18±0.15	1.13±0.10	1.15±0.18	1.06±0.24	1.04±0.07	1.12±0.20
1 hr pm	1.12± 0.14	1.08±0.10	1.08±0.17	0.96±0.19	1.02±0.07	1.10±0.14
24 hrs pm	0.87±0.13	0.87±0.18	0.93±0.13	0.78±0.10	0.93±0.12	0.85±0.15
Specific µ-calpain activity (U)						
15 min pm	0.023±0.003	0.023±0.003	0.023±0.003	0.023±0.004	0.023±0.002	0.023±0.003
1 hr pm	0.021±0.003	0.022±0.003	0.020±0.003	0.020±0.004	0.021±0.002	0.021±0.003
24 hrs pm	0.016±0.003	0.016±0.004	0.016±0.003	0.016±0.002	0.019±0.002	0.016±0.003
m-calpain activity (U/g)						
15 min pm	0.80^{ab}±0.08	0.80^{ab}±0.06	0.85^{a}±0.08	0.80^{ab}±0.05	0.75^{b}±0.08	0.76^{b}±0.08
1 hr pm	0.81^{b}±0.06	0.82^{ab}±0.09	0.87^{a}±0.08	0.79^{b}±0.04	0.73^{c}±0.09	0.77^{bc}±0.07
24 hrs pm	0.84^{ab}±0.09	0.89^{a}±0.07	0.84^{ab}±0.06	0.80^{b}±0.08	0.78^{b}±0.13	0.79^{b}±0.09
Specific m-calpain activity (U)						
15 min pm	0.016±0.002	0.016±0.002	0.017±0.002	0.018±0.001	0.017±0.002	0.015±0.002
1 hr pm	0.015±0.002	0.017±0.002	0.016±0.001	0.017±0.002	0.016±0.002	0.015±0.002
24 hrs pm	0.015±0.002	0.016±0.002	0.015±0.002	0.016±0.002	0.016±0.002	0.015±0.002
Calpastatin/µ -calpain ratio						
15 min pm	1.02^{abc}±0.16	0.92^{c}±0.20	1.18^{a}±0.17	1.15^{ab}±0.16	1.01^{bc}±0.21	1.08^{abc}±0.22
1 hr pm	0.99 ±0.19	0.90±0.16	1.10±0.21	1.16±0.26	0.99±0.22	1.03±0.21
24 hrs pm	1.05± 0.17	0.89±0.17	0.98±0.26	1.02±0.17	1.06±0.25	0.91±0.30
Calpastatin/µ+m-calpain ratio						
15 min pm	0.61^{abc}±0.10	0.54^{c}±0.11	0.67^{a}±0.08	0.64^{bc}±0.06	0.58^{ab}±0.11	0.65^{bc}±0.12
1 hr pm	0.57± 0.10	0.51±0.10	0.61± 0.11	0.62±0.12	0.57±0.11	0.60±0.11
24 hrs pm	0.53 ±0.08	0.43±0.09	0.50±0.12	0.50±0.10	0.57±0.14	0.50±0.14

Means in the same row with different superscripts are significantly different (p<0.05)

At 15 minutes post-mortem, SM of SAB goats had a higher (p<0.05) m-calpain activity (0.85 U/g) than that recorded in SM of VTV and XL goats (0.75 U/g and 0.76 U/g) respectively. On the other hand, SM of MBZ, NCS, and VT goats did not differ in m-calpain activity and on average were similar the rest of ecotypes (Table 4.70). At 1 hour post-mortem, SM of SAB goats had a higher (p<0.001) m-calpain activity (0.87 U/g) than that recorded in SM of VTV and XL goats (0.73 U/g and 0.77 U/g) respectively. The SM of MBZ and VT goats did not differ in m-calpain activity, but on average were similar to NCS goats and XL goats. At 24 hours post-mortem, SM of NCS goats had a higher (p<0.05) m-calpain activity (0.89 U/g) than that recorded in SM of VTV, VT and XL goats (~0.79 U/g). On the other hand, none of those goat ecotypes differed from MBZ and SAB goats (about 0.84 U/g). There were no goat ecotype differences (p>0.05) in SM specific m-calpain activity with time post-mortem (Table 4.66).

4.5.3 The effects of sex on calpain systems in the *m. longissimus dorsi* and *m. semimembranosus*

The effects of sex on the calpain system for the LD are presented in Table 4.71. Unlike the LD of goat ecotype, differences of goat ecotypes were recorded in SM calpastatin/µ-calpain and calpastatin/µ+m-calpain ratio at 15 minutes post-mortem (Table 4.66). The SM of SAB goats had higher (p<0.01) calpastatin/µ-calpain ratio (1.18), followed by VT goats (1.18) than that recorded in SM of NCS and VTV goats (0.92 and 1.01). The MBZ and XL goats did not differ in calpastatin/µ-calpain and were similar on average to the rest of the goat ecotypes (Table 4.70). Thereafter, goat ecotypes did not differ (p>0.05) in SM calpastatin/µ-calpain ratio (p>0.05) at 1 hour and 24 hours post-mortem.

The SM of SAB goats had higher calpastatin/µ+m-calpain ratio (0.67) than that recorded in SM of NCS goats (0.54). The SM of VT and XL did not differ in calpastatin/µ+m-calpain ratio, but were on average similar to the rest of the goat ecotypes (Table 4.70). From 1 hour to 24 hours post-mortem, calpastatin/µm-calpain ratio decreased by ~12.7–26.3% with time post-mortem, except in SM of VTV goats that slightly dropped by 1.4% lower than those recorded in LD (Table 4.70).

Table 4.71 Mean values and (± SD) for the effects of sex on calpain system for the *m. longissimus dorsi*

	Sex	
	Does	Bucks
Extractable protein (gram)		
15 min pm	54.27[a] ± 3.75	50.96[b] ± 3.93
1 hr pm	55.61[a] ± 4.26	51.310[b] ± 4.101
24 hrs pm	57.50[a] ± 4.83	52.50[b] ± 4.74
Calpastatin inhibitor (U/g)		
15 min pm	1.11 ± 0.228	1.21 ± 0.26
1 hr pm	0.97 ± 0.224	1.05 ± 0.21
24 hrs pm	0.70[a] ± 0.218	0.82[b] ± 0.23
Specific calpastatin inhibitor (U)		
15 min pm	0.020 ± 0.005	0.023 ± 0.006
1 hr pm	0.018[a] ± 0.005	0.021[b] ± 0.005
24 hrs pm	0.012[a] ± 0.005	0.016[b] ± 0.006
µ-calpain activity (U/g)		
15 min pm	1.16 ± 0.17	1.12 ± 0.18
1 hr pm	1.08 ± 0.17	1.09 ± 0.13
24 hrs pm	0.72[a] ± 0.16	0.82[b] ± 0.16
Specific µ-calpain activity (U)		
15 min pm	0.021 ± 0.003	0.021 ± 0.004
1 hr pm	0.019[a] ± 0.003	0.021[b] ± 0.003
24 hrs pm	0.014[a] ± 0.004	0.017[b] ± 0.005
m-calpain activity (U/g)		
15 min pm	0.79[a] ± 0.10	0.84[b] ± 0.07
1 hr pm	0.80 ± 0.09	0.83 ± 0.09
24 hrs pm	0.80[a] ± 0.11	0.85[b] ± 0.08
Specific m-calpain activity (U)		
15 min pm	0.013[a] ± 0.005	0.017[b] ± 0.004
1 hr pm	0.013[a] ± 0.005	0.018[b] ± 0.004
24 hrs pm	0.013[a] ± 0.005	0.017[b] ± 0.005
Calpastatin/µ -calpain ratio		
15 min pm	0.96 ± 0.201	1.06 ± 0.21
1 hr pm	0.91 ± 0.22	0.98 ± 0.21
24 hrs pm	0.97 ± 0.27	1.00 ± 0.28
Calpastatin/µ+m-calpain ratio		
15 min pm	0.57 ± 0.11	0.60 ± 0.12
1 hr pm	0.52 ± 0.112	0.55 ± 0.11
24 hrs pm	0.45 ± 0.12	0.49 ± 0.13

Means in the same row with different superscripts are significantly different (p<0.05)

There were significant effects of sex in LD extractable protein with time post-mortem (Table 4.65). The LD of does had higher (p<0.01) extractable protein than the LD of bucks (54.27 g *vs* 50.96 g) (55.61 g *vs* 51.31 g) and (57.50 g *vs* 52.50 g) at 15 minutes, 1 hour and 24 hours post-mortem respectively (Tables 4.65 & 4.71). The were no sex effects in LD calpastatin inhibitor at 15 minutes and 1 hour post-mortem, but rather at 24 hours post-mortem where differences were observed (Table 4.65). The LD of bucks had higher (p<0.05) activity of calpastatin inhibitor than that recorded in LD of does (0.82 U/g *vs* 0.70 U/g). There were no sex effects in LD specific calpastatin inhibitor at 15 minutes post-mortem, but differences were observed at 1 hour and 24 hours post-mortem. The LD of bucks had higher (p<0.01) specific calpastatin inhibitor (0.021 U *vs* 0.018 U) and (0.016 U *vs* 0.012 U) at 1 hour and 24 hours post-mortem respectively (Tables 4.65 & 4.71).

The effects of sex on µ-calpain activity did not differ (p>0.05) at 15 minutes and 1 hour post-mortem (Table 4.65). At 24 hours post-mortem, LD of bucks had higher (p<0.01) µ-calpain activity than LD does (0.82 U/g *vs* 0.72 U/g). There were no sex differences (p>0.05) in LD specific µ-calpain activity at 15 minutes post-mortem. At 1 hour and 24 hours post-mortem, sex had an effect on specific µ-calpain activity (Table 4.65). The LD of bucks had higher (p<0.05) specific µ-calpain activity than that recorded in LD of does (0.021 U/g *vs* 0.019 U/g) at 1 hour post-mortem (Table 4.71). The LD of bucks continued to have higher (p<0.01) specific µ-calpain (0.017 U *vs* 0.014 U) at 24 hours post-mortem.

The LD of bucks had a higher (p<0.05) m-calpain activity than that recorded in LD of does (0.84 U/g *vs* 0.79 U/g) and (0.85 U/g vs 0.80 U/g) at 15 minutes and 24 hours post-mortem respectively (Table 4.71). There were sex differences (p<0.05) in LD specific m-calpain activity with time post-mortem (Table 4.65). The LD of bucks had a higher (p<0.05) specific m-calpain activity than that recorded in does (0.017 U *vs* 0.013 U) at 15 minutes, 1 hour and 24 hours post-mortem. There were no sex differences (p>0.05) in calpastatin/µ-calpain and calpastatin/µ+m-calpain with time post-mortem.

Table 4.72 Mean values and (± SD) for the sex on calpain systems for the *m. semimembranosus*

	Sex	
	Does	Bucks
Extractable protein (gram)		
15 min pm	51.08[a] ± 5.00	46.34[b] ± 3.61
1 hr pm	52.79[a] ± 4.35	47.91[b] ± 3.467
24 hrs pm	56.31[a] ± 4.67	50.39[b] ± 4.31
Calpastatin inhibitor (U/g)		
15 min pm	1.15 ± 0.214	1.202 ± 0.258
1 hr pm	1.06 ± 0.216	1.078 ± 0.192
24 hrs pm	0.81 ± 0.209	0.883 ± 0.263
Specific calpastatin inhibitor (U)		
15 min pm	0.023[a] ± 0.006	0.027[b] ± 0.006
1 hr pm	0.021 ± 0.005	0.022 ± 0.006
24 hrs pm	0.014[a] ± 0.005	0.018[b] ± 0.006
µ-calpain activity (U/g)		
15 min pm	1.14 ± 0.16	1.10 ± 0.18
1 hr pm	1.08 ± 0.15	1.04 ± 0.14
24 hrs pm	0.86 ± 0.14	0.88 ± 0.15
Specific µ-calpain activity (U)		
15 min pm	0.022 ± 0.004	0.024 ± 0.005
1 hr pm	0.021 ± 0.002	0.021 ± 0.004
24 hrs pm	0.017 ± 0.005	0.019 ± 0.004
m-calpain activity (U/g)		
15 min pm	0.79 ± 0.08	0.800 ± 0.06
1 hr pm	0.80 ± 0.09	0.804 ± 0.04
24 hrs pm	0.82 ± 0.09	0.829 ± 0.08
Specific m-calpain activity (U)		
15 min pm	0.016[a] ± 0.005	0.019[b] ± 0.003
1 hr pm	0.016[a] ± 0.005	0.020[b] ± 0.002
24 hrs pm	0.014[a] ± 0.005	0.018[b] ± 0.004
Calpastatin/µ-calpain ratio		
15 min pm	1.02 ± 0.189	1.101 ± 0.22
1 hr pm	0.99 ± 0.21	1.067 ± 0.22
24 hrs pm	0.96 ± 0.223	0.99 ± 0.23
Calpastatin/µ+m-calpain ratio		
15 min pm	0.60 ± 0.10	0.64 ± 0.12
1 hr pm	0.57 ± 0.101	0.60 ± 0.11
24 hrs pm	0.48 ± 0.11	0.53 ± 0.11

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of sex on the calpain system for the SM are presented in Table 4.72. The does had higher extractable protein (p<0.001) than that recorded in SM of bucks (51.08 g *vs* 46.34 g), (52.79 g *vs* 47.91 g) and (56.31 g *vs* 50.39 g) at 15 minutes, 1 hour and 24 hours post-mortem respectively (Table 4.72). The sex differences observed was a result of the interaction effect of bucks and does from NCS, SAB and XL, overall there would have been no differences (Table 4.68).

There were no sex differences (p>0.05) in calpastatin inhibitor with time post-mortem (Table 4.66). There were sex effects (p<0.01) in SM specific calpastatin inhibitor at 15 minutes and 24 hours post-mortem but no differences were observed at 1 hour post-mortem. The SM of bucks had higher (p<0.01) specific calpastatin inhibitor (0.027 U *vs* 0.023 U) and (0.018 U *vs* 0.014 U) at 15 minutes and 24 hours post-mortem (Table 4.72).

There were no sex effects (p>0.05) in SM µ-calpain activity, specific µ-calpain activity and m-calpain activity with time post-mortem (Table 4.66). The SM of bucks had higher (p<0.01) specific m-calpain activity than that recorded in SM of does (0.019 U *vs* 0.016 U), (0.020 U *vs* 0.016 U) and (0.018 U *vs* 0.014 U) respectively at 15 minutes, 1 hour and 24 hours post-mortem. There were no sex effects (p>0.05) in SM calpastatin/µ-calpain ratio and calpastatin/µ+m-calpain ratio with time post-mortem.

4.6 Instrumental colour coordinates and surface myoglobin redox of the goat ecotypes in the *m. longissimus dorsi* (LD) and *m. semimembranosus* (SM)

4.6.1 Effects of interaction for goat ecotype and sex on instrumental colour coordinates

The interaction effects of goat ecotype, and sex on instrumental colour coordinates for the LD and SM muscles are presented in Tables 4.73 & 4.74. There were no interaction effects (p>0.05) between the goat ecotype and sex effects in both muscle (LD and SM) lightness, redness, yellowness, Chrome and hue angle measured at 1 day and 4 days post-mortem (Table 4.73 & 4.74).

Table 4.73 Mean values and (± SD) for the interaction effect of goat ecotype, sex and post-mortem aging on surface colour coordinates (L*, a*, b*, Chroma, hue angle) of the *m. longissimus dorsi*

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
L*													
1 day pm	37.04± 1.30	40.72± 3.45	35.42± 2.83	38.21 ±1.79	35.41± 2.39	37.31± 3.49	40.12 ±3.48	39.60± 3.64	37.77 ±2.24	42.31± 4.63	37.07± 2.96	36.36 ±4.23	0.286
4 days pm	38.75± 1.08	40.54± 2.92	36.30± 3.04	39.05± 2.52	37.58± 1.48	37.95± 4.58	40.79 ±2.67	39.79± 2.76	38.09 ±1.44	40.47 ±2.94	38.87 2.95	38.39± 4.77	0.604
a*													
1 day pm	17.59± 1.49	17.00± 1.85	17.55± 1.05	17.83± 2.24	18.08± 1.37	17.81± 1.69	16.72 ±2.12	17.53± 1.50	16.85± 1.90	15.66± 2.10	16.05 ± 1.34	16.44± 1.64	0.825
4 days pm	18.63± 1.37	18.06± 1.28	18.57± 0.72	18.66± 1.59	18.69± 0.53	18.38± 1.01	17.80 ±1.08	17.50± 0.84	17.96 ±2.06	17.60 ±0.70	16.98± 0.95	17.82± 2.33	0.820
b*													
1 day pm	11.23± 1.11	12.31± 0.96	11.31± 1.04	12.15± 1.75	11.74± 1.17	11.96± 2.17	12.36± 2.35	13.25± 2.51	12.22± 1.27	11.72± 0.90	10.58± 1.87	10.53± 1.74	0.885
4 days pm	12.89± 1.21	13.20± 1.45	12.62± 0.86	13.23± 1.05	12.89± 0.45	12.75± 1.29	13.51± 1.52	13.00± 1.79	13.20± 1.58	12.92± 1.07	11.79± 0.87	12.70± 2.61	0.836
Chroma													
1 day pm	20.87± 1.84	21.00± 1.95	20.89± 1.39	21.59± 2.81	21.56± 1.78	21.47± 2.54	20.83± 2.89	22.01± 2.67	20.82± 2.20	19.57± 2.15	19.24± 2.13	19.53± 2.29	0.914
4 days pm	22.66± 1.76	22.39± 1.70	22.46± 1.00	22.88± 1.83	22.71± 0.60	22.39± 1.34	22.35± 1.77	21.82± 1.62	22.29± 2.59	21.84± 1.14	20.68± 1.20	21.91± 3.35	0.836
Hue angle													
1 day pm	32.49± 0.78	35.99± 1.97	32.75± 1.39	34.18± 1.24	32.94± 0.76	33.67± 2.89	36.28± 3.67	36.74± 3.06	35.99± 1.69	37.41± 2.88	33.14± 2.55	32.41± 2.30	0.331
4 days pm	34.64± 1.25	36.09± 2.32	34.17± 1.29	35.34± 1.33	34.57± 0.89	34.69± 2.46	37.10± 1.51	36.46± 3.13	36.29± 0.54	36.23± 1.52	34.70± 1.35	35.14± 2.87	0.792

Means in the same row with different superscripts are significantly different (p<0.05); L*- lightness, a*- redness, b*-yellowness; post-mortem

Table 4.74 Mean values and (± SD) for the interaction effect of goat ecotype, sex and aging on instrumental colour coordinates (L*, a*, b*, Chroma, hue angle) for the *m. semimembranosus*

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
L*													
1 day pm	33.91± 1.47	35.76± 2.44	32.81± 2.94	35.96± 3.36	34.43± 2.10	35.34± 3.26	35.87± 3.76	36.93± 1.46	33.84 1.58	36.45 2.13	34.49 3.63	35.65 2.53	0.898
4 days pm	36.38± 2.42	38.39± 2.34	35.70± 2.18	37.06± 2.45	34.76± 3.04	36.03± 3.77	38.95± 2.38	37.49 2.78	36.65 2.15	38.14 0.89	36.47 2.54	35.69 3.94	0.648
a*													
1 day pm	19.32± 0.78	18.98± 1.89	18.97± 0.96	18.45± 2.18	19.93± 1.01	19.14± 1.08	18.03± 1.57	19.36± 1.14	17.89± 1.26	18.98± 1.52	18.09± 1.28	18.52± 2.04	0.453
4 days pm	18.72± 1.15	18.80± 1.09	18.87± 0.63	19.80± 1.32	20.37± 1.23	19.29± 2.06	18.37± 1.15	18.35± 2.19	18.51± 1.64	19.26± 0.97	18.47± 1.13	18.98± 1.86	0.589
b*													
1 day pm	12.08± 0.53	12.72± 1.94	11.66± 1.42	11.98± 1.53	12.72± 1.15	12.33± 1.53	12.12± 1.52	13.30± 1.14	11.64± 0.95	12.81± 1.41	11.65± 1.93	11.98± 1.86	0.834
4 days pm	12.87± 0.82	13.14± 1.38	12.79± 1.05	13.59± 1.45	13.75± 1.40	12.96± 2.76	13.18± 0.84	12.67± 2.51	13.42± 1.42	13.83± 0.42	12.63± 1.15	12.80± 2.24	0.852
Chroma													
1 day pm	22.79± 0.90	22.86± 2.62	22.28± 1.50	22.01± 2.58	23.65± 1.43	22.78± 1.66	21.75± 1.92	23.49 1.55	21.34 1.57	22.91 1.99	21.54 2.11	22.07 2.71	0.619
4 days pm	22.74± 1.22	22.94± 1.63	22.81± 1.08	24.02± 1.90	24.58± 1.76	23.27± 3.21	22.62± 1.38	22.31± 3.19	22.87± 2.15	23.717± 1.02	22.38± 1.55	22.92± 2.74	0.715
Hue angle													
1 day pm	32.00± 0.72	33.70 1.68	31.47 2.10	32.98± 1.76	32.49± 1.34	32.68± 2.16	33.86± 2.83	34.42± 1.07	33.04± 0.49	33.95± 1.47	32.56± 2.56	32.76± 1.47	0.868
4 days pm	34.53± 1.83	34.86± 1.69	34.06± 1.39	34.38± 1.27	33.93± 1.35	33.56± 3.19	35.65± 0.89	34.37± 2.52	35.96± 0.61	35.71± 0.66	34.30± 1.13	33.76± 2.67	0.919

4.6.2 Effects interaction of goat ecotypes on instrumental colour coordinates

Table 4.75 Mean values and (± SD) for the interaction effects of goat ecotypes on instrumental colour coordinates (L, a*, b*, Chroma, hue angle) of the *m. longissimus dorsi*

	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
L*							
1 day pm	38.37^{ab}± 2.83	36.58^{b}± 2.76	36.20^{b} ±2.91	39.89^{a}± 3.34	39.47^{a}± 3.81	36.74^{b}± 3.46	0.026
4 days pm	39.40 ±2.02	37.45± 3.056	37.74 ±2.97	40.34± 2.59	38.98± 2.271	38.65 ±3.72	0.234
a*							
1 day pm	17.38± 1.56	17.67 ±1.57	17.96 ±1.44	17.08 ±1.81	16.40± 1.92	16.23± 1.43	0.094
4 days pm	18.42± 1.31	18.61± 1.09	18.56± 0.74	17.66± 0.93	17.83± 1.62	17.37± 1.70	0.120
b*							
1 day pm	11.62 ±1.15	11.66 ±1.37	11.83 ±1.58	12.75± 2.31	12.03± 1.10	10.56± 1.74	0.078
4 days pm	13.00± 1.24	12.88± 0.95	12.83± 0.85	13.28± 1.56	13.09± 1.33	12.21± 1.85	0.548
Chroma							
1 day pm	20.92± 1.78	21.18± 2.01	21.52± 2.02	21.35± 2.69	20.36± 2.12	19.38± 2.12	0.176
4 days pm	22.56± 1.66	62.64± 1.34	22.57± 0.94	22.12± 1.62	22.12± 2.07	21.25± 2.41	0.384
Hue angle							
1 day pm	33.76^{b}± 2.16	33.35^{b}± 1.47	33.24^{b}± 1.87	36.49^{a}± 3.21	36.52^{a}± 2.13	32.81^{b}± 2.37	0.001
4 days pm	35.17^{bc} ±1.76	34.66^{c}± 1.38	34.62^{c}± 1.62	36.81^{a} ±2.22	36.27^{ab} ±0.91	34.91^{bc}± 2.10	0.037

Means in the same row with different superscripts are significantly different (p<0.05); L*- lightness, a*- redness, b*yellowness; pm -post-mortem.

The effects of goat ecotypes on instrumental colour coordinates for the LD are presented in Table 4.75. The LD of VTV and VT goats were (p<0.05) lighter (39.5 and 39.9) than LD of NCS, SAB and XL goats (~36.5) at 1 day post-mortem. On average, LD of MBZ goats (38.4) did not differ in lightness from those goat ecotypes at 1 day post-mortem (Table 4.75).

Table 4.76 Mean values and (± SD) of interaction effects of goat ecotypes on instrumental meat coordinates (L*, a*, b*, Chroma, hue angle) of the *m. semimembranosus*

	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value ($p<F$)
L*							
1 day pm	34.58± 1.38	34.12± 3.41	34.81± 2.54	36.34± 2.54	34.82± 2.13	36.74± 3.46	0.574
4 days pm	37.11± 2.49	36.27± 2.29	35.29± 3.26	38.30± 2.52	37.21± 1.86	38.65± 3.72	0.201
a*							
1 day pm	19.20± 1.21	18.76 ±1.52	19.60± 1.07	18.62 ±1.49	18.30± 1.37	16.23± 1.43	0.197
4 days pm	18.75± 1.07	19.26± 1.04	19.92± 1.64	18.36± 1.57	18.79± 1.40	17.37± 1.70	0.148
b*							
1 day pm	12.31 ±1.12	11.79 ±1.11	12.56 ±1.27	12.65± 1.42	12.08± 1.20	10.56± 1.74	0.614
4 days pm	12.97± 1.00	13.13± 1.24	13.42± 2.00	12.95± 1.67	13.58± 1.11	12.21± 1.85	0.816
Chroma							
1 day pm	22.82± 1.60	22.17± 1.92	23.29± 1.52	22.52± 1.90	21.93± 1.79	19.38± 2.12	0.406
4 days pm	22.81± 1.13	23.32± 1.53	24.04± 2.43	22.48± 2.19	23.19± 1.77	21.25± 2.41	0.467
Hue angle							
1 day pm	32.62± 1.38	32.10± 2.04	32.57± 1.64	34.10± 2.12	33.38 ±0.99	32.81± 2.37	0.187
4 days pm	34.65 ±1.70	34.19± 1.29	33.78± 2.17	36.08± 1.80	35.84 ±0.59	34.91 ±2.10	0.133

Means in the same row with different superscripts are significantly different ($p<0.05$); L*- lightness, a*- redness, b*-yellowness; post-mortem.

An increase of lightness was observed in LD of goat ecotypes with no differences ($p>0.05$) at 4 days post-mortem, with the exception of LD for VTV goats that dropped (0.489; $p>0.05$). There were no goat ecotype differences ($p>0.05$) in LD redness, yellowness and Chroma at 1 day and 4 days post-mortem (Table 4.75). Nonetheless, an increase in redness, yellowness and Chroma was observed with post-mortem aging which were significant (Table 4.79).

The LD of VTV and VT goats had higher ($p<0.001$) hue angle (36.5) than LD of MBZ, NCS, SAB and XL goats ranging between 32.8-33.8 at 1 day post-mortem. At 4 days post-mortem, hue angle increased in LD of MBZ, NCS, SAB and XL goats except in LD of VTV

that decreased (0.25) at 4 days post-mortem. On the other hand, LD of VT goat had a higher (p<0.05) hue angle (36.8) followed by LD of VTV goats (36.3) than LD of NCS and SAB goats (34.6). The LD of MBZ and XL goats had similar hue angle and did not differ from LD NCS and SAB goats (Table 4.83).

The effects of goat ecotypes on instrumental colour coordinates for the SM are presented in Table 4.76. Unlike the LD, no goat ecotype differences (p>0.05) were observed in SM instrumental meat coordinates (L*, a*, b*, Chroma and hue angle) with post-mortem (Table 4.76).

4.6.3 Effects interaction of sex on instrumental colour coordinates

Table 4.77 Mean values and (± SD) for the interaction effects of sex on instrumental meat coordinates (L*, a*, b*, Chroma, hue angle) of the *m. longissimus dorsi*

	Sex		Significance
	Does	Bucks	p-value (p<F)
L*			
1 day pm	36.95^{a} ± 2.85	38.66^{b} ± 3.78	0.022
4 days pm	38.28 ± 2.50	39.19 ± 3.47	0.221
a*			
1 day pm	17.18 ± 1.58	17.11 ± 1.81	0.920
4 days pm	18.13 ± 1.26	18.04 ± 1.44	0.894
b*			
1 day pm	11.50 ± 1.52	11.89 ± 1.85	0.303
4 days pm	12.761 ± 1.15	12.95 ± 1.58	0.536
Chroma			
1 day pm	20.69 ± 2.02	20.86 ± 2.41	0.703
4 days pm	22.18 ± 1.60	22.23 ± 1.96	0.832
Hue angle			
1 day pm	33.70^{a} ± 2.36	34.70^{b} ± 2.81	0.058
4 days pm	35.09 ± 1.50	35.55 ± 2.26	0.301

Means in the same row with different superscripts are significantly different (p<0.05); L*- lightness, a*- redness, b*-yellowness, pm-post-mortem.

The interaction effects of sex on instrumental colour coordinates measured at 1 day and 4 days post-mortem for the LD and SM muscles are presented in Tables 4.77 & 4.78. The bucks

were lighter (p<0.05) as compared to LD of does (38.66 *vs* 36.95) at 1 day post-mortem. No effects of sex were observed at 4 days post-mortem (Table 4.77).

Table 4.78 Mean values and (± SD) of interaction effects of sex and aging on instrumental meat coordinates (L*, a*, b*, Chroma, hue angle) of the *m. semimembranosus*

	Sex		Significances
	Does	Bucks	p-values (p<F)
L*			
1 day pm	34.16^{a} ± 2.61	35.95^{b} ± 2.49	0.011
4 days pm	36.35 ± 2.62	36.94 ± 2.96	0.370
a*			
1 day pm	18.78 ± 1.31	18.87 ± 1.60	0.762
4 days pm	18.93 ± 1.29	19.10 ± 1.60	0.623
b*			
1 day pm	11.99 ± 1.31	12.44 ± 1.53	0.212
4 days pm	13.09 ± 1.13	13.12 ± 1.89	0.889
Chroma			
1 day pm	22.30 ± 1.70	22.61 ± 2.13	0.480
4 days pm	23.03 ± 1.62	23.19 ± 2.34	0.717
Hue angle			
1 day pm	32.47 ± 1.89	33.30 ± 1.63	0.074
4 days pm	23.03 ± 1.62	23.19 ± 2.33	0.539

Means in the same row with different superscripts are significantly different (p<0.05); L*- lightness, a*- redness, b*-yellowness, pm-post-mortem.

Sex had no effect on LD redness, yellowness and Chroma measured post-mortem (1 day and 4 days). The bucks had a higher hue angle than that recorded in does (34.70 *vs* 33.70) at 1 day post-mortem and no differences were observed at 4 days post-mortem.

The interaction effects of sex on instrumental colour coordinates measured at 1 day and 4 days post-mortem for the SM are presented in Table 4.78. In SM sex effect on lightness was less in comparison to LD. The SM of bucks were lighter (p<0.01) than the LD of does (35.95 *vs* 34.16) at 1 day post-mortem. No sex effects were observed at 4 days post-mortem (Table 4.78). There were no interaction effects of sex and aging in SM redness, yellowness, Chroma and hue angle with post-mortem (1 day and 4 days). Although there were no sex effects with post-mortem aging, the ageing effect on all colour parameters (LD and SM) were significant (Section 4.6.4; Table 4.79).

4.6.4 Effects of aging on instrumental colour coordinates goat ecotypes

Table 4.79 Mean values and (± SD) for the effects of aging on meat colour coordinates (L*, a*, b*, chroma, hue angle) for *m. longissimus dorsi* and *m. semimembranosus*

	Post-mortem aging		Significance
	1 day pm	4 days pm	*p*-value (*p*<F)
M. longissimus dorsi			
L*	37.66^{a}±3.35	38.66^{b} ± 2.95	<0.001
a*	17.15^{a}±1.67	18.09^{b}± 1.32	<0.001
b*	11.66^{a}± 1.66	12.84^{b}± 1.33	<0.001
Chroma	20.76^{a} ±2.178	22.20^{b} ± 1.74	<0.001
Hue angle	34.11^{a}±2.58	35.28^{b}± 1.85	<0.001
M. semimembranosus			
L*	34.90^{a} ±2.69	36.59^{b}±2.76	<0.001
a*	18.82^{a}± 1.42	19.00^{b} ±1.42	<0.001
b*	12.18^{a} ±1.41	13.10^{b} ± 1.48	<0.001
Chroma	22.43^{a} ±1.88	23.09^{b} ±1.93	0.001
Hue angle	32.82^{a}± 1.82	34.49^{b} ±1.77	<0.001

Means in the same row with different superscripts are significantly different (*p*<0.05); L*- lightness, a*- redness, b*yellowness; pm - post-mortem.

The effects of aging on instrumental colour coordinates for the LD and SM muscles are presented in Table 4.79. Instrumental colour coordinates in LD samples increased (*p*<0.001) from 1 day post-mortem to 4 days post-mortem (aging) (Table 4.79), e.g. L* (0.95), a* (0.95) b* (1.18), Chroma (1.44) and hue angle (1.17). Similarly, instrumental colour coordinates in SM samples increased (*p*<0.001) with post-mortem aging, e.g. L* (1.70), a* (0.19), b* (0.92), Chroma (0.67) and hue angle (1.67). Meat colour improved with post-mortem aging (1 day to 4 days).

4.6.5 Interaction effects of goat ecotype and sex on surface myoglobin redox

The interaction of goat ecotype and sex on surface myoglobin redox for the LD and SM muscles are presented in Table 4.80. There were no interaction effects (*p*>0.05) for goat ecotype and sex in both muscles (LD and SM) surface myoglobin redox (metmyoglobin, deoxymyoglobin and oxymyoglobin) at 1 day and 4 days post-mortem aging (Table 4.80).

Table 4.80 Mean fraction values and (± SD) of interaction effect of goat ecotypes and sex on surface myoglobin redox of the *m. longissimus dorsi* and *m. semimembranosus*

		Ecotype × Sex												Significance
		MBZ		NCS		SAB		VT		VTV		XL		*p*-value
		Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
LD	Metmyoglobin													
	1 day pm	10.6± 2.9	7.5± 2.6	9.6± 1.9	8.6± 4.2	10.0± 1.4	10.4± 3.2	5.8± 3.8	7.8± 2.6	7.8± 3.2	5.7± 4.0	8.9± 2.9	8.7± 2.9	0.494
	4 days pm	11.0± 3.4	8.3± 2.2	9.7± 2.0	6.6± 2.9	9.7± 2.1	9.2± 2.8	7.0± 1.9	7.8± 1.7	8.2± 4.0	9.3± 2.3	8.0± 1.8	9.0± 2.4	0.216
	Deoxymyoglobin													
	1 day pm	66.6± 11.9	66.0± 10.4	63.3± 6.7	62.8± 11.8	59.9± 5.6	62.0± 10.0	68.2± 20.1	60.5± 23.6	67.0± 10.8	68.3± 3.5	72.7± 11.3	69.8± 8.4	0.956
	4 days pm	63.3± 11.7	57.8± 8.1	58.7± 6.2	60.2± 7.9	56.3± 7.0	58.2± 4.0	58.2± 10.9	60.0± 12.4	56.2± 14.1	61.3± 3.5	71.3± 8.8	59.7± 12.7	0.336
	Oxymyoglobin													
	1 day pm	22.4± 10.0	26.5± 9.0	26.9± 5.7	28.8± 9.2	30.1± 4.7	27.8± 9.8	26.0± 16.6	32.0± 22.0	25.4± 7.8	26.0± 3.0	18.7± 10.6	21.2± 7.3	0.961
	4 days pm	25.9± 8.6	34.3± 6.4	31.7± 5.3	33.2± 5.3	33.7± 5.8	33.0± 4.9	34.6± 9.5	32.0± 10.9	35.4± 10.0	29.3± 4.0	20.4± 8.0	31.5± 10.8	0.130
SM	Metmyoglobin													
	1 day pm	13.7± 1.5	12.2± 1.7	14.3± 1.1	11.6± 3.5	15.9± 2.2	13.6± 1.1	11.8± 1.9	13.5± 2.4	11.6± 1.7	13.7± 3.1	14.5± 2.7	13.9± 1.5	0.068
	4 days pm	16.6± 3.6	13.0± 1.2	14.1± 1.6	10.6± 2.5	14.6± 1.4	13.0± 1.2	12.0± 2.2	11.5± 2.1	13.4± 1.9	13.3± 2.5	13.6± 1.7	13.0± 1.9	0.239
	Deoxymyoglobin													
	1 day pm	65.0± 6.7	65.0± 9.2	62.4± 6.2	66.0± 8.0	52.7± 4.8	60.2± 7.7	67.0± 10.4	56.5± 13.3	65.6± 7.5	59.3± 10.7	62.7± 10.2	61.5± 10.0	0.236
	4 days pm	51.9± 6.1	55.3± 8.5	54.0± 6.1	55.6± 3.8	46.6± 4.2	53.8± 9.4	59.2± 7.8	59.0± 9.6	50.0± 9.5	54.7± 7.0	59.6± 6.9	54.8± 11.1	0.605
	Oxymyoglobin													
	1 day pm	21.0± 6.2	23.0± 8.3	23.1± 6.5	22.6± 5.6	31.4± 4.5	26.2± 7.5	21.2± 9.2	30.0± 11.0	22.6± 7.8	27.3± 8.1	22.7± 6.2	24.5± 8.3	0.443
	4 days pm	31.7± 3.6	31.8± 7.5	31.6± 5.1	33.6± 3.5	38.7± 4.3	33.6± 8.9	28.8± 5.8	29.5± 7.9	37.0± 8.4	31.7± 6.7	31.7± 3.6	31.8± 7.5	0.490

4.6.6 The interaction effects of goat ecotypes on surface myoglobin redox

Table 4.81 Mean fraction values and (± SD) of interaction effects of goat ecotypes on surface myoglobin redox of the *m. longissimus dorsi* and *m. semimembranosus*

		Ecotype						Significance
		MBZ	NCS	SAB	VT	VTV	XL	*p*-value (*p*<F)
LD	Metmyoglobin							
	1 day pm	9.5± 3.1	9.2 ±2.9	10.2± 2.2	6.7± 3.3	7.0± 3.4	8.8 ±2.7	0.066
	4 days pm	10.0± 3.3	8.4± 2.8	9.5± 2.3	7.3± 1.7	8.6± 3.3	8.5± 2.1	0.255
	Deoxymyoglobin							
	1 day pm	66.4± 10.9	63.1± 8.6	60.8± 7.4	64.8± 20.7	67.5± 8.5	71.4± 9.8	0.331
	4 days pm	61.3 ± 10.4	59.3 ± 6.7	57.1 ± 5.8	59.0 ± 10.8	58.1 ± 11.2	65.9 ± 11.9	0.267
	Oxymyoglobin							
	1 day pm	23.9± 9.4	27.7± 7.0	29.2± 7.0	28.7± 18.1	25.6± 6.1	19.8± 9.0	0.236
	4 days pm	28.9± 8.7	32.3± 5.1	33.4± 5.2	33.4± 9.5	33.1± 8.5	25.5± 10.7	0.094
SM	Metmyoglobin							
	1 day pm	13.3± 1.6	13.2± 2.7	14.9± 2.1	12.6± 2.2	12.4± 2.3	13.5± 2.3	0.093
	4 days pm	15.3^{a}± 3.4	12.7^{bc}± 2.6	13.9^{bc}± 1.5	11.8^{c}± 2.0	0.134^{bc}± 2.0	13.3^{bc}± 1.8	0.012
	Deoxymyoglobin							
	1 day pm	65.0± 7.3	63.9± 6.9	55.8± 7.0	62.3± 12.3	63.3± 8.7	62.9± 9.7	0.155
	4 days pm	53.1^{abc}± 6.8	54.7^{ab}± 5.1	49.6^{c}± 7.4	59.1^{a}± 8.0	51.8^{bc}± 8.4	57.9^{ab}± 8.9	0.042
	Oxymyoglobin							
	1 day pm	21.7± 6.7	22.9± 5.9	29.3± 6.2	25.1± 10.4	24.4± 7.7	23.8± 8.5	0.257
	4 days pm	31.7^{ab}± 5.0	32.4^{ab}± 4.4	36.6^{a}± 6.8	29.0^{b}± 6.4	35.0^{a}± 7.8	29.0^{b} ± 7.9	0.047

Means in the same row with different superscripts are significantly different (p<0.05); pm-post-mortem.

The effects of goat ecotypes on instrumental colour coordinates for the LD and SM muscles are presented in Table 4.81. There were no goat ecotype differences (p>0.05) in surface myoglobin redox at 1 day post-mortem (Table 4.81). Unlike the LD, goat ecotypes differed in SM surface myoglobin redox at 4 days past-mortem aging. The SM of MBZ goats had a higher (p<0.05) percentage of metmyoglobin (15.3%) than SM of VT goats (11.8%).

The SM of NCS, SAB, VTV and XL goats did not differ in metmyoglobin but on average they were similar to SM of VT goats. The SM of VT goats had a higher (p<0.05)

percentage of deoxymyoglobin (59.1%) than that recorded in LD of SAB goats (49.6%). The SM of NCS and XL goats did not differ in percentage of deoxymyoglobin and were similar to the rest of goat ecotypes, except SAB goats. The SM of SAB and VTV goats had higher (p<0.05) percentage of oxymyoglobin (36.6% and 35.0% respectively) than VT and XL goats (29.0%). The SM of MBZ and NCS goats did not differ and on average similar to the rest of goat ecotype.

4.6.7 Effects interaction of sex on surface myoglobin redox

Table 4.82 Mean fraction values and (± SD) of interaction effects of sex on surface redox *m. longissimus dorsi*

			Sex		Significance
			Does	Bucks	p-value (p<F)
LD	Metmyoglobin				
		1 day pm	9.0 ± 2.9	8.3 ± 3.2	0.404
		4 days pm	9.1 ± 2.8	8.3 ± 2.4	0.303
	Deoxymyoglobin				
		1 day pm	66.1 ± 11.4	65 ± 11.9	0.664
		4 days pm	61.0 ± 10.7	59.4 ± 8.4	0.463
	Oxymyoglobin				
		1 day pm	24.8 ± 9.0	26.7 ± 10.8	0.443
		4 days pm	29.8 ± 9.1	32.3 ± 7.2	0.180
SM	Metmyoglobin				
		1 day pm	13.8 ± 2.3	12.9 ± 2.2	0.081
		4 days pm	14.2^{a} ± 2.5	12.4^{b} ± 2.0	0.002
	Deoxymyoglobin				
		1 day pm	62.1 ± 8.7	62.1 ± 9.4	0.985
		4 days pm	53.4 ± 7.8	55.7 ± 8.0	0.304
	Oxymyoglobin				
		1 day pm	24.0 ± 7.7	25.3 ± 7.8	0.553
		4 days pm	32.4 ± 6.8	31.9 ± 7.1	0.851

Means in the same row with different superscripts are significantly different (p<0.05); pm -post-mortem

The effects of sex on instrumental colour coordinates for the LD and SM muscles are presented in Table 4.82. There were no sex differences (p>0.05) in the surface myoglobin redox with time post-mortem in LD of goat ecotypes (Table 4.82).

Semimembranosus samples did not differ (p>0.05) in deoxymyoglobin and oxymyoglobin but differences were observed in metmyoglobin with time post-mortem (Table 4.82). There were no sex differences in SM metmyoglobin at 1 day post-mortem. The SM of does had a higher metmyoglobin than SM of buck (14.2% *vs* 12.4%) at 4 days post-mortem**.**

4.6.8 Effects of post-mortem aging on surface myoglobin redox for goat ecotypes

Table 4.83 Mean fraction values and (± SD) for the effects of post-mortem aging on surface myoglobin redox for *m. longissimus dorsi* and *m. semimembranosus*

	Post-mortem aging		Significance
	1 day pm	4 days pm	p-value (p<F)
M. longissimus dorsi			
Metmyoglobin	8.7 ± 3.1	8.8 ± 2.6	0.837
Deoxymyoglobin	65.6^{a} ± 11.5	60.4^{b} ± 9.7	0.002
Oxymyoglobin	25.6^{a} ± 10.1	30.8^{b} ± 8.4	0.001
M. semimembranosus			
Metmyoglobin	13.4± 2.3	13.4 ± 2.5	0.879
Deoxymyoglobin	62.1^{a} ± 8.9	54.4^{b} ± 7.9	<0.001
Oxymyoglobin	24.5^{a} ± 7.7	32.2^{b} ± 6.8	<0.001

Means in the same row with different superscripts are significantly different (p<0.05).

The effects of post-mortem aging on surface myoglobin redox for the LD and SM muscles are presented in Table 4.83. Post-mortem aging had no effects (p<0.05) in LD percentage of metmyoglobin of both muscle (LD and SM). In the LD, percentage of deoxymyoglobin values decreased with (about 5.2%; p<0.01) with post-mortem aging and oxymyoglobin percentage increased with 5.2% (p<0.001) with post-mortem aging (1 day - 4 days). In the SM, percentage of deoxymyoglobin decreased and increased in percentage of oxymyoglobin by (7.7%; p<0.001) aged for 1 day - 4 days post-mortem but much higher as compared to the LD (Table 4.83). However, those patterns improved instrumental colour coordinates with post-mortem aging.

4.7 Muscle fibre characteristics of goat ecotypes

Table 4.84 Mean values and (± SD) of effects of goat ecotype on the muscle fibre typing in *m. longissimus dorsi*

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(*p*<F)
Fibre cross-sectional area (CSA)													
Red fibre (µm²)	1826± 381.1	1403± 362.3	1944± 318.1	1921 ±558.9	1845± 197.8	1900± 226.3	1316± 250.2	1161± 117.6	1686± 364.2	1803 ±675.9	1459± 208.9	1841± 577.6	0.2082
Intermediate fibre (µm²)	2418± 412.7	2055± 317.8	2569± 336.8	2374 ± 604.9	2595± 497.7	2621 ±167.1	1819± 377.4	1697± 310.1	2169± 425.2	2115± 668.1	2217± 322.8	2324± 520.9	0.8324
White fibre (µm²)	3432± 551.7	3091± 751.1	3558± 346.4	3427± 649.4	3302± 471.9	3172± 629.5	2751± 540.8	2657± 534.7	3275± 644.8	3278± 110.4	3220± 363.3	3396± 514.0	0.9409
Fibre type composition													
Red fibre %	36.9 ±3.19	38.7± 2.08	38.5± 3.10	38.7± 0.77	38.2± 2.53	36.7± 5.01	36.0± 2.63	38.7± 1.65	39.1± 5.20	36.8± 5.10	37.9 ± 2.80	37.2 ± 0.87	0.510
Intermediate fibre %	28.4 ±3.08	29.6± 5.30	28.3 ±2.60	25.7± 3.74	28.9± 2.99	30.2± 2.33	31.1± 6.39	29.9± 3.59	30.2± 5.46	34.9± 7.14	31.9 ± 8.48	28.6 ± 4.32	0.493
White fibre %	35.9 ±3.18	34.6± 3.71	32.9 ±3.77	34.2± 3.25	35.1± 2.67	36.9 ±5.23	35.7± 2.88	33.8± 2.59	33.7± 4.66	34.5± 5.22	34.2 ± 4.43	35.9 ± 1.78	0.773

Means in the same row with different superscripts are significantly different (p<0.5)

Table 4.85 Mean values and (± SD) of effects of goat ecotype on the muscle fibre typing in *m. semimembranosus*

	Ecotype × Sex												Significance
	MBZ		NCS		SAB		VT		VTV		XL		*p*-value
	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	Does	Bucks	(p<F)
Fibre cross-sectional area (CSA)													
Red fibre (µm²)	1843 ± 233.9	1576 ± 510.9	2166± 351.5	1452 ± 389.1	1957 ± 325.6	2186 ± 768.9	1436 ± 267.7	1479 ± 481.5	1756 ± 367.6	1941 ± 215.3	1758 ± 613.2	1761.8± 272.3	0.113
Intermediate fibre (µm²)	2609^{abc} ±426.9	2038^{cde} ±498.7	2819^{a} ±470.2	1792^{e} ±520.7	2616^{abc} ± 440.8	2698^{ab} ±910.4	1934^{de} ±229.2	2060^{cde} ±750.4	2477^{abcd} ± 347.6	2270^{abcd} ± 406.5	2057^{cde} ±546.5	2116.9^{bcde} ± 208.5	0.055
White fibre (µm²)	3471± 667.0	3222± 803.8	3550± 728.6	2544± 852.2	3553± 509.8	4143± 1200.8	2961 ± 506.1	2987± 1312.8	3665 ± 675.7	3714 ± 564.0	3086 ± 865.6	3178.8± 479.9	0.267
Fibre type composition													
Red fibre %	40.6± 3.57	38.0± 2.17	41.9± 3.04	41.3± 5.29	37.4± 3.99	37.1± 2.90	39.5± 2.40	37.7± 2.30	43.3± 6.82	43.1± 6.84	40.7± 3.61	39.4± 1.46	0.978
Intermediate fibre %	30.1± 6.59	28.7± 3.48	28.6± 2.82	28.1± 8.89	33.3± 6.56	29.7± 3.96	28.1± 2.20	29.2± 0.93	29.7± 6.94	28.4± 5.72	31.5± 4.93	31.6± 6.88	0.948
White fibre %	30.2± 5.43	35.6± 1.76	30.9± 2.44	32.8± 6.27	32.8± 3.42	31.7± 3.99	32.4± 2.59	32.4± 2.49	29.4± 2.82	30.4± 3.05	30.3± 3.70	33.6± 1.89	0.367

Means in the same row with different superscripts are significantly different (p<0.5)

4.7.1 The interaction effects of goat ecotype and sex on the muscle fibre typing in the *m. longissimus dorsi* and *m. semimembranosus*

The interaction effects of goat ecotypes on the muscle fibre typing for the LD and SM muscles are presented in Tables 4.84 & 4.85. There were no interaction effects of goat ecotype and sex in LD fibre typing cross sectional areas (CSA) and percentage muscle fibre type (Table 4.84). There were no interaction (p>0.05) effects of goat ecotype and sex in red and white fibres and percentage muscle fibres for the measured SM (Table 4.85). The SM of does from NCS had largest (p<0.05) intermediate fibre compared to bucks (2819 µm² *vs* 1792 µm²). On average, SM of bucks and does from MBZ, SAB, VT, VTV and XL goats had similar intermediate fibre type. However, if it was not for the interaction between effects on LD of NCS goats and sex there would have been no significant differences (Table 4.8).

4.7.2 The effects of goat ecotypes on the muscle fibre typing in the *m. longissimus dorsi* and *m. semimembranosus*

Table 4.86 Mean values and (± SD) of effects of goat ecotypes on the muscle fibre typing in *m. longissimus dorsi*

	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (p<F)
Fibre cross-sectional area (CSA)							
Red fibre (µm²)	1672^{a}± 414.1	1935^{a}± 411.0	1868^{a}± 201.9	1247^{b}± 207.7	1730^{a} ± 458.3	1636^{a} ± 447.3	0.002
Intermediate fibre	2286^{ab}± 407.3	2487^{a}± 452.8	2606^{a}± 381.4	1765^{b}± 333.8	2149^{ab}± 481.3	2270^{ab}± 416.9	0.001
White fibre (µm²)	3308± 617.6	3504± 472.6	3248± 519.6	2709± 505.8	3276± 767.2	3308± 434.3	0.076
Fibre type composition							
Red fibre %	37.6±2.9	38.6±2.3	37.6±3.6	37.2±2.5	38.2±4.9	37.6±2.1	0.927
Intermediate fibre %	28.8±3.8	27.2±3.2	29.4±2.7	30.6±5.1	32.0±6.1	30.4±6.8	0.337
White fibre %	35.5±3.3	33.5±3.5	35.8±3.8	34.9±2.8	34.0±4.5	35.0±3.4	0.651

Means in the same row with different superscripts are significantly different (p<0.05)

The effects of goat ecotypes on the muscle fibre typing for the LD and SM muscles are presented in Tables 4.86 & 4.87. The LD of VT goats had the (p<0.01) smallest red fibres (1247 μm^2) as compared to LD of MBZ, NCS, SAB, VTV and XL goats with values that ranged between (1636-1935 μm^2). Similarly, with Intermediate fibre, LD of VT goats were the smallest (p<0.001) as compared to LD of SAB and NCS goats (2606 μm^2 and 2487 μm^2 respectively). On average, LD of MBZ, VTV and XL goats did not differ and were similar to LD of VT, SAB and NCS goats (Table 4.86). Lastly, goat ecotypes did not differ (p>0.05) on the white fibre type that were in the range of 2709-3504 μm^2. Overall mean of red fibre had the smallest cross-sectional area, followed by intermediate fibres and lastly white fibres. There were no goat ecotype differences (p>0.05) in LD percentage of muscle fibre typing. The mean values of red, intermediate and white fibres ranged between 37.6-38.6%, 27.2-32.0% and 33.5-35.5% respectively (Table 4.86).

Table 4.87 Mean values and (± SD) for the effects of goat ecotypes on the muscle fibre typing characteristics in *m. semimembranosus*

	Ecotype						Significance
	MBZ	NCS	SAB	VT	VTV	XL	*p*-value (p<F)
Fibre cross-sectional area (CSA)							
Red fibre (μm²)	1746± 359.6	1868± 507.6	2053 ± 535.6	1455± 351.1	1825 ± 315.6	1760± 467.8	0.075
Intermediate fibre	2401^{ab}± 516.5	2391^{ab}± 706.4	2650^{a} ± 639.7	1990^{b}± 491.8	2399^{ab}± 357.5	2087^{b}± 395.6	0.044
White fibre (μm²)	3381± 690.4	3131± 906.8	3799± 870.9	2973 ± 880.1	3683± 593.7	3132± 668.9	0.111
Fibre type composition							
Red fibre %	39.7^{bc} ±3.3	41.6^{ab} ±3.9	37.2^{c} ±3.4	38.7^{bc} ±2.4	43.2^{a} ±6.3	40.1^{abc} ±2.8	0.018
Intermediate fibre %	29.6± 5.5	28.4± 5.8	31.8± 5.7	28.6± 1.8	29.2± 6.1	31.5± 5.7	0.543
White fibre %	32.2± 5.1	31.7± 4.3	32.3± 3.5	32.4± 2.4	29.8± 2.7	31.8± 3.4	0.701

Means in the same row with different superscripts are significantly different (p<0.05)

There were no goat ecotype differences (p>0.05) in SM red and white fibres (CSA). The SM of VT and XL goats had the smallest (p<0.05) intermediate fibres (1990 μm^2 and 2087

μm^2 respectively) than that recorded in SM of SAB goats (2650 μm^2). On average, SM of MBZ, NCS and VTV goats did not differ and were similar to the rest of the ecotypes.

The SM of SAB goats had the smallest (p<0.01) percentage of red fibres (37.2%) than that recorded in those recorded in SM of VTV goats (43.2%). The percentage of red fibre recorded in SM of NCS goats differed from SAB goats. The SM of MBZ and VT goat were similar but differed from SM of VTV goats. On the other hand, SM of XL goats were similar to the rest of goat ecotypes. There were no goat ecotype differences (p>0.05) in percentage of intermediate fibres and white fibres that ranged 28.4-31.8% and 29.8-32.4% respectively (Table 4.87).

4.7.3 The effects of sex on the muscle fibre typing in the *m. longissimus dorsi* and *m. semimembranosus*

Table 4.88 Mean values and (± SD) for the effects of sex on muscle fibre typing characteristics in *m. longissimus dorsi*

	Sex		Significance
	Does	Bucks	p-value (p<F)
Fibre cross-sectional area (CSA)			
Red fibre (µm²)	1698 ± 351.7	1697 ± 503.2	0.931
Intermediate fibre (µm²)	2333 ± 455.2	2232 ± 505.0	0.385
White fibre (µm²)	3284 ± 513.8	3193 ± 660.34	0.564
Fibre type composition			
Red fibre %	37.80 ± 3.178	37.79 ± 2.787	0.988
Inter-mediate fibre %	29.71 ± 5.049	29.41 ± 4.648	0.788
White fibre %	34.59 ± 3.571	35.09 ± 3.488	0.597

Means in the same row with different superscripts are significantly different (p<0.05).

The effects of sex on the muscle fibre typing for the LD and SM muscles are presented in Tables 4.88 & 4.89. There were no sex effects (p>0.05) on CSA and percentage of muscle fibre in LD (Table 4.88). There were no sex differences (p>0.05) in SM muscle fibre (CSA) (Table 4.89) except in the intermediate fibres, e.g. SM does had higher intermediate fibres than SM bucks (2451 µm² *vs* 2161 µm²). The sex differences observed could be caused by the

interaction effects of NCS and its sexes, but overall there were no sex differences in other ecotypes (Table 4.85). Sex did not differ (p>0.05) in percentage of red and intermediate fibres. The SM of does had smaller percentage of white fibres than that recorded in SM bucks (30.99% *vs* 32.86%).

Table 4.89 Mean values and (± SD) for the effects of sex on muscle fibre typing characteristics in *m. semimembranosus*

	Sex		Significance
	Does	Bucks	p-value (p<F)
Fibre cross sectional area (CSA)			
Red fibre (µm²)	1843 ± 419.9	1733 ± 512.4	0.337
Intermediate fibre (µm²)	2451^{a} ± 509.8	2161^{b} ± 609.3	0.041
White fibre (µm²)	3396 ± 672.3	3277 ± 980.4	0.644
Fibre type composition			
Red fibre %	40.48 ± 4.166	39.27 ± 3.853	0.249
Inter-mediate fibre %	30.35 ± 5.314	29.46 ± 5.423	0.498
White fibre %	30.99^{a} ± 3.592	32.86^{b} ± 3.638	0.050

Means in the same row with different superscripts are significantly different (p<0.05).

4.8 Correlations between carcasses muscles and meat quality characteristics

4.8.1 Correlation between muscle fibre type and meat quality

The correlation between muscle fibre typing and meat quality traits for the LD and SM muscles are presented in Table 4.90 and 4.91.

Table 4.90 Correlation coefficients between muscle fibres type and meat quality traits for the *m. longissimus dorsi* (pooled data for all the goats)

	Cross sectional area			Fibre percentage		
	Red	Intermediate	White	Red	Intermediate	White
pH	-0,257*	-0,284*	-0,202	0,114	-0,164	0,017
Temp	-0,056	-0,121	-0,269*	-0,062	0,159	-0,018
Drip loss	0,219*	0,290*	0,235*	0,010	-0,035	-0,081
WHC_D4	-0,153	-0,083	-0,014	-0,126	-0,125	0,285*
WBSF	-0,119	-0,119	-0,163	0,192	0,172	-0,273*
Sarcomere Length	0,037	-0,112	-0,155	-0,224*	-0,116	0,310*
L*_D1	-0,219	-0,332**	-0,316**	-0,044	0,211	0,019
L*_D4	-0,126	-0,203	-0,209	-0,076	0,241*	0,055
a*_D1	0,268*	0,247*	0,087	0,118	-0,126	-0,138
a*_D4	0,331**	0,202	0,086	0,126	0,025	-0,132
Chroma_D4	0,268*	0,122	0,025	0,127	0,074	-0,126
Hue angle_D1	-0,257*	-0,385*	-0,365*	0,024	0,150	-0,032
Hue angle_D4	-0,129	-0,212*	-0,182	0,041	0,166	-0,015
MetMb_D1	0,227*	0,339**	0,279*	0,138	-0,140	-0,002
MetMb_D4	0,263*	0,259*	0,218	0,136	-0,004	-0,074
DeoxyMb_D4	-0,274*	-0,217	-0,158	-0,274*	0,102	0,135
OxyMb_D4	0,246*	0,182	0,127	0,274*	-0,127	-0,132

WHC_D4- water holding capacity taken at 4 days; WBSF- Warner Bratzler Shear Force; Chroma_D4– taken at 4 days post-mortem; Hue angle_D1- taken at 1 day post-mortem, Hue angle- taken at 4 days post-mortem; L*_D1- meat lightness of fresh meat samples taken at 1 day post-mortem, L*_D4- meat lightness of fresh meat samples taken at 4 days post-mortem; a*_D1- meat redness of fresh meat samples taken at 1 day post-mortem, a*_D4- meat redness of fresh meat samples taken at 4 days post-mortem; Chroma_D4– taken at 4 days post-mortem; Hue angle_D1- taken at 1 day post-mortem, Hue angle- taken at 4 days post-mortem; MetMb_D1- metmyoglobin (brownness) of meat sample taken at 1 day post-mortem; MetMb _D4- Metmyoglobin (brownness) of meat sample taken at 4 days post-mortem; DeoxyMb_D4- Deoxymyoglobin (purpleness) taken at 4 days post-mortem; OxyMb_D4- Oxymyoglobin (redness) of meat taken at 4 days post-mortem.

Table 4.91 Correlation coefficients between muscle fibres and meat quality traits for the *m. semimembranosus* (pooled data for all the goats)

	Cross sectional area			Fibre percentage		
	Red	Intermediate	White	Red	Intermediate	White
pH	-0,157	-0,152	-0,003	-0,002	-0,145	0,083
Drip loss	-0,091	-0,090	-0,088	-0,213*	0,203	0,186
Cooking loss	-0,342*	-0,417***	-0,383**	0,085	-0,094	-0,078
Thawing loss	0,048	-0,417***	-0,383**	0,085	-0,094	-0,078
MFL_D4	-0,109	0,086	0,218*	-0,314*	-0,037	0,156
WHC_D4	0,193	0,197	0,288*	-0,132	0,067	0,048
Fat	0,167	0,249*	0,190	0,017	-0,152	0,131
L*_D1	-0,286*	0,055	-0,167	0,080	-0,001	0,034
L*_D4	-0,307*	-0,248*	-0,219*	0,029	0,093	0,090
a*_D1	0,251*	-0,322*	-0,287*	-0,010	0,087	0,113
a*_D4	0,171	-0,337**	-0,285*	0,078	0,049	-0,007
b*_D1	0,025	0,236*	0,053	-0,071	0,217*	-0,126
h*_D1	-0,242*	0,152	-0,005	-0,060	0,221*	-0,088
h*_D4	-0,216*	-0,014	-0,054	-0,038	0,065	-0,021
MetMb_D1	0,394**	-0,201	-0,216*	0,121	0,068	-0,114
MetMb_D4	0,244*	0,037	-0,058	-0,151	0,170	0,097
DeoxyMb_D1	-0,187	0,335**	0,276*	-0,068*	0,329**	-0,277*
DeoxyMb_D4	-0,229	0,299*	0,175	0,135	0,092	-0,294*
OxyMb_D1	0,103	-0,113	-0,012	0,153	-0,246*	-0,014
OxyMb_D4	0,181	-0,259*	-0,150	-0,129	-0,045	0,202

MFL_D4- Myofibril fragment length at 4 days post-mortem; WHC_D4- water holding capacity taken at 4 days; L*_D1- meat lightness of fresh meat samples taken at 1 day post-mortem, L*_D4- meat lightness of fresh meat samples taken at 4 days post-mortem; a*_D1- meat redness of fresh meat samples taken at 1 day post-mortem, ; a*_D4- meat redness of fresh meat samples taken at 4 days post-mortem; b*_D1- meat yellowness of fresh meat samples taken at 1 day post-mortem, b*_D4- meat yellowness of fresh meat samples taken at 4 days post-mortem; Chroma_D1– taken at 1 day post-mortem, Chroma_D4 – taken at 4 days post-mortem; Hue angle_D1 - taken at 1 day post-mortem, Hue angle_D4- taken at 4 days post-mortem; MetMb_D1- Metmyoglobin (brownness) of meat sample taken at 1 day post-mortem, MetMb_D4- metmyoglobin (brownness) of meat sample taken at 4 days post-mortem , DeoxyMb_D1- Deoxymyoglobin (purpleness) taken at 1 post-mortem, DeoxyMb_D4- Deoxymyoglobin (purpleness) taken at 4 days post-mortem; OxyMb_D1- Oxymyoglobin (redness) of meat taken at 1 day post-mortem, OxyMb_D4- Oxymyoglobin (redness) of meat taken at 4 days post-mortem

4.8.2 Correlation coefficients between biochemical parameters and meat quality traits

The correlation between biochemical parameters and meat quality traits for the LD and SM muscles are presented in Table 4.92 and 4.93.

Table 4.92 Correlation coefficients between biochemical parameters and pH, temperature, cooking loss, thawing loss, drip loss, water holding capacity, sarcomere length and myofibril fragment length for the *m. longissimus dorsi* (pooled data for all the goats)

	pH	Temperature	Cooking Loss	Thawing Loss	Drip loss	WHCD1	WHCD4	sacromere Length	MFL_D1	MFL_D4
Lac 15	-0.343*	0.065	0.090	0.136	0.404**	-0.105	-0.109	0.015	-0.388**	-0.304**
Lac 1	-0.329*	-0.110	0.026	0.087	0.353*	-0.144	-0.071	0.014	-0.23089	-0.117
Lac 3	-0.269*	-0.219	0.088	0.039	0.320*	-0.099	-0.169	-0.205	-0.15352	-0.1
Lac 6	-0.464***	-0.240	0.055	0.153	0.272*	-0.196	-0.165	-0.289*	-0.330**	-0.376**
Lac 24	-0.509***	-0.098	-0.148	0.087	0.395**	0.011	0.054	-0.095	-0.1273	-0.346**
Gluc 15	0.156	-0.276*	0.003	0.180	-0.097	-0.026	0.015	-0.014	0.06	-0.041
Gluc 1	-0.138	-0.156	0.125	0.158	0.238*	-0.059	-0.018	-0.063	-0.028	-0.071
Gluc 3	0.144	-0.233	0.252*	-0.111	0.064	-0.063	-0.147	-0.039	-0.14	-0.039
Gluc 6	-0.109	-0.050	0.054	0.082	0.030	-0.001	-0.101	-0.067	-0.155	-0.086
Gluc 24	-0.130	0.080	-0.022	0.181	0.214	0.009	-0.111	-0.1163	0.033	-0.016
Glyc 15	-0.299*	-0.239*	-0.086	0.187	0.186	-0.209	-0.106	-0.045	-0.081	-0.271*
Glyc 1	-0.380**	-0.169	-0.147	0.234	0.322**	-0.100	-0.188	-0.104	0.014	-0.186
Glyc 3	-0.327**	-0.297*	-0.199	0.098	0.220	0.034	-0.140	-0.128	0.061	-0.164
Glyc 6	-0.218	-0.201	-0.113	0.021	0.089	-0.107	0.083	0.083	0.109	-0.018
Glyc 24	-0.015	-0.030	0.105	0.082	-0.023	-0.012	0.099	0.099	0.258*	0.12115
G6P 15	-0.177	-0.011	0.175	0.033	0.178	-0.037	-0.098	-0.098	0.147	0.03
G6P 1	-0.129	0.047	0.211	-0.014	0.252*	-0.221	-0.043	-0.043	-0.072	-0.23
G6P 3	-0.264*	0.325*	-0.172	0.034	0.395***	0.198	-0.070	-0.07	-0.053	-0.173
G6P 6	-0.194	0.226	0.124	-0.039	0.090	0.023	-0.169	-0.169	0.004	-0.07
G6P 24	-0.529***	-0.077	0.006	-0.028	0.234	0.078	-0.209	-0.209	-0.049	-0.171
ATP 15	0.325**	-0.074	0.293*	-0.047	-0.242*	-0.209	0.105	0.105	0.237	0.256*
ATP 1	-0.031	-0.187	-0.026	-0.043	-0.122	0.164	-0.137	-0.137	-0.118	0.1
ATP 3	0.051	-0.120	0.057	-0.164	-0.162	0.003	-0.097	-0.097	-0.062	-0.008
ATP 6	0.142	-0.095	0.138	0.060	-0.154	0.170	-0.001	-0.07	0.18	0.306**
ATP 24	0.058	-0.059	0.262*	0.062	-0.123	0.211	-0.054	-0.054	0.167	0.067
CP 15	0.213	0.082	-0.036	0.205	-0.244*	0.037	0.057	0.057	0.266*	0.350**
CP 1	0.184	-0.270*	0.039	0.063	-0.188	0.026	0.078	0.078	0.073	0.218
CP 3	-0.023	-0.024	0.053	-0.028	0.064	-0.091	-0.053	-0.053	-0.048	0.006
CP 6	-0.116	0.083	-0.129	0.111	0.249*	0.091	0.148	0.1483	0.022	0.092
CP 24	0.227	0.031	0.301*	-0.062	-0.131	-0.081	0.035	0.035	0.168	0.079
GP 15	-0.352*	-0.188	-0.144	-0.091	0.285*	-0.105	-0.058	-0.058	-0.164	-0.320**
GP 1	-0.470***	-0.180	-0.189	-0.019	0.462***	-0.091	-0.074	-0.074	-0.183	-0.250*
GP 3	-0.399***	-0.335**	-0.223	0.036	0.377*	-0.062	-0.217	-0.217	-0.056	-0.194
GP 6	-0.518***	-0.298*	-0.178	0.091	0.278*	-0.020	-0.173	-0.173	-0.187	-0.270*
GP 24	-0.484***	-0.083	0.068	0.083	0.347**	-0.100	-0.079	-0.079	0.023	-0.225

Lac 15- lactate concentration at 15 minutes post-mortem, Lac 1- lactate concentration at 1 hour post-mortem, Lac 3- lactate concentration at 3 hours post-mortem, Lac 24- lactate concentration at 24 hours post-mortem. Glu 15- glucose concentration at 15 minutes post-mortem, Glu 1- glucose concentration at 1 hour post-mortem, Glu 3- glucose concentration at 3 hours post-mortem, Glu 6- glucose concentration at 6 hours post-mortem, Glu 24- glucose concentration at 24 hours post-mortem. Glyc 15- glycogen concentration at 15 minutes post-mortem, Glyc 1- glycogen concentration at 1 hours post-mortem, Glyc 3- glycogen concentration at 3 hours post-mortem, Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glucose-6-phosphate concentration at 15 minutes post-mortem, G6P 1- glucose-6-phosphate concentration at 1 hours, G6P 3- glucose-6-phosphate concentration at 3 hours post-mortem, G6P 6- glucose-6-phosphate concentration at 6 hours post-mortem, G6P 24- glucose-6-phosphate concentration at 24 hours post-mortem, ATP 15- ATP content at 15 minutes, ATP 1- ATP content at 1 hour post-mortem, ATP 3- ATP content at 3 hours post-mortem, ATP 6- ATP content at 6 hours post-mortem, ATP 24- ATP content at 24 hours post-mortem, CP 15- creatine phosphate at 15 minutes post-mortem, CP 1- creatine phosphate at 1 hour post-mortem, CP 3- creatine phosphate at 3 hours post-mortem, CP 6- creatine phosphate at 6 hours post-mortem, CP 24- creatine phosphate at 24 hours post-mortem, GP 15- glycolytic potential at 15 minutes post-mortem, GP 1- glycolytic potential at 1 hour, GP 3- glycolytic potential at 3 hours post-mortem, GP 6- glycolytic potential at 6 hours post-mortem, GP 24- glycolytic potential at 24 hours post-mortem. WHCD1- water holding capacity measured at 1 day post-mortem, WHCD4- water holding capacity measured at 4 days post-mortem.

Table 4.93 Correlation coefficients between biochemical parameters and pH, temperature, cooking loss, thawing loss, drip loss, water holding capacity, sarcomere length and myofibril fragment length for the *m. semimembranosus* (pooled data for all the goats)

	pH	Temperature	Cooking Loss	Thawing Loss	Drip loss	WHCD1	WHCD4	WBSF	Sarcomere Length	MFL D1	MFL D4
Lac 15	-0,343*	0,065	0,090	0,136	0,404**	-0,105	-0,109	-0,129	0,015	-0,388*	-0,304*
Lac 1	-0,329*	-0,110	0,026	0,087	0,353*	-0,144	-0,071	-0,024	0,008	-0,231	-0,117
Lac 3	-0,269*	-0,219	0,088	0,039	0,320*	-0,099	-0,169	0,129	-0,205	-0,154	-0,100
Lac 6	-0,464***	-0,240	0,055	0,153	0,272*	-0,196	-0,165	0,060	-0,289*	-0,330**	-0,376*
Lac 24	-0,509***	-0,098	-0,148	0,087	0,395**	0,011	0,054	-0,013	-0,095	-0,127	-0,346**
Glu 15	0,156	-0,276*	0,003	0,180	-0,097	-0,026	0,015	0,138	-0,014	0,060	-0,041
Glu 1	-0,138	-0,156	0,125	0,158	0,238*	-0,059	-0,018	0,340**	-0,063	-0,028	-0,071
Glu 3	0,144	-0,233	0,252*	-0,111	0,064	-0,063	-0,147	0,173	-0,039	-0,140	-0,039
Glu 6	-0,109	-0,050	0,054	0,082	0,030	-0,001	-0,101	0,316*	-0,067	-0,155	-0,086
Glu 24	-0,130	0,080	-0,022	0,181	0,214	0,009	-0,111	0,365	-0,116	0,033	-0,016
Glyc 15	-0,299*	-0,239*	-0,086	0,187	0,186	-0,209	-0,106	-0,062	-0,045	-0,081	-0,271*
Glyc 1	-0,380**	-0,169	-0,147	0,234	0,322**	-0,100	-0,188	-0,068	-0,104	0,014	-0,186
Glyc 3	-0,327**	-0,297*	-0,199	0,098	0,220	0,034	-0,140	-0,072	-0,128	0,061	-0,164
Glyc 6	-0,218	-0,201	-0,113	0,021	0,089	-0,107	0,083	0,067	0,044	0,109	-0,009
Glyc 24	-0,015	-0,030	0,105	0,082	-0,023	-0,012	0,099	0,083	-0,033	0,258*	0,121
G6P 15	-0,177	-0,011	0,175	0,033	0,178	-0,037	-0,098	0,238	0,021	0,147	0,030
G6P 1	-0,129	0,047	0,211	-0,014	0,252*	-0,221	-0,043	0,137	-0,086	-0,072	-0,230
G6P 3	-0,264*	0,325*	-0,172	0,034	0,395***	0,198	-0,070	-0,018	0,078	-0,053	-0,173
G6P 6	-0,194	0,226	0,124	-0,039	0,090	0,023	-0,169	0,057	0,215	0,004	-0,070
G6P 24	-0,529***	-0,077	0,006	-0,028	0,234	0,078	-0,209	0,101	0,194	-0,049	-0,171
ATP 15	0,325**	-0,074	0,293*	-0,047	-0,242*	-0,209	0,105	0,172	-0,225	0,237	0,256*
ATP 1	-0,031	-0,187	-0,026	-0,043	-0,122	0,164	-0,137	0,439***	0,185	-0,118	0,100
ATP 3	0,051	-0,120	0,057	-0,164	-0,162	0,003	-0,097	0,455***	0,041	-0,062	-0,008
ATP 6	0,142	-0,095	0,138	0,060	-0,154	0,170	-0,001	0,250*	-0,018	0,180	0,306**
ATP 24	0,058	-0,059	0,262*	0,062	-0,123	0,211	-0,054	0,420***	0,053	0,167	0,067
CP 15	0,213	0,082	-0,036	0,205	-0,244*	0,037	0,057	0,240*	-0,002	0,266*	0,350**
CP 1	0,184	-0,270*	0,039	0,063	-0,188	0,026	0,078	0,344**	-0,052	0,073	0,218
CP 3	-0,023	-0,024	0,053	-0,028	0,064	-0,091	-0,053	0,074	-0,152	-0,048	0,006
CP 6	-0,116	0,083	-0,129	0,111	0,249*	0,091	0,148	-0,284*	0,041	0,022	0,092
CP 24	0,227	0,031	0,301*	-0,062	-0,131	-0,081	0,035	0,050	-0,137	0,168	0,079
GP 15	-0,352*	-0,188	-0,144	-0,091	0,285*	-0,105	-0,058	-0,227	0,244*	-0,164	-0,320**
GP 1	-0,470***	-0,180	-0,189	-0,019	0,462***	-0,091	-0,074	-0,149	0,223	-0,183	-0,250*
GP 3	-0,399***	-0,335**	-0,223	0,036	0,377*	-0,062	-0,217	-0,037	0,091	-0,056	-0,194
GP 6	-0,518***	-0,298*	-0,178	0,091	0,278*	-0,020	-0,173	-0,061	0,188	-0,187	-0,270*
GP 24	-0,484***	-0,083	0,068	0,083	0,347**	-0,100	-0,079	0,064	0,111	0,023	-0,225

Lac 15- lactate concentration at 15 minutes post-mortem, Lac 1- lactate concentration at 1 hour post-mortem, Lac 3- lactate concentration at 3 hours post-mortem, Lac 24- lactate concentration at 24 hours post-mortem. Glu 15- glucose concentration at 15 minutes post-mortem, Glu 1- glucose concentration at 1 hour post-mortem, Glu 3- glucose concentration at 3 hours post-mortem, Glu 6- glucose concentration at 6 hours post-mortem, Glu 24- glucose concentration at 24 hours post-mortem. Glyc 15- glycogen concentration at 15 minutes post-mortem, Glyc 1- glycogen concentration at 1 hours post-mortem, Glyc 3- glycogen concentration at 3 hours post-mortem Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glucose-6-phosphate concentration at 15 minutes post-mortem, G6P 1- glucose-6-phosphate concentration at 1 hours, G6P 3- glucose-6-phosphate concentration at 3 hours post-mortem, G6P 6- glucose-6-phosphate concentration at 6 hours post-mortem, G6P 24- glucose-6-phosphate concentration at 24 hours post-mortem, ATP 15- ATP content at 15 minutes, ATP 1- ATP content at 1 hour post-mortem, ATP 3- ATP content at 3 hours post-mortem, ATP 6- ATP content at 6 hours post-mortem, ATP 24- ATP content at 24 hours post-mortem, CP 15- creatine phosphate at 15 minutes post-mortem, CP 1- creatine phosphate at 1 hour post-mortem, CP 3- creatine phosphate at 3 hours post-mortem, CP 6- creatine phosphate at 6 hours post-mortem, CP 24- creatine phosphate at 24 hours post-mortem, GP 15- glycolytic potential at 15 minutes, GP 1- glycolytic potential at 1 hour, GP 3- glycolytic potential at 3 hours post-mortem, GP 6- glycolytic potential at 6 hours post-mortem, GP 24- glycolytic potential at 24 hours post-mortem. MFL_D1- Myofibril fragment length at 1 day post-mortem MFL_D4- Myofibril fragment length at 4 days post-mortem; WHC_D1- water holding capacity taken at 1 day; WHC_D4- water holding capacity taken at 4 days post-mortem

4.8.3 Correlation coefficients between biochemical parameters and instrumental colour coordinates and surface myoglobin redox

The correlation between biochemical parameters and meat quality traits for the LD and SM muscles are presented in Table 4.94 and 4.95.

Table 4.94 Correlation coefficients between biochemical parameters and colour for the *m. longissimus dorsi* (pooled data for all the goats)

	L*1	L*4	a*1	a*4	b*1	*b4	Chroma 1	Chroma 4	Hue angle1	Hue angle4	MetMb 1	MetMb 4	DeoxyMb 1	DeoxyMb 4	OxyMb 1	OxyMb 4
Lac 15	-0,145	-0,035	0,131	0,015	-0,048	-0,054	0,060	-0,017	-0,188	-0,081	0,058	0,059	0,044	0,164	-0,072	-0,208
Lac 1	-0,205	-0,085	0,212	0,072	-0,022	-0,008	0,121	0,039,	-0,267	-0,079	0,122	0,058	-0,005	0,098	-0,040	-0,131
Lac 3	-0,136	-0,038	0,142	0,117	-0,085	0,057	0,051	0,095	-0,273*	-0,024	0,063	0,092	0,033	-0,029	-0,060	0,005
Lac 6	-0,063	-0,016	0,139	0,007	0,051	-0,025	0,061	-0,010	-0,187	-0,014	-0,111	0,002	0,148	0,041	-0,134	-0,046
Lac 24	-0,073	0,007	0,242*	0,113	0,059	-0,028	0,175	0,055	-0,127	-0,136	0,018	0,133	-0,030	0,120	0,028	-0,186
Glu 15	0,072	0,057	-0,135	0,044	-0,081	0,152	-0,121	0,097	0,028	0,181	0,041	0,158	0,116	-0,229	-0,144	0,215
Glu 1	-0,026	0,044	0,106	0,227	-0,026	0,214	0,055	0,235	-0,142	0,092	0,023	0,155	-0,067	-0,164	0,053	0,141
Glu 3	0,022	0,023	-0,162	-0,121	-0,205	-0,090	-0,191	-0,116	-0,151	-0,015	-0,092	0,020	0,280*	0,078	-0,290**	-0,088
Glu 6	0,008	0,046	0,139	0,182	0,046	0,119	0,105	0,163	-0,068	0,004	0,037	0,058	-0,079	-0,032	0,090	0,005
Glu 24	0,055	0,130	0,123	0,147	0,097	0,181	0,119	0,169	0,030	0,137	-0,019	0,088	-0,074	-0,159	0,087	0,152
Glyc 15	-0,049	0,036	0,136	0,197	-0,040	0,104	0,067	0,168	-0,176	-0,036	0,067	0,133	0,097	-0,019	-0,141	-0,026
Glyc 1	-0,067	0,143	0,167	0,323**	-0,040	0,202	0,086	0,289*	-0,196	-0,023	0,225	0,265*	-0,054	-0,044	0,015	-0,039
Glyc 3	-0,045	0,118	0,191	0,378**	-0,036	0,260*	0,103	0,348**	-0,206	0,011	0,3**	0,366**	-0,104	-0,185	0,013	0,092
Glyc 6	0,007	0,061	0,204	0,417***	0,027	0,299**	0,140	0,389***	-0,126	0,038	0,220	0,289**	-0,096	-0,255*	0,028	0,197

Lac 15- lactate concentration at 15 minutes post-mortem, Lac 1- lactate concentration at 1 hour post-mortem, Lac 3- lactate concentration at 3 hours post-mortem, Lac 24- lactate concentration at 24 hours post-mortem. Glu 15- glucose concentration at 15 minutes post-mortem, Glu 1- glucose concentration at 1 hour post-mortem, Glu 3- glucose concentration at 3 hours post-mortem, Glu 6- glucose concentration at 6 hours post-mortem, Glu 24- glucose concentration at 24 hours post-mortem. Glyc 15- glycogen concentration at 15 minutes post-mortem, Glyc 1- glycogen concentration at 1 hours post-mortem, Glyc 3- glycogen concentration at 3 hours post-mortem Glyc 6- glycogen concentration at 6 hours post-mortem. L* 1 & 4- meat lightness of fresh meat samples taken at 1 day and 4 days post-mortem; a* 1 & 4- meat redness of fresh meat samples taken at 1 day and 4 days post-mortem; b* 1 & 4- meat yellowness of fresh meat samples taken at 1 day and 4 days post-mortem. Chroma 1 & 4 – taken at 1 day and 4 days post-mortem; Hue angle - taken at 1 day and 4 days post-mortem; MetMb 1 & 4 - metmyoglobin (brownness) of meat sample taken at 1 and 4 days post-mortem, DeoxyMb- Deoxymyoglobin (purpleness) of taken at 1 and 4 days post-mortem; OxyMb, - oxymyoglobin (redness) of meat taken at 1 and 4 days post-mortem

Table 4.94 Correlation coefficients between biochemical parameters and colour for the *m. longissimus dorsi* (pooled data for all the goats) (Continues)

	L*1	L*4	a*1	a*4	b*1	*b4	Chroma1	Chroma4	Hue angle1	Hue angle4	MetMb 1	MetMb 4	DeoxyMb 1	DeoxyMb 4	OxyMb 1	OxyMb 4
Glyc 24	-0,064	-0,005	0,159	0,160	0,061	0,083	0,127	0,135	-0,057	-0,028	0,103	0,150	-0,066	-0,069	0,038	0,031
G6P 15	-0,105	-0,020	0,081	0,149	0,025	0,123	0,062	0,146	-0,031	0,037	0,141	0,163	-0,148	-0,176	0,123	0,138
G6P 1	0,031	0,012	0,042	-0,050	0,011	-0,078	0,029	-0,068	0,001	-0,051	-0,114	0,009	-0,026	0,014	0,048	-0,018
G6P 3	0,015	0,069	0,134	-0,093	0,154	-0,015	0,136	0,059	0,016	-0,008	0,021	0,020	-0,111	0,078	-0,290	-0,049
G6P 6	0,016	0,177	0,111	0,300**	0,067	0,226	0,207	-0,065	0,133	0,091	-0,116	-0,038	0,024	0,065	0,126	-0,085
G6P 24	-0,060	-0,195	0,290**	0,047	-0,262*	-0,064	-0,241*	0,283*	-0,150	0,044	0,241*	0,207	-0,272*	-0,184	0,235*	0,150
ATP 15	-0,211	-0,200	-0,204	-0,011	-0,360**	-0,144	-0,316**	0,004	-0,172	-0,189	0,126	0,265*	0,121	-0,106	-0,177	0,042
ATP 1	-0,248*	-0,134	-0,252*	-0,079	-0,216	-0,099	-0,229	-0,072	-0,281*	-0,209	0,232	0,280*	0,118	0,043	-0,203	-0,142
ATP 3	-0,111	-0,326	-0,214	-0,123	-0,285*	-0,233	-0,255*	-0,095	-0,097	-0,060	0,008	0,176	0,129	0,003	-0,155	-0,068
ATP 6	-0,246*	0,012	-0,211	-0,027	-0,024	0,015	-0,031	-0,179	-0,193	-0,229	-0,002	0,052	0,109	0,060	-0,131	-0,081
ATP 24	0,000	0,055	-0,031	0,163	0,218	0,243*	0,157	-0,011	0,041	0,069	-0,025	0,029	0,070	-0,014	-0,077	0,000
CP 15	0,054	-0,068	0,097	-0,110	-0,217	-0,064	-0,293**	0,208	0,216	0,199	0,055	0,074	-0,213	-0,294**	0,223	0,308**
CP 1	0,006	0,015	-0,317**	-0,095	-0,311**	-0,090	-0,311**	-0,099	446,000	0,013	0,057	0,021	0,078	-0,068	-0,116	0,065
CP 3	-0,122	-0,025	-0,279*	0,121	-0,047	0,040	0,033	0,093	-0,174	-0,044	-0,073	-0,040	0,187	0,013	-0,198	-0,002
CP 6	-0,035	0,092	0,083	-0,087	-0,078	0,026	-0,115	-0,040	0,020	-0,087	0,251*	0,079	-0,170	0,036	0,124	-0,054
CP 24	-0,015	0,025	-0,130	0,194	-0,042	0,093	0,083	0,161	-0,203	0,112	0,030	-0,147	0,055	-0,017	-0,075	0,055
GP 15	-0,089	0,099	0,164	0,277	-0,046	0,159	0,115	0,238	-0,271	-0,046	0,084	0,144	0,105	0,021	-0,156	-0,077
GP 1	-0,128	0,099	0,220	0,277*	-0,046	0,159	0,115	0,238	-0,271*	-0,032	0,192	0,199	-0,003	0,040	-0,064	-0,107
GP 3	-0,105	0,099	0,217	0,277**	-0,046	0,159	0,115	0,238**	-0,271**	-0,007	0,252*	0,321**	-0,044	-0,143	-0,038	0,059
GP 6	-0,039	0,039	0,266*	0,296**	0,001	0,196	0,162	0,264*	-0,214	0,029	0,071	0,190	0,018	-0,156	-0,051	0,113
GP 24	-0,082	0,056	0,315**	0,230	0,097	0,087	0,238*	0,178	-0,137	-0,079	0,099	0,213	-0,111	-0,004	0,093	-0,067

Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glucose-6-phosphate concentration at 15 minutes post-mortem, G6P 1- glucose-6-phosphate concentration at 1 hours, G6P 3- glucose-6-phosphate concentration at 3 hours post-mortem, G6P 6- glucose-6-phosphate concentration at 6 hours post-mortem, G6P 24- glucose-6-phosphate concentration at 24 hours post-mortem, ATP 15- ATP content at 15 minutes, ATP 1- ATP content at 1 hour post-mortem, ATP 3- ATP content at 3 hours post-mortem, ATP 6- ATP content at 6 hours post-mortem, ATP 24- ATP content at 24 hours post-mortem, CP 15- creatine phosphate at 15 minutes post-mortem, CP 1- creatine phosphate at 1 hour post-mortem, CP 3- creatine phosphate at 3 hours post-mortem, CP 6- creatine phosphate at 6 hours post-mortem, CP 24- creatine phosphate at 24 hours post-mortem, GP 15- glycolytic potential at 15 minutes, GP 1- glycolytic potential at 1 hour, GP 3- glycolytic potential at 3 hours post-mortem, GP 6- glycolytic potential at 6 hours post-mortem, GP 24- glycolytic potential at 24 hours post-mortem. L* 1 & 4- meat lightness of fresh meat samples taken at 1 day and 4 days post-mortem; a* 1 & 4- meat redness of fresh meat samples taken at 1 day and 4 days post-mortem; b* 1 & 4- meat yellowness of fresh meat samples taken at 1 day and 4 days post-mortem. Chroma 1 & 4 – taken at 1 day and 4 days post-mortem; Hue angle - taken at 1 day and 4 days post-mortem; MetMb 1 & 4 - metmyoglobin (brownness) of meat sample taken at 1 day and 4 days post-mortem, DeoxyMb- Deoxymyoglobin (purpleness) of taken at 1 day and 4 days post-mortem; OxyMb, - oxymyoglobin (redness) of meat taken at 1 day and 4 days post-mortem.

Table 4.95 Correlation coefficients between biochemical parameters and meat colour for the *m. semimembranosus* (pooled data for all the goats)

	L*1	L*4	a*1	a*4	b*1	*b4	Chroma1	Chroma4	Hue angle1	Hue angle4	MetMb 1	MetMb 4	DeoxyMb 1	DeoxyMb 4	OxyMb 1	OxyMb 4
Lac 15	-0,040	-0,133	0,026	-0,077	-0,016	-0,018	0,009	-0,054	-0,067	0,065	0,100	0,133	0,050	0,027	-0,102	-0,082
Lac 1	0,013	-0,020	-0,028	0,160	-0,025	0,200	-0,029	0,183	0,002	0,173	0,373**	0,176	-0,037	-0,161	0,011	0,124
Lac 3	0,025	0,045	0,213	0,227	0,152	0,269*	0,196	0,252*	0,019	0,242*	0,191	0,315**	-0,304**	-0,356**	0,232	0,299**
Lac 6	-0,010	0,147	0,134	0,264*	0,093	0,302**	0,121	0,287*	0,017	0,262*	0,192	0,332**	-0,204	-0,413***	0,171	0,367**
Lac 24	0,182	-0,181	0,301**	-0,147	0,297**	-0,224	0,311**	-0,185	0,169	-0,254*	0,012	0,308**	-0,167	-0,358**	0,129	0,319**
Glu 15	0,009	0,045	-0,055	0,134	-0,074	0,122	-0,067	0,133	-0,061	0,075	0,080	-0,055	-0,029	0,094	0,033	-0,098
Glu 1	0,104	0,025	0,177	-0,167	0,144	-0,105	0,169	-0,146	0,067	0,012	0,129	0,150	-0,097	-0,205	0,082	0,173
Glu 3	0,018	0,309**	0,086	0,104	0,045	0,229	0,073	0,160	-0,019	0,305**	-0,186	0,359**	0,060	-0,103	-0,102	-0,017
Glu 6	0,264*	0,229	-0,022	0,153	0,115	0,217	0,032	0,185	0,231	0,227	-0,030	0,062	0,049	-0,150	0,008	0,150
Glu 24	0,030	-0,005	0,100	-0,041	0,048	-0,031	0,084	-0,038	-0,027	0,000	0,041	0,138	0,141	-0,159	-0,154	0,138
Glyc 15	0,097	0,148	0,013	0,038	0,022	0,106	0,017	0,068	0,026	0,166	-0,012	0,096	0,061	0,023	-0,089	-0,053
Glyc 1	0,129	0,046	0,085	-0,027	0,098	-0,018	0,093	-0,024	0,079	0,013	-0,074	0,193	0,059	-0,180	-0,071	0,151
Glyc 3	0,092	0,018	0,067	0,060	0,063	0,066	0,067	0,065	0,042	0,050	-0,043	0,085	0,145	-0,030	-0,150	0,023
Glyc 6	-0,038	-0,195	0,028	0,068	0,007	-0,062	0,022	0,014	-0,030	-0,210	0,104	0,104	0,069	-0,045	-0,075	0,021
Glyc 24	-0,146	0,073	0,076	-0,045	0,009	-0,049	0,051	-0,050	-0,078	-0,013	0,074	-0,103	-0,079	0,101	0,050	-0,083
G6P 15	0,096	0,244*	0,025	0,332**	0,035	0,359**	0,030	0,355**	0,041	0,250*	0,123	-0,005	0,034	0,159	-0,063	-0,175
G6P 1	0,220	-0,050	0,326**	0,160	0,377**	0,075	0,361**	0,128	0,268*	-0,042	0,424***	0,058	-0,329**	-0,286*	0,339**	0,311**
G6P 3	-0,012	0,128	0,114	0,251*	0,091	0,249*	0,108	0,258*	0,028	0,163	0,428***	0,306**	-0,176	-0,145	0,075	0,063
G6P 6	0,111	0,044	0,329**	0,410***	0,352**	0,319**	0,355**	0,385**	0,214	0,089	0,507***	0,254*	-0,385*	-0,185	0,313**	0,142
G6P 24	0,007	-0,149	0,362**	-0,132	0,218	-0,177	0,318	-0,157	-0,037	-0,134	-0,063	0,219	-0,392	-0,430	0,298	0,423

Lac 15- lactate concentration at 15 minutes post-mortem, Lac 1- lactate concentration at 1 hour post-mortem, Lac 3- lactate concentration at 3 hours post-mortem, Lac 24- lactate concentration at 24 hours post-mortem. Glu 15- glucose concentration at 15 minutes post-mortem, Glu 1- glucose concentration at 1 hour post-mortem, Glu 3- glucose concentration at 3 hours post-mortem, Glu 6- glucose concentration at 6 hours post-mortem, Glu 24- glucose concentration at 24 hours post-mortem. Glyc 15- glycogen concentration at 15 minutes post-mortem, Glyc 1- glycogen concentration at 1 hours post-mortem, Glyc 3- glycogen concentration at 3 hours post-mortem Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glycogen concentration at 15 minutes post-mortem, G6P 1- glycogen concentration at 1hour post-mortem, G6P 3- glycogen concentration at 3 hours post-mortem, G6P 6- glycogen concentration at 6 hours post-mortem, G6P 24- glycogen concentration at 24 hours post-mortem, L* 1 & 4- meat lightness of fresh meat samples taken at 1 day and 4 days post-mortem; a* 1 & 4- meat redness of fresh meat samples taken at 1 day and 4 days post-mortem; b* 1 & 4- meat yellowness of fresh meat samples taken at 1 day and 4 days post-mortem. Chroma 1 & 4 – taken at 1 day and 4 days post-mortem; Hue angle - taken at 1 day and 4 days post-mortem; MetMb 1 & 4 - metmyoglobin (brownness) of meat sample taken at 1 day and 4 days post-mortem, DeoxyMb- Deoxymyoglobin (purpleness) of taken at 1 day and 4 days post-mortem; OxyMb, - oxymyoglobin (redness) of meat taken at 1 day and 4 days post-mortem.

Table 4.95 Correlation coefficients between biochemical parameters and meat colour for the *m. semimembranosus* (pooled data for all the goats) (Continues)

	L*1	L*4	a*1	a*4	b*1	*b4	Chroma1	Chroma4	Hue angle1	Hue angle4	MetMb 1	MetMb 4	DeoxyMb 1	DeoxyMb 4	OxyMb 1	OxyMb 4
ATP 15	-0,212	-0,070	-0,100	-0,062	-0,196	-0,047	-0,145	-0,061	-0,188	0,041	-0,022	0,110	0,064	-0,011	-0,063	-0,036
ATP 1	-0,205	-0,113	-0,041	-0,112	-0,076	-0,143	-0,056	-0,130	-0,076	-0,088	-0,170	0,048	0,073	-0,074	-0,079	0,068
ATP 3	-0,107	-0,002	-0,121	-0,049	-0,169	-0,019	-0,145	-0,039	-0,139	0,028	0,049	0,027	0,219	0,032	-0,195	-0,052
ATP 6	-0,189	-0,081	-0,126	0,044	-0,214	0,045	-0,168	0,045	-0,229	0,024	0,101	0,031	0,042	-0,027	-0,061	0,013
ATP 24	-0,074	0,125	0,001	0,073	-0,046	0,106	-0,018	0,088	-0,086	0,139	0,142	-0,140	-0,016	-0,090	-0,011	0,163
CP 15	0,045	-0,105	-0,076	-0,064	-0,089	-0,065	-0,085	-0,068	-0,051	-0,020	0,100	0,284*	-0,045	-0,231	0,009	0,164
CP 1	-0,122	0,017	0,035	0,077	-0,006	0,067	0,022	0,075	-0,052	0,032	0,102	0,144	-0,012	-0,074	-0,013	0,030
CP 3	-0,109	-0,044	-0,043	0,129	0,009	0,047	-0,022	0,098	0,063	-0,056	-0,117	0,110	-0,135	-0,058	0,115	0,034
CP 6	-0,036	0,027	-0,113	0,033	-0,165	0,075	-0,140	0,054	-0,136	0,076	-0,002	0,080	0,147	-0,168	-0,125	0,154
CP 24	0,129	-0,004	-0,025	-0,088	0,018	-0,057	-0,010	-0,077	0,055	0,010	0,088	0,120	-0,035	-0,150	0,035	0,136
GP 15	0,115	0,070	0,012	0,052	0,022	0,130	0,016	0,088	0,026	0,196	0,079	0,124	0,067	0,040	-0,108	-0,084
GP 1	0,146	0,016	0,129	0,094	0,137	0,123	0,137	0,110	0,102	0,123	0,271*	0,288*	-0,027	-0,282*	-0,003	0,235
GP 3	0,082	0,091	0,214	0,264*	0,164	0,315**	0,201	0,294**	0,045	0,281*	0,169	0,347**	-0,125	-0,290*	0,056	0,225
GP 6	0,008	0,075	0,163	0,340**	0,132	0,308**	0,157	0,337**	0,043	0,173	0,297**	0,374**	-0,176	-0,414***	0,142	0,357**
GP 24	0,087	-0,357**	0,363**	0,052	0,291*	-0,097	0,348**	-0,011	0,086	-0,218	0,369**	0,271*	-0,228	-0,362**	0,164	0,333

ATP 15- ATP content at 15 minutes, ATP 1- ATP content at 1 hour post-mortem, ATP 3- ATP content at 3 hours post-mortem, ATP 6- ATP content at 6 hours post-mortem, ATP 24- ATP content at 24 hours post-mortem, CP 15- creatine phosphate at 15 minutes post-mortem, CP 1- creatine phosphate at 1 hour post-mortem, CP 3- creatine phosphate at 3 hours post-mortem, CP 6- creatine phosphate at 6 hours post-mortem, CP 24- creatine phosphate at 24 hours post-mortem, GP 15- glycolytic potential at 15 minutes, GP 1- glycolytic potential at 1 hour, GP 3- glycolytic potential at 3 hours post-mortem, GP 6- glycolytic potential at 6 hours post-mortem, GP 24- glycolytic potential at 24 hours post-mortem. L* 1 & 4- meat lightness of fresh meat samples taken at 1 day and 4 days post-mortem; a* 1 & 4- meat redness of fresh meat samples taken at 1 day and 4 days post-mortem; b* 1 & 4- meat yellowness of fresh meat samples taken at 1 day and 4 days post-mortem. Chroma 1 & 4 – taken at 1 day and 4 days post-mortem; Hue angle - taken at 1 day and 4 days post-mortem; MetMb 1 & 4 - metmyoglobin (brownness) of meat sample taken at 1 day and 4 days post-mortem, DeoxyMb- Deoxymyoglobin (purpleness) of taken at 1 day and 4 days post-mortem; OxyMb, - oxymyoglobin (redness) of meat taken at 1 day and 4 days post-mortem

4.8.4 Correlation coefficients between biochemical parameters and calpain systems

The correlation between biochemical parameters and calpain system for the LD and SM muscles are presented in Table 4.96 and 4.97.

Table 4.96 Correlation coefficients between biochemical parameters and calpain systems for the *m. longissimus dorsi* (pooled data for all the goats)

	Mpt (g) 15	Mpt (g)1	Mpt (g) 24	CalpIn 15	CalpIn S15	CalpIn 1	CalpIn 1 S	CalpIn 24	CalpIn S24	µcap 15	µcap S 15
Lac 15	0,370**	0,417***	0,430***	-0,352**	-0,409**	-0,375**	-0,220	-0,215	-0,307**	0,011	-0,146
Lac 1	0,216	0,288*	0,331**	-0,161	-0,218	-0,075	0,000	-0,119	-0,248*	-0,092	-0,118
Lac 3	0,063	0,221	0,239*	-0,124	-0,168	-0,108	-0,029	-0,126	-0,236*	-0,220	-0,163
Lac 6	0,242*	0,308**	0,321**	-0,256*	-0,269*	-0,234	-0,201	-0,254*	-0,348**	-0,028	0,067
Lac 24	0,387***	0,415**	0,395***	-0,015	-0,146	-0,045	-0,163	-0,177	-0,194	0,343**	0,134
Glu 15	0,098	0,054	-0,014	0,295**	0,201	0,206	0,033	0,278*	0,188	0,261*	0,363**
Glu 1	0,082	0,202	0,239*	0,020	0,019	-0,010	0,004	-0,074	-0,140	-0,024	-0,161
Glu 3	0,044	0,115	0,007	-0,007	-0,118	-0,035	0,056	-0,096	-0,160	-0,040	-0,111
Glu 6	0,073	0,078	0,105	-0,028	0,026	-0,135	-0,083	-0,028	-0,059	-0,081	-0,161
Glu 24	0,056	0,151	0,204	0,081	0,094	-0,005	-0,142	-0,098	-0,073	0,025	-0,078
Glyc 15	0,323**	0,279*	0,268*	-0,124	-0,122	-0,080	-0,099	-0,257*	-0,276*	0,203	0,126
Glyc 1	0,418***	0,377**	0,358**	0,036	0,022	0,049	-0,093	0,024	-0,090	0,293**	0,117
Glyc 3	0,338**	0,300**	0,276*	-0,019	-0,018	-0,018	-0,149	0,057	-0,001	0,176	0,004
Glyc 6	0,167	0,144	0,081	-0,075	-0,015	0,003	-0,093	0,060	0,092	0,046	-0,056
Glyc 24	0,089	0,113	0,028	0,033	0,059	0,029	0,007	0,093	0,104	-0,020	-0,152
G6P 15	0,195	0,229	0,273*	0,018	0,022	-0,195	-0,172	0,014	0,046	0,228	-0,206
G6P 1	0,236	0,210	0,230	-0,082	-0,128	-0,028	-0,202	-0,230	-0,059	0,142	-0,069

Mpt (g) 15- extractable proteins (grams), Mpt (g) 1- extractable proteins 1 hour post-mortem, Mpt (g) 24- extractable protein at 24 hours, CalpIn 15- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S15- Specific alpastatin inhibitor at 15 minutes post-mortem, CalpIn 1- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S1- Specific calpastatin inhibitor at 1hour post-mortem, CalpIn 24- calpastatin inhibitor at 24 minutes post-mortem, CalpIn S24- Specific calpastatin inhibitor at 24 hours post-mortem, µcap 15- µ-calpain at 15 minutes post-mortem, µcap S15- Specific µ-calpain at 15 minutes post-mortem. Lac 15- lactate concentration at 15 minutes post-mortem, Lac 1- lactate concentration at 1 hour post-mortem, Lac 3- lactate concentration at 3 hours post-mortem, Lac 24- lactate concentration at 24 hours post-mortem. Glu 15- glucose concentration at 15 minutes post-mortem, Glu 1- glucose concentration at 1 hour post-mortem, Glu 3- glucose concentration at 3 hours post-mortem, Glu 6- glucose concentration at 6 hours post-mortem, Glu 24- glucose concentration at 24 hours post-mortem. Glyc 15- glycogen concentration at 15 minutes post-mortem, Glyc 1- glycogen concentration at 1 hour post-mortem, Glyc 3- glycogen concentration at 3 hours post-mortem Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glycogen concentration at 15 minutes post-mortem, G6P 1- glycogen concentration at 1hour post-mortem

Table 4.96 Correlation coefficients between biochemical parameters and calpain systems for the *m. longissimus dorsi* (pooled data for all the goats) (Continues)

	Mpt (g) 15	Mpt (g)1	Mpt (g) 24	CalpIn 15	CalpIn S15	CalpIn 1	CalpIn 1 S	CalpIn 24	CalpIn S24	µcap 15	µcap S 15
G6P 3	0,207	0,219	0,266*	-0,221	-0,190	-0,137	-0,132	-0,301**	-0,301**	-0,013	-0,112
G6P 6	0,184	0,208	0,157	-0,052	-0,083	-0,016	-0,032	-0,103	-0,173	0,119	-0,036
G6P 24	0,342**	0,317**	0,275*	-0,228	-0,277*	-0,210	-0,225	-0,168	-0,303**	0,050	-0,136
ATP 15	0,077	0,029	-0,060	-0,100	-0,137	-0,076	-0,181	-0,021	-0,077	-0,111	-0,111
ATP 1	0,278*	0,202	0,228	0,012	-0,077	0,128	0,045	0,170	0,116	-0,041	-0,072
ATP 3	0,185	0,088	0,127	0,026	-0,076	0,113	0,016	0,172	0,222	-0,076	-0,020
ATP 6	0,114	0,179	0,121	0,175	0,126	0,212	0,084	0,209	0,207	0,015	0,078
ATP 24	0,116	0,047	0,079	0,023	-0,007	-0,045	-0,001	-0,010	0,022	0,094	-0,114
CP 15	-0,317**	-0,301**	-0,232	0,264*	0,352**	0,204	0,104	0,190	0,204	-0,014	0,058
CP 1	-0,016	-0,080	0,036	0,303*	0,361**	0,304**	0,241*	0,156	0,225	0,073	0,007
CP 3	0,105	0,121	0,095	-0,013	-0,131	-0,009	-0,130	0,047	-0,144	-0,013	-0,011
CP 6	-0,048	0,051	-0,024	-0,094	-0,100	-0,093	-0,072	-0,044	-0,127	-0,209	-0,141
CP 24	-0,146	0,099	-0,080	0,012	0,043	-0,063	-0,163	0,096	0,097	0,111	-0,021
GP 15	0,409***	0,38**	0,377**	-0,215	-0,213	-0,191	-0,172	-0,264*	-0,313**	0,184	0,018
GP 1	0,466***	0,452***	0,464***	-0,110	-0,160	-0,081	-0,160	-0,091	-0,227	0,175	0,017
GP 3	0,307**	0,373**	0,359**	-0,099	-0,132	-0,091	-0,133	-0,060	-0,169	0,005	-0,105
GP 6	0,312**	0,346**	0,312*	-0,255*	-0,216	-0,186	-0,222	-0,163	-0,185	0,001	-0,032
GP 24	0,385**	0,427***	0,376**	-0,022	-0,109	-0,057	-0,176	-0,131	-0,158	0,248*	-0, 00952

Glyc 3- glycogen concentration at 3 hours post-mortem Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glucose-6-phosphate concentration at 15 minutes post-mortem, G6P 1- glucose-6-phosphate concentration at 1 hours, G6P 3- glucose-6-phosphate concentration at 3 hours post-mortem, G6P 6- glucose-6-phosphate concentration at 6 hours post-mortem, G6P 24- glucose-6-phosphate concentration at 24 hours post-mortem, ATP 15- ATP content at 15 minutes, ATP 1- ATP content at 1 hour post-mortem, ATP 3- ATP content at 3 hours post-mortem, ATP 6- ATP content at 6 hours post-mortem, ATP 24- ATP content at 24 hours post-mortem, CP 15- creatine phosphate at 15 minutes post-mortem, CP 1- creatine phosphate at 1 hour post-mortem, CP 3- creatine phosphate at 3 hours post-mortem, CP 6- creatine phosphate at 6 hours post-mortem, CP 24- creatine phosphate at 24 hours post-mortem, GP 15- glycolytic potential at 15 minutes, GP 1- glycolytic potential at 1 hour, GP 3- glycolytic potential at 3 hours post-mortem, GP 6- glycolytic potential at 6 hours post-mortem, GP 24- glycolytic potential at 24 hours post-mortem. Mpt (g) 15- extractable proteins (grams), Mpt (g) 1- extractable proteins 1 hour post-mortem, Mpt (g) 24- extractable protein at 24 hours, CalpIn 15- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S15- Specific alpastatin inhibitor at 15 minutes post-mortem, CalpIn 1- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S1- Specific calpastatin inhibitor at 1hour post-mortem, CalpIn 24- calpastatin inhibitor at 24 minutes post-mortem, CalpIn S24- Specific calpastatin inhibitor at 24 hours post-mortem, µcap 15- µ-calpain at 15 minutes post-mortem, , µcap S15- Specific µ-calpain at 15 minutes post-mortem

Table 4.96 Correlation coefficients between biochemical parameters and calpain systems for the *m. longissimus dorsi* (pooled data for all the goats) (Continues)

	µcap 1	µcap S 1	µcap 24	µcap S 24	Mcalp 15	Mcalp S 15	Mcalp 1	Mcalp 1 Spec	Mcalp 24	Mcalp 24 Spec	CalpSt_ µcap 15	CalpSt_µc ap 1	CalpSt_ µcap 24	CalpSt_ Mcalp 15	CalpSt_ Mcalp 1	CalpSt_ Mcalp 24
Lac 15	-0,004	-0,046	-0,191	-0,295**	-0,228	-0,436***	-0,153	-0,422***	-0,254*	-0,521***	-0,381**	-0,336**	-0,102	-0,335**	-0,320**	-0,069
Lac 1	-0,117	-0,163	-0,289*	-0,389***	-0,049	-0,326**	-0,126	-0,361**	-0,173	-0,442***	-0,068	0,013	0,036	-0,095	-0,010	0,030
Lac 3	-0,154	-0,310**	-0,340**	-0,331**	-0,057	-0,301**	-0,170	-0,349**	-0,244*	-0,416***	0,066	0,011	0,052	0,012	-0,022	0,045
Lac 6	0,033	-0,217	-0,287*	-0,255**	0,036	-0,231	0,061	-0,241*	-0,085	-0,308**	-0,234	-0,244*	-0,186	-0,272*	-0,274*	-0,185
Lac 24	0,167	-0,125	-0,224	-0,334**	-0,007	-0,183	-0,001	-0,277*	-0,124	-0,254*	-0,264*	-0,134	-0,055	-0,198	-0,104	-0,042
Glu 15	0,053	-0,012	0,232	0,138	-0,010	0,095	-0,094	0,084	-0,122	-0,024	0,073	0,115	0,125	0,169	0,171	0,289*
Glu 1	-0,047	-0,146	-0,129	-0,136	-0,095	-0,274*	-0,102	-0,243*	-0,236*	-0,345**	0,013	0,010	0,012	0,037	0,016	0,037
Glu 3	0,057	0,076	-0,165	-0,118	0,017	-0,091	0,011	-0,071	-0,147	-0,070	-0,055	-0,096	-0,028	-0,063	-0,091	-0,018
Glu 6	-0,065	-0,160	-0,085	-0,068	-0,183	-0,174	-0,108	-0,058	-0,235	-0,204	-0,048	-0,121	-0,036	-0,014	-0,110	0,027
Glu 24	0,025	-0,059	0,021	-0,005	-0,185	-0,215	-0,107	-0,182	-0,214	-0,229	0,013	-0,026	-0,106	0,085	0,023	-0,075
Glyc 15	0,131	-0,176	-0,305**	-0,271*	0,095	-0,179	0,205	-0,063	0,056	-0,297**	-0,268*	-0,100	-0,063	-0,248*	-0,121	-0,210
Glyc 1	0,258*	-0,062	-0,106	-0,085	0,049	-0,205	0,089	-0,181	0,065	-0,217	-0,162	-0,085	0,059	-0,087	-0,033	0,047
Glyc 3	0,111	-0,096	0,019	0,021	-0,018	-0,182	-0,030	-0,219	-0,050	-0,220	-0,135	-0,058	0,027	-0,082	-0,017	0,085
Glyc 6	0,046	-0,152	0,080	0,125	-0,027	-0,078	0,070	-0,039	0,081	0,009	-0,086	-0,023	-0,012	-0,071	-0,014	0,015
Glyc 24	-0,037	-0,073	0,012	-0,079	-0,138	-0,090	-0,067	-0,164	-0,064	0,004	0,051	0,077	0,143	0,069	0,085	0,170
G6P 15	0,039	0,027	0,044	-0,141	-0,219	-0,344**	-0,325**	-0,356**	-0,245*	-0,317**	-0,115	-0,029	-0,012	0,005	0,051	0,091
G6P 1	0,138	-0,129	-0,122	-0,059	-0,225	-0,331**	-0,085	-0,197	-0,231	-0,264*	-0,221	-0,236	-0,145	-0,135	-0,194	-0,143
G6P 3	0,082	-0,074	-0,358**	-0,253*	-0,260*	-0,322**	-0,095	-0,236*	-0,174	-0,250*	-0,233	-0,251*	-0,088	-0,186	-0,221	-0,165
G6P 6	0,163	0,103	-0,168	-0,165	-0,108	-0,159	-0,002	-0,173	0,001	-0,083	-0,215	-0,105	-0,071	-0,162	-0,056	-0,109
G6P 24	0,073	-0,008	0,040	-0,101	0,015	-0,188	0,052	-0,243*	-0,111	-0,279*	-0,250*	-0,247*	-0,217	-0,259*	-0,243*	-0,150

Lac 15- lactate concentration at 15 minutes post-mortem, Lac 1- lactate concentration at 1 hour post-mortem, Lac 3- lactate concentration at 3 hours post-mortem, Lac 24- lactate concentration at 24 hours post-mortem. Glu 15- glucose concentration at 15 minutes post-mortem, Glu 1- glucose concentration at 1 hour post-mortem, Glu 3- glucose concentration at 3 hours post-mortem, Glu 6- glucose concentration at 6 hours post-mortem, Glu 24- glucose concentration at 24 hours post-mortem. Glyc 15- glycogen concentration at 15 minutes post-mortem, Glyc 1- glycogen concentration at 1 hours post-mortem, Glyc 3- glycogen concentration at 3 hours post-mortem Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glycogen concentration at 15 minutes post-mortem, G6P 1- glycogen concentration at 1hour post-mortem. µcap 1- µcalpain at 1 hour post-mortem, µcap S1- Specific µcalpain at 1 hour post-mortem, µcap 24- µcalpain at 24 hour post-mortem, Mcap 15- m-calpain at 15 minutes post-mortem, Mcap S1- Specific m-calpain at 1 hour post-mortem, Mcap 24- Specific m-calpain at 24 hour post-mortem, Mcap S24- Specific m-calpain at 24 hours post-mortem, CalSt_µcap 15- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S15- Specific calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap 1- calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap S1- Specific calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap 24- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S24- Specific calpastatin/µ-calpain at 24 minutes post-mortem

Table 4.96 Correlation coefficients between biochemical parameters and calpain systems for the *m. longissimus dorsi* (pooled data for all the goats) (Continues)

	µcap 1	µcap S 1	µcap 24	µcap S 24	Mcalp 15	Mcalp S 15	Mcalp 1	Mcalp 1 Spec	Mcalp 24	Mcalp 24 Spec	CalpSt_ µcap 15	CalpSt_µ cap 1	CalpSt _ µcap 24	CalpSt_ Mcalp 15	CalpSt_ Mcalp 1	CalpSt_ Mcalp 24
ATP 1	0,064	-0,140	0,008	0,044	-0,137	-0,118	-0,125	-0,105	-0,014	-0,243*	0,109	0,055	0,148	0,144	0,106	0,215
ATP 3	-0,051	-0,215	0,132	0,153	-0,247*	-0,026	-0,129	-0,096	-0,046	-0,027	0,097	0,095	0,086	0,134	0,119	0,200
ATP 6	0,136	0,139	0,083	0,060	-0,161	-0,114	-0,135	-0,229	0,058	0,020	0,173	0,089	0,150	0,225	0,165	0,263*
ATP 24	0,096	0,006	-0,008	-0,057	-0,244*	-0,228	-0,206	-0,108	-0,243*	-0,082	-0,119	-0,137	-0,057	-0,022	-0,067	0,047
CP 15	-0,188	-0,110	0,276*	0,245*	-0,093	0,087	-0,205	0,153	0,031	0,167	0,329**	0,325**	0,004	0,363**	0,326**	0,122
CP 1	0,105	0,014	0,186	0,228	0,045	0,066	0,032	0,156	0,171	0,029	0,316**	0,232	0,070	0,352**	0,271*	0,065
CP 3	0,005	-0,217	0,102	-0,025	-0,055	-0,026	-0,004	-0,079	-0,097	-0,075	-0,001	-0,047	0,010	0,020	-0,054	0,035
CP 6	-0,144	-0,058	-0,095	-0,082	0,005	-0,038	-0,132	-0,119	-0,173	-0,129	0,069	-0,004	0,026	0,002	-0,029	0,041
CP 24	-0,017	-0,037	0,179	0,111	-0,031	0,058	-0,219	-0,054	-0,134	0,056	-0,089	-0,061	-0,071	-0,036	-0,009	0,041
GP 15	0,105	-0,174	-0,336**	-0,318**	-0,044	-0,344**	0,072	-0,232	-0,060	-0,436***	-0,349**	-0,183	-0,053	-0,305**	-0,185	-0,162
GP 1	0,111	-0,147	-0,269*	-0,295**	-0,091	-0,409***	-0,093	-0,398**	-0,191	-0,473***	-0,213	-0,124	0,037	-0,183	-0,087	0,048
GP 3	0,009	-0,242*	-0,216	-0,197	-0,065	-0,334**	-0,122	-0,380**	-0,198	-0,419***	-0,088	-0,065	0,039	-0,149	-0,050	0,073
GP 6	0,072	-0,266*	-0,156	-0,111	-0,039	-0,278*	0,082	-0,217	-0,031	-0,261*	-0,253*	-0,220	-0,172	-0,075	-0,228	-0,147
GP 24	0,119	-0,133	-0,143	-0,291**	-0,095	-0,239*	-0,039	-0,344**	-0,172	-0,266*	-0,207	-0,109	-0,031	-0,263*	-0,075	0,008

ATP 1- ATP content at 1 hour post-mortem, ATP 3- ATP content at 3 hours post-mortem, ATP 6- ATP content at 6 hours post-mortem, ATP 24- ATP content at 24 hours post-mortem, CP 15- creatine phosphate at 15 minutes post-mortem, CP 1- creatine phosphate at 1 hour post-mortem, CP 3- creatine phosphate at 3 hours post-mortem, CP 6- creatine phosphate at 6 hours post-mortem, CP 24- creatine phosphate at 24 hours post-mortem, GP 15- glycolytic potential at 15 minutes, GP 1- glycolytic potential at 1 hour, GP 3- glycolytic potential at 3 hours post-mortem, GP 6- glycolytic potential at 6 hours post-mortem, GP 24- glycolytic potential at 24 hours post-mortem. µcap 1- µcalpain at 1 hour post-mortem, µcap S1- Specific µcalpain at 1 hour post-mortem, µcap 24- µcalpain at 24 hour post-mortem, Mcap 15- m-calpain at 15 minutes post-mortem, Mcap S1- Specific m-calpain at 1 hour post-mortem, Mcap 24- Specific m-calpain at 24 hour post-mortem, Mcap S24- Specific m-calpain at 24 hours post-mortem, CalSt_µcap 15- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S15- Specific calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap 1- calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap S1- Specific calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap 24- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S24- Specific calpastatin/µ-calpain at 24 minutes post-mortem

Table 4.97 Correlation coefficients between biochemical parameters and calpain systems for the *m. semimembranosus* (pooled data for all the goats)

	Mp(g)15	Mp(g)1	Mp(g)24	CapIn15	CalpIn S15	CapIn1	CapInS1	CapIn24	CapInS24	µcap 15	µcap S15
Lac 15	0,099	0,172	-0,025	-0,054	-0,113	0,010	-0,161	0,056	0,078	-0,011	-0,131
Lac 1	0,210	0,306**	0,105	0,132	-0,004	0,070	-0,023	0,148	0,124	0,235*	0,112
Lac 3	0,124	0,223	0,076	0,019	-0,014	0,157	0,074	0,130	0,055	-0,021	-0,060
Lac 6	0,213	0,275*	0,234*	0,086	-0,009	0,167	0,023	0,125	-0,021	-0,030	-0,205
Lac 24	0,177	0,163	0,053	-0,072	-0,179	0,070	-0,053	0,029	0,006	-0,009	-0,141
Glu 15	0,152	0,216	0,168	0,030	0,099	0,051	-0,171	0,133	0,093	0,088	-0,067
Glu 1	0,090	0,030	-0,083	-0,120	-0,124	0,054	0,010	-0,092	-0,066	-0,155	-0,132
Glu 3	0,186	0,248*	0,083	-0,078	-0,186	-0,123	-0,082	-0,093	-0,131	-0,053	-0,186
Glu 6	-0,281*	-0,245*	-0,242*	-0,259*	-0,078	-0,166	-0,093	0,045	0,131	-0,302**	0,021
Glu 24	-0,024	-0,071	-0,051	-0,015	0,043	-0,069	0,029	-0,050	-0,108	0,227	0,197
Glyc 15	0,010	0,004	-0,086	0,046	0,009	0,017	-0,040	-0,110	-0,047	0,119	0,054
Glyc 1	0,010	-0,060	-0,076	0,065	0,021	0,155	0,162	0,026	0,019	-0,032	-0,057
Glyc 3	0,101	0,075	0,114	0,050	0,017	0,134	0,020	-0,007	-0,037	0,024	-0,077
Glyc 6	0,123	0,080	0,186	0,007	-0,011	0,061	0,003	0,039	0,041	0,117	-0,099
Glyc 24	0,083	0,046	0,081	0,173	0,120	0,281*	0,116	0,047	0,105	0,004	-0,076
G6P 15	0,147	0,106	-0,013	-0,059	-0,081	0,006	-0,089	-0,081	0,042	0,100	-0,088
G6P 1	0,020	0,034	0,109	-0,202	-0,107	-0,151	-0,070	-0,105	-0,166	-0,092	-0,110
G6P 3	0,360**	0,263*	0,291*	0,013	-0,158	0,161	-0,023	-0,136	-0,163	-0,008	-0,210
G6P 6	0,138	0,210	0,145	-0,075	-0,259*	-0,019	0,031	-0,083	-0,043	-0,107	-0,214
G6P 24	0,267*	0,264*	0,212*	0,145	-0,071	0,094	-0,122	0,014	-0,100	0,105	-0,032

Lac 15- lactate concentration at 15 minutes post-mortem, Lac 1- lactate concentration at 1 hour post-mortem, Lac 3- lactate concentration at 3 hours post-mortem, Lac 24- lactate concentration at 24 hours post-mortem. Glu 15- glucose concentration at 15 minutes post-mortem, Glu 1- glucose concentration at 1 hour post-mortem, Glu 3- glucose concentration at 3 hours post-mortem, Glu 6- glucose concentration at 6 hours post-mortem, Glu 24- glucose concentration at 24 hours post-mortem. Glyc 15- glycogen concentration at 15 minutes post-mortem, Glyc 1- glycogen concentration at 1 hours post-mortem, Glyc 3- glycogen concentration at 3 hours post-mortem Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glycogen concentration at 15 minutes post-mortem, G6P 1- glycogen concentration at 1hour post-mortem, G6P 3- glycogen concentration at 3 hours post-mortem, G6P 6- glycogen concentration at 6 hours post-mortem, G6P 24- glycogen concentration at 24 hours post-mortem. Mpt (g) 15- extractable proteins (grams), Mpt (g) 1- extractable proteins 1 hour post-mortem, Mpt (g) 24- extractable protein at 24 hours, CalpIn 15- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S15- Specific alpastatin inhibitor at 15 minutes post-mortem, CalpIn 1- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S1- Specific calpastatin inhibitor at 1hour post-mortem, CalpIn 24- calpastatin inhibitor at 24 minutes post-mortem, CalpIn S24- Specific calpastatin inhibitor at 24 hours post-mortem, µcap 15- µ-calpain at 15 minutes post-mortem, , µcap S15- Specific µ-calpain at 15 minutes post-mortem

Table 4.97 Correlation coefficients between biochemical parameters and calpain systems for the *m. semimembranosus* (pooled data for all the goats) (Continues)

	Mp(g)15	Mp(g)1	Mp(g)24	CapIn15	CalpIn S15	CapIn1	CapInS1	CapIn24	CapInS24	µcap 15	µcap S15
ATP 15	0,205	0,225	0,283*	-0,002	-0,010	0,014	-0,282*	0,060	-0,015	0,048	-0,064
ATP 1	0,116	0,126	0,137	-0,059	-0,058	-0,081	-0,081	0,048	0,039	0,261*	0,041
ATP 3	0,091	0,076	0,052	0,018	0,103	-0,023	-0,074	0,114	0,087	0,265*	0,179
ATP 6	0,000	0,005	0,115	0,086	0,034	0,041	0,004	0,053	0,002	-0,113	-0,030
ATP 24	-0,045	-0,074	0,032	-0,165	-0,106	-0,001	-0,092	-0,085	-0,105	-0,142	-0,088
CP 15	0,253*	0,224	0,260*	-0,103	-0,113	0,042	-0,212*	0,026	-0,091	-0,006	-0,157
CP 1	0,154	0,108	0,073	-0,134	-0,222	-0,157	0,009	0,053	0,101	0,243*	-0,040
CP 3	0,073	0,028	0,129	-0,136	-0,253*	-0,117	-0,139	0,077	0,107	0,031	-0,225
CP 6	-0,115	-0,195	-0,035	0,034	0,167	0,011	0,138	0,114	0,110	-0,074	0,078
CP 24	-0,083	-0,134	-0,107	-0,118	0,013	-0,089	0,016	0,033	0,071	-0,094	-0,014
GP 15	0,048	0,069	-0,092	0,011	-0,033	0,013	-0,104	-0,053	0,016	0,128	-0,002
GP 1	0,106	0,097	-0,016	0,047	-0,026	0,151	0,139	0,059	0,047	0,031	-0,058
GP 3	0,218	0,259*	0,174	0,043	-0,036	0,209	0,059	0,055	-0,021	-0,003	-0,134
GP 6	0,237*	0,278*	0,293**	0,045	-0,049	0,158	0,015	0,124	0,011	-0,004	-0,250*
GP 24	0,233	0,197	0,117	0,032	-0,115	0,176	-0,021	0,039	0,005	0,045	-0,135

ATP 1- ATP content at 1 hour post-mortem, ATP 3- ATP content at 3 hours post-mortem, ATP 6- ATP content at 6 hours post-mortem, ATP 24- ATP content at 24 hours post-mortem, CP 15- creatine phosphate at 15 minutes post-mortem, CP 1- creatine phosphate at 1 hour post-mortem, CP 3- creatine phosphate at 3 hours post-mortem, CP 6- creatine phosphate at 6 hours post-mortem, CP 24- creatine phosphate at 24 hours post-mortem, GP 15- glycolytic potential at 15 minutes, GP 1- glycolytic potential at 1 hour, GP 3- glycolytic potential at 3 hours post-mortem, GP 6- glycolytic potential at 6 hours post-mortem, GP 24- glycolytic potential at 24 hours post-mortem. Mpt (g) 15- extractable proteins (grams), Mpt (g) 1- extractable proteins 1 hour post-mortem, Mpt (g) 24- extractable protein at 24 hours, CalpIn 15- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S15- Specific alpastatin inhibitor at 15 minutes post-mortem, CalpIn 1- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S1- Specific calpastatin inhibitor at 1hour post-mortem, CalpIn 24- calpastatin inhibitor at 24 minutes post-mortem, CalpIn S24- Specific calpastatin inhibitor at 24 hours post-mortem, µcap 15- µ-calpain at 15 minutes post-mortem, , µcap S15- Specific µ-calpain at 15 minutes post-mortem.

Table 4.97 Correlation coefficients between biochemical parameters and calpain systems for the *m. semimembranosus* (pooled data for all the goats) (Continues)

	µcap 1	µcap S1	µcap 24	µcap S 24	Mcalp 15	Mcalp S 15	Mcalp 1	Mcalp S1	Mcalp 24	Mcalp S24	CalpSt_ UC15	CalpSt_ UC1	CalpSt_ UC24	CalpSt_ Mcalp 15	CalpSt_ Mcalp 1	CalpSt_ Mcalp 24
Lac 15	-0,009	-0,191	-0,073	0,067	-0,136	-0,168	-0,283*	-0,351	-0,014	0,062	-0,063	-0,033	0,079	-0,046	0,022	0,102
Lac 1	0,215	0,184	-0,102	-0,066	-0,028	-0,195	-0,045	-0,377**	0,043	-0,010	-0,073	-0,055	0,308**	0,011	0,013	0,202
Lac 3	0,073	0,100	-0,090	-0,087	-0,064	-0,143	-0,094	-0,311**	-0,005	-0,055	0,036	0,091	0,236*	0,048	0,146	0,188
Lac 6	-0,008	-0,105	-0,065	-0,033	0,015	-0,117	-0,070	-0,251*	-0,102	-0,141	0,123	0,128	0,177	0,116	0,162	0,173
Lac 24	0,155	0,008	-0,035	-0,051	-0,045	-0,045	-0,052	-0,090	-0,165	-0,007	-0,056	-0,004	0,044	-0,070	0,056	0,128
Glu 15	0,164	-0,202	0,307**	0,145	0,050	-0,084	0,143	0,079	-0,003	-0,043	-0,031	-0,092	-0,075	-0,011	-0,091	0,044
Glu 1	-0,148	-0,100	-0,244*	-0,131	-0,141	-0,144	-0,036	0,003	-0,253*	-0,159	0,020	0,162	0,137	-0,019	0,121	0,085
Glu 3	-0,090	-0,117	-0,149	-0,238*	-0,160	-0,207*	-0,231	-0,347**	-0,079	-0,155	-0,048	-0,033	-0,012	-0,030	-0,012	-0,039
Glu 6	-0,228	0,092	-0,209	-0,062	-0,313**	-0,062	-0,212	-0,031	-0,168	0,153	-0,042	0,006	0,145	-0,094	-0,039	0,153
Glu 24	0,138	0,302**	-0,034	-0,077	0,007	0,037	-0,103	-0,135	-0,008	-0,046	-0,201	-0,178	-0,036	-0,123	-0,108	-0,039
Glyc 15	0,197	0,112	-0,157	-0,226	-0,191	-0,195	-0,146	-0,012	-0,186	-0,038	-0,042	-0,063	-0,008	0,035	0,027	-0,034
Glyc 1	0,116	0,117	-0,077	-0,092	-0,202	-0,107	-0,119	-0,036	-0,049	0,018	0,080	0,088	0,054	0,126	0,167	0,054
Glyc 3	0,215	0,086	-0,014	-0,131	-0,025	-0,119	0,083	0,035	0,262*	0,151	0,033	-0,033	-0,005	0,046	0,019	-0,062
Glyc 6	0,196	0,103	0,136	-0,025	0,045	-0,074	0,171	0,051	0,419***	0,270*	-0,108	-0,103	-0,044	-0,071	-0,073	-0,073
Glyc 24	0,116	0,008	0,009	0,073	-0,038	-0,181	0,047	0,092	0,095	0,126	0,180	0,179	0,081	0,199	0,215	0,065
G6P 15	0,103	-0,047	-0,017	0,071	0,122	-0,206*	-0,045	-0,133	0,035	0,109	-0,163	-0,056	-0,125	-0,156	-0,011	-0,067
G6P 1	0,081	0,061	-0,050	0,000	-0,230	-0,110	-0,054	-0,049	-0,124	-0,168	-0,132	-0,074	-0,041	-0,133	-0,029	-0,057
G6P 3	-0,014	-0,057	-0,150	-0,217	0,147	-0,114	0,074	-0,076	-0,006	-0,217	0,018	0,174	-0,070	-0,016	0,169	-0,104
G6P 6	-0,011	0,051	-0,023	0,023	-0,011	-0,037	0,077	-0,156	-0,057	-0,107	0,023	0,057	-0,091	-0,013	0,047	-0,091
G6P 24	0,127	0,106	0,052	-0,160	0,045	-0,019	-0,062	-0,229	-0,189	-0,374**	0,058	0,017	0,044	0,088	0,081	0,066

Lac 15- lactate concentration at 15 minutes post-mortem, Lac 1- lactate concentration at 1 hour post-mortem, Lac 3- lactate concentration at 3 hours post-mortem, Lac 24- lactate concentration at 24 hours post-mortem. Glu 15- glucose concentration at 15 minutes post-mortem, Glu 1- glucose concentration at 1 hour post-mortem, Glu 3- glucose concentration at 3 hours post-mortem, Glu 6- glucose concentration at 6 hours post-mortem, Glu 24- glucose concentration at 24 hours post-mortem. Glyc 15- glycogen concentration at 15 minutes post-mortem, Glyc 1- glycogen concentration at 1 hours post-mortem, Glyc 3- glycogen concentration at 3 hours post-mortem Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 6- glycogen concentration at 6 hours post-mortem, Glyc 24- glycogen concentration at 24 hours post-mortem, G6P 15- glycogen concentration at 15 minutes post-mortem, G6P 1- glycogen concentration at 1hour post-mortem, G6P 3- glycogen concentration at 3 hours post-mortem, G6P 6- glycogen concentration at 6 hours post-mortem, G6P 24- glycogen concentration at 24 hours post-mortem. µcap 1- µcalpain at 1 hour post-mortem, µcap S1- Specific µcalpain at 1 hour post-mortem, µcap 24- µcalpain at 24 hour post-mortem, Mcap 15- m-calpain at 15 minutes post-mortem, Mcap S1- Specific m-calpain at 1 hour post-mortem, Mcap 24- Specific m-calpain at 24 hour post-mortem, Mcap S24- Specific m-calpain at 24 hours post-mortem, CalSt_µcap 15- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S15- Specific calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap 1- calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap S1- Specific calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap 24- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S24- Specific calpastatin/µ-calpain at 24 minutes post-mortem

Table 4.97 Correlation coefficients between biochemical parameters and calpain systems for the *m. semimembranosus* (pooled data for all the goats) (Continues)

	µcap 1	µcap S1	µcap 24	µcap S 24	Mcalp 15	Mcalp S 15	Mcalp 1	Mcalp S1	Mcalp 24	Mcalp S24	CalpSt_ UC15	CalpSt_ UC1	CalpSt_ UC24	CalpSt_ Mcalp 15	CalpSt_ Mcalp 1	CalpSt_ Mcalp 24
ATP 15	0,125	-0,192	0,196	0,031	0,215	-0,161	0,104	-0,067	0,125	-0,148	-0,065	-0,181	-0,014	-0,094	-0,186	-0,017
ATP 1	0,265*	0,136	0,187	0,037	0,242*	0,072	0,111	-0,137	0,085	-0,020	-0,288*	-0,246*	-0,046	-0,253*	-0,192	-0,060
ATP 3	0,299**	0,043	0,099	0,121	0,237*	0,113	0,161	0,073	0,195	0,163	-0,218	-0,228	0,090	-0,177	-0,167	0,063
ATP 6	-0,144	-0,177	0,165	0,084	0,175	0,046	0,089	0,067	0,216	0,077	0,164	0,078	-0,088	0,108	0,014	-0,049
ATP 24	-0,098	-0,021	0,082	0,064	0,012	0,100	0,041	-0,026	0,037	0,109	-0,027	0,058	-0,201	-0,091	0,027	-0,010
CP 15	-0,010	-0,264*	0,035	-0,053	0,083	-0,247*	0,072	-0,123	0,027	-0,240	-0,101	-0,041	-0,021	-0,125	-0,062	-0,037
CP 1	0,116	0,172	0,075	-0,022	0,043	-0,136	-0,074	-0,382**	0,077	0,023	-0,365**	-0,163	0,005	-0,300**	-0,122	-0,019
CP 3	-0,012	-0,063	0,181	0,008	0,131	0,104	0,059	-0,087	0,011	-0,030	-0,189	-0,100	-0,071	-0,210	-0,111	-0,040
CP 6	-0,042	0,134	-0,089	-0,174	-0,010	0,085	0,149	0,050	0,158	0,081	0,067	0,030	0,162	0,074	-0,014	0,090
CP 24	-0,129	-0,078	0,108	0,171	0,015	-0,022	-0,106	-0,066	-0,077	0,042	-0,059	0,031	-0,071	-0,102	0,041	0,017
GP 15	0,211	0,039	-0,129	-0,181	-0,204	-0,255*	-0,218	-0,107	-0,189	-0,001	-0,094	-0,091	0,020	-0,014	0,016	0,030
GP 1	0,183	0,213	-0,146	-0,145	-0,252*	-0,242*	-0,145	-0,259*	-0,064	-0,040	0,007	0,061	0,192	0,078	0,161	0,130
GP 3	0,179	0,102	-0,101	-0,198	-0,048	-0,210	-0,018	-0,229	0,164	0,021	0,045	0,064	0,142	0,058	0,136	0,066
GP 6	0,073	-0,021	-0,007	-0,045	0,005	-0,150	0,018	-0,208	0,112	0,025	0,047	0,062	0,134	0,052	0,102	0,115
GP 24	0,211	0,063	-0,014	-0,049	-0,045	-0,103	-0,070	-0,118	-0,141	-0,049	0,006	0,048	0,070	0,019	0,136	0,139

ATP 1- ATP content at 1 hour post-mortem, ATP 3- ATP content at 3 hours post-mortem, ATP 6- ATP content at 6 hours post-mortem, ATP 24- ATP content at 24 hours post-mortem, CP 15- creatine phosphate at 15 minutes post-mortem, CP 1- creatine phosphate at 1 hour post-mortem, CP 3- creatine phosphate at 3 hours post-mortem, CP 6- creatine phosphate at 6 hours post-mortem, CP 24- creatine phosphate at 24 hours post-mortem, GP 15- glycolytic potential at 15 minutes, GP 1- glycolytic potential at 1 hour, GP 3- glycolytic potential at 3 hours post-mortem, GP 6- glycolytic potential at 6 hours post-mortem, GP 24- glycolytic potential at 24 hours post-mortem, µcap 1- µcalpain at 1 hour post-mortem, µcap S1- Specific µcalpain at 1 hour post-mortem, µcap 24- µcalpain at 24 hour post-mortem, Mcap 15- m-calpain at 15 minutes post-mortem, Mcap S1- Specific m-calpain at 1 hour post-mortem, Mcap 24- Specific m-calpain at 24 hour post-mortem, Mcap S24- Specific m-calpain at 24 hours post-mortem, CalSt_µcap 15- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S15- Specific calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap 1- calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap S1- Specific calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap 24- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S24- Specific calpastatin/µ-calpain at 24 minutes post-mortem.

4.8.5 Correlation coefficients between calpain systems and meat quality characteristics

The correlation between biochemical parameters and calpain system for the LD and SM muscles are presented in Table 4.98 and 4.99

Table 4.98 Correlation coefficients between biochemical parameters and calpain systems for the *m. longissimus dorsi* (pooled data for all the goats)

	pH_	Temp_	cookingL	TLoss	dripL	WHCD1	WHCD4	WBSF	SL	MFL_1	MFL_4	DM%	Ash%	Prot%	Fat%
Mpg15	-0,417***	-0,211	-0,311**	0,225	0,435***	0,189	0,164	-0,324**	-0,230	-0,321*	-0,399**	0,624***	-0,127	0,21917	0,436***
Mpg1	-0,422**	-0,209	-0,259*	0,201	0,541***	0,091	0,134	-0,234	-0,277*	-0,348*	-0,354**	0,664***	-0,144	0,213	0,489
Mpg24	-0,525***	-0,090	-0,227	0,200	0,527***	0,146	0,107	-0,233	-0,280*	-0,369*	-0,320**	0,654***	-0,077	0,090	-0,498
CapIn15	0,359**	-0,192	0,078	-0,061	-0,215	0,118	0,009	0,374**	-0,051	0,523***	0,322**	-0,111	-0,262*	-0,048	-0,040
CapIn S15	0,357**	-0,097	0,098	-0,073	-0,296**	0,053	0,021	0,324**	-0,021	0,466***	0,359**	-0,185	-0,148	-0,131	-0,090
CapIn1	0,290*	-0,245*	0,131	-0,103	-0,319**	0,115	0,020	0,272*	0,125	0,526***	0,456***	-0,144	-0,244*	0,698	0,217
CapInS1	0,321**	-0,165	0,261*	-0,017	-0,339**	-0,017	-0,105	0,202	0,177	0,443***	0,366**	-0,294**	-0,212	0,793	0,045
CapIn24	0,278*	-0,214	0,057	-0,103	-0,295**	0,121	-0,089	0,157	0,013	0,359**	0,439	-0,203	-0,234	0,326	0,188
CapInS24	0,382**	-0,141	0,064	-0,135	-0,419***	0,204	-0,058	0,154	0,036	0,406**	0,452***	-0,304**	-0,124	0,080	0,045
µcap 15	0,261*	-0,230	-0,145	0,052	0,164	-0,050	0,240*	-0,101	0,014	0,017	-0,218	0,117	-0,081	-0,144	0,131
µcap 1S15	-0,078	-0,226	-0,011	0,075	-0,002	-0,173	0,135	0,011	0,109	0,010	-0,102	-0,137	-0,024	-0,113	-0,078
µcap 1	0,262*	-0,001	-0,055	0,233	0,175	0,017	0,036	-0,124	-0,133	0,037	-0,123	0,217	-0,110	-0,162	0,252

Mpt (g) 15- extractable proteins (grams), Mpt (g) 1- extractable proteins 1 hour post-mortem, Mpt (g) 24- extractable protein at 24 hours, CalpIn 15- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S15- Specific alpastatin inhibitor at 15 minutes post-mortem, CalpIn 1- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S1- Specific calpastatin inhibitor at 1hour post-mortem, CalpIn 24- calpastatin inhibitor at 24 minutes post-mortem, CalpIn S24- Specific calpastatin inhibitor at 24 hours post-mortem, µcap 15- µ-calpain at 15 minutes post-mortem, , µcap S15- Specific µ-calpain at 15 minutes post-mortem; Temp- Temperature at 24 hours post-mortem; TLoss_ Thawing loss; driploss_Drip loss; WHC_D1- water holding capacity taken at 1 day; WHC_D4- water holding capacity taken at 4 days post-mortem; WBSF- Warner Bratzler Shear Force; MFL_D1- Myofibril fragment length at 1 day post-mortem MFL_D4- Myofibril fragment length at 4 days post-mortem

Table 4.98 Correlation coefficients between biochemical parameters and calpain systems for the m. longissimus dorsi (pooled data for all the goats (Continues)

	pH_	Temp_	CookingL	TLoss	DripL	WHCD1	WHCD4	WBSF	SL	MFL 1	MFL 4	DM%	Ash%	Prot%	Fat %
µcap 1S1	0,262*	-0,196	0,069	0,032	-0,119	-0,131	0,153	-0,081	0,109	0,256*	0,166	-0,221	-0,112	-0,44***	0,063
µcap 24	0,358**	-0,208*	-0,017	-0,150	-0,423***	0,224	0,221	0,008	0,063	0,179	0,127	-0,383**	-0,052	-0,117	-0,214
µcap S24	0,068	-0,273*	-0,010	-0,076	-0,447***	0,039	0,012	0,017	0,090	0,188	0,147	-0,335**	-0,178	-0,083	-0,305**
Mcalp 15	0,275*	-0,037	0,115	-0,172	-0,185	-0,211	-0,051	0,016	0,020	0,103	0,024	-0,158	0,035	-0,226	-0,010
Mcalp S15	-0,048	-0,206	0,104	-0,222	-0,483***	-0,122	-0,022	0,090	0,128	0,209	0,111	-0,418**	-0,036	-0,323**	-0,262*
Mcalp 1	0,248	-0,063	-0,001	0,001	-0,034	-0,146	-0,024	-0,064	-0,020	-0,103	-0,101	-0,029	0,184	-0,170	0,059
Mcalp S1	0,417***	0,063	0,095	-0,177	-0,431	-0,027	-0,002	0,058	0,196	0,177	0,184	-0,427***	0,086	-0,333**	-0,265*
Mcalp 24	0,119	-0,142	0,071	-0,085	-0, 243*	-0,079	-0,072	-0,124	0,044	0,081	0,059	-0,102	0,160	-0,263*	0,062
Mcalp S24	0,417***	0,063	0,165	-0,236	-0,428***	-0,042	-0,069	0,037	0,161	0,366**	0,327**	-0,420**	0,042	-0,415***	-0,249*
CalpSt_ µcap 15	0,33**	-0,109	0,152	-0,177	-0,352**	0,191	-0,178	0,403**	-0,063	0,425**	0,511**	-0,192	-0,201	0,100	-0,121
CalpSt_ µcap 1	0,142	-0,018	0,137	-0,239*	-0,411***	0,055	-0,004	0,333**	0,201	0,474***	0,504***	-0,289**	-0,120	0,071	-0,292**
CalpSt_ µcap 24	0,303**	-0,002	0,077	0,002	0,023	-0,018	-0,297**	0,097	-0,080	0,245*	0,361**	0,015	-0,193	-0,012	-0,043
Calp_ Mcalp 15	0,335**	-0,128	0,092	-0,126	-0,271*	0,251*	-0,116	0,382**	-0,081	0,423**	0,455***	-0,106	-0,251*	0,110	-0,074
Calp_ Mcalp 1	0,205	-0,153	0,134	-0,179	-0,395***	0,115	0,011	0,329**	0,182	0,541***	0,524***	-0,235*	-0,210	0,054	-0,262*
Calp_ Mcalp 24	0,312**	-0,025	0,068	-0,047	-0,098	0,116	-0,152	0,236	-0,044	0,284*	0,381**	-0,073	-0,263*	0,022	-0,113

µcap S1- Specific µcalpain at 1 hour post-mortem, µcap 24- µcalpain at 24 hour post-mortem, Mcap 15- m-calpain at 15 minutes post-mortem, Mcap S1- Specific m-calpain at 1 hour post-mortem, Mcap 24- Specific m-calpain at 24 hour post-mortem, Mcap S24- Specific m-calpain at 24 hours post-mortem, CalSt_µcap 15- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S15- Specific calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap 1- calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap S1- Specific calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap 24- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S24- Specific calpastatin/µ-calpain at 24 minutes post-mortem. Temp- Temperature at 24 hours post-mortem; TLoss_ Thawing loss; driploss_Drip loss; WHC_D1- water holding capacity taken at 1 day; WHC_D4- water holding capacity taken at 4 days post-mortem; WBSF- Warner Bratzler Shear Force; MFL_D1- Myofibril fragment length at 1 day post-mortem MFL_D4- Myofibril fragment length at 4 days post-mortem

Table 4.99 Correlation coefficients between biochemical parameters and calpain systems for the *m. semimembranosus* (pooled data for all the goats)

	pH_	Temp_	CookingL	TLoss	DripL	WHCD1	WHCD4	WBSF	SL	MFL 1	MFL 4
Mpg15	-0,172	-0,223	-0,178	0,205	-0,321*	0,266*	0,131	0,102	-0,333**	-0,439***	-0,130
Mpg1	-0,207	-0,160	-0,245*	0,159	-0,189	0,222	0,205	-0,002	-0,19998	-0,459***	-0,175
Mpg24	-0,181	-0,135	-0,304**	0,030	-0,244*	0,196	0,231	0,028	-0,285*	-0,289**	-0,081
CapIn15	0,231	-0,212	0,048	-0,129	-0,024	0,080	0,120	0,287*	-0,162	0,239*	0,442***
CapIn S15	0,341**	-0,103	0,142	-0,175	0,131	-0,129	0,047	0,254*	0,032	0,410***	0,394***
CapIn1	0,139	-0,195	0,185	-0,051	-0,060	0,197	0,106	0,468***	-0,159	0,156	0,348**
CapInS1	0,186	0,020	0,254*	-0,107	-0,004	-0,032	-0,093	0,321**	0,023	0,316**	0,349**
CapIn24	0,129	-0,314**	0,264*	-0,080	-0,004	0,236*	0,068	0,457***	-0,140	0,246*	0,330**
CapInS24	0,215	-0,265*	0,401***	-0,042	0,067	0,183	0,014	0,421***	-0,066	0,232	0,342**
µcap 15	0,058	-0,228	-0,053	0,077	-0,045	0,093	0,208	0,099	-0,084	-0,086	0,022
µcap 1S15	0,233	-0,250*	0,199	-0,040	0,136	-0,147	0,115	0,162	0,211	0,183	0,177
µcap 1	-0,133	-0,232	-0,095	0,159	-0,048	0,256*	0,152	0,122	0,056	-0,160	-0,104
µcap 1S1	-0,084	-0,010	0,209	0,005	0,154	0,155	0,117	-0,005	0,127	0,245*	-0,012

Mpt (g) 15- extractable proteins (grams), Mpt (g) 1- extractable proteins 1 hour post-mortem, Mpt (g) 24- extractable protein at 24 hours, CalpIn 15- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S15- Specific alpastatin inhibitor at 15 minutes post-mortem, CalpIn 1- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S1- Specific calpastatin inhibitor at 1hour post-mortem, CalpIn 24- calpastatin inhibitor at 24 minutes post-mortem, CalpIn S24- Specific calpastatin inhibitor at 24 hours post-mortem, µcap 15- µ-calpain at 15 minutes post-mortem, , µcap S15- Specific µ-calpain at 15 minutes post-mortem; Temp- Temperature at 24 hours post-mortem; TLoss_ Thawing loss; driploss_Drip loss; WHC_D1- water holding capacity taken at 1 day; WHC_D4- water holding capacity taken at 4 days post-mortem; WBSF- Warner Bratzler Shear Force; MFL_D1- Myofibril fragment length at 1 day post-mortem MFL_D4- Myofibril fragment length at 4 days post-mortem**.**

Table 4.99 Correlation coefficients between biochemical parameters and calpain systems for the *m. semimembranosus* (pooled data for all the goats) (Continues)

	pH_	Temp_	CookingL	TLoss	DripL	WHCD1	WHCD4	WBSF	SacromereL	MFL 1	MFL 4
µcap 24	0,176	-0,280*	-0,044	-0,221	-0,073	0,286*	0,158	0,242*	-0,178	0,142	0,223
µcap S24	0,283*	-0,017	0,168	-0,154	0,111	0,147	0,175	0,160	0,045	0,254*	0,320**
Mcalp 15	0,047	-0,134	0,080	0,048	-0,076	-0,165	0,035	0,132	-0,134	0,055	0,115
Mcalp S15	0,173	0,146	0,114	-0,095	0,020	-0,213	0,033	0,014	0,004	0,406***	0,152
Mcalp 1	-0,066	-0,163	0,111	0,065	-0,073	-0,090	-0,014	0,126	-0,076	-0,042	0,165
Mcalp S1	0,191	-0,052	0,150	-0,039	0,032	-0,197	-0,099	0,103	0,099	0,170	0,217
Mcalp 24	-0,005	-0,088	-0,030	0,047	-0,164	-0,096	-0,118	0,077	-0,089	-0,039	-0,085
Mcalp S24	0,201	0,043	0,070	-0,006	0,012	-0,044	-0,159	-0,015	0,083	0,166	0,001
CalpSt_ µcap 15	0,179	-0,019	0,078	-0,179	0,006	-0,007	-0,050	0,210	-0,114	0,307**	0,426***
CalpSt_ µcap 1	0,208	0,006	0,208	-0,158	0,007	0,015	0,012	0,286*	-0,157	0,267*	0,385***
CalpSt_ µcap 24	-0,004	-0,203	0,309**	0,080	0,010	0,077	0,067	0,338**	-0,058	0,265*	0,362**
Calp_ Mcalp 15	0,210	-0,081	0,047	-0,192	0,013	0,075	0,019	0,243*	-0,118	0,223	0,2281
Calp_ Mcalp 1	0,196	-0,024	0,157	-0,143	0,002	0,131	0,069	0,328**	-0,148	0,313**	0,468***
Calp_ Mcalp 24	0,067	-0,239*	0,297**	0,011	0,039	0,214	0,071	0,424	-0,033	0,247*	0,339**

µcap 24- µcalpain at 24 hour post-mortem, Mcap 15- m-calpain at 15 minutes post-mortem, Mcap S1- Specific m-calpain at 1 hour post-mortem, Mcap 24- Specific m-calpain at 24 hour post-mortem, Mcap S24- Specific m-calpain at 24 hours post-mortem, CalSt_µcap 15- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S15- Specific calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap 1- calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap S1- Specific calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap 24- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S24- Specific calpastatin/µ-calpain at 24 minutes post-mortem. Temp- Temperature at 24 hours post-mortem; TLoss_ Thawing loss; driploss_Drip loss; WHC_D1- water holding capacity taken at 1 day; WHC_D4- water holding capacity taken at 4 days post-mortem; WBSF- Warner Bratzler Shear Force; MFL_D1- Myofibril fragment length at 1 day post-mortem MFL_D4- Myofibril fragment length at 4 days post-mortem.

4.8.6 Correlation coefficients between calpain systems and instrumental colour coordinates and surface myoglobin redox

The correlation between biochemical parameters and calpain system for the LD and SM muscles are presented in Table 4.100 and 4.101.

Table 4.100 The correlation coefficient between calpain systems and meat colour *m. longissimus dorsi* (pooled data for all goats)

	L1	L4	a*1	a*4	b*1	*b4	Chroma 1	Chroma 4	Hue angle1	Hue angle4	MetMb 1	MetMb 4	Deoxy Mb 1	Deoxy Mb 4	OxyMb 1	OxyMb 4
Mpg15	-0,539***	0,018	0,039	-0,036	-0,365**	-0,345**	-0,14	-0,176	-0,557***	-0,466***	0,32**	0,239*	0,11	0,197	-0,223	-0,466***
Mpg1	-0,531***	-0,328*	-0,005	-0,017	-0,411***	-0,291**	-0,186	-0,14	-0,589***	-0,404	0,258*	0,247*	0,165	0,154	-0,268*	-0,404***
Mpg24	-0,501**	-0,307	0,093	0,054	-0,283**	-0,222	-0,07	-0,067	-0,497***	-0,370**	0,276*	0,22	0,015	0,121	-0,102	-0,370**
CapIn15	0,031	0,013**	-0,329**	-0,09	-0,236	-0,004	-0,308**	-0,055	-0,045	0,065	-0,011	0,019	-0,1567	-0,092	-0,185	0,065
CapIn S15	0,046	-0,032	-0,148	-0,015	-0,027	0,051	-0,101	0,017	0,079	0,063	0,038	-0,004	-0,036	-0,177	-0,022	0,063
CapIn1	-0,009	-0,032	-0,161	0,002	-0,118	0,016	-0,15	0,01	-0,061	-0,003	0,002	0,017	-0,065	-0,088	-0,091	-0,003
CapInS1	0,142	0,04	-0,206	-0,168	-0,078	-0,086	-0,16	-0,14	0,057	0,018	-0,08	-0,122	0,081	0,124	-0,082	0,018
CapIn24	0,096	0,044	-0,215	0,034	-0,121	0,083	-0,184	0,059	0,005	0,068	0,073	0,022	0,059	-0,096	-0,096	0,068
CapInS24	0,158	0,011	-0,19	0,003	-0,017	0,083	-0,122	0,04	0,141	0,099	0,139	-0,036	-0,034	-0,162	0,032	0,099
µcap 15	-0,259*	-0,141	-0,075	-0,114	-0,21	-0,188	-0,137	-0,151	-0,266*	-0,19	0,158	0,118	0,076	0,006	-0,145	-0,19
µcap 1S15	0,043	0,262*	-0,266*	-0,258*	-0,182	-0,117	-0,244*	-0,208	-0,03	0,067	-0,103	0,015	0,253*	0,015	-0,261*	0,067
µcap 1	-0,202	-0,069	-0,129	-0,21	-0,223	-0,255*	-0,177	-0,241*	-0,206	-0,185	0,024	-0,012	0,137	0,11	-0,171	-0,185
µcap 1S1	-0,062	-0,08	-0,049	-0,171	0,01	-0,161	-0,022	-0,173	0,029	-0,107	0,031	-0,09	-0,624	0,065	0,427	-0,107
µcap 24	0,013	0,025	-0,213	-0,035	-0,16	0,044	-0,202	-0,002	-0,04	0,1	0,047	0,045	0,053	-0,202	-0,087	0,1

Mpt (g) 15- extractable proteins (grams), Mpt (g) 1- extractable proteins 1 hour post-mortem, Mpt (g) 24- extractable protein at 24 hours, CalpIn 15- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S15- Specific alpastatin inhibitor at 15 minutes post-mortem, CalpIn 1- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S1- Specific calpastatin inhibitor at 1hour post-mortem, CalpIn 24- calpastatin inhibitor at 24 minutes post-mortem, CalpIn S24- Specific calpastatin inhibitor at 24 hours post-mortem, µcap 15- µ-calpain at 15 minutes post-mortem, , µcap S15- Specific µ-calpain at 15 minutes post-mortem; µcap 1- µ-calpain at 1 hour post-mortem, , µcap S1- Specific µ-calpain at 1 hour post-mortem, µcap 24- µ-calpain at 24 hours post-mortem; L* 1 & 4- meat lightness of fresh meat samples taken at 1 day and 4 days post-mortem; a* 1 & 4- meat redness of fresh meat samples taken at 1 day and 4 days post-mortem; b* 1 & 4- meat yellowness of fresh meat samples taken at 1 day and 4 days post-mortem. Chroma 1 & 4 – taken at 1 day and 4 days post-mortem; Hue angle - taken at 1 day and 4 days post-mortem; MetMb 1 & 4 - metmyoglobin (brownness) of meat sample taken at 1 day and 4 days post-mortem, DeoxyMb- Deoxymyoglobin (purpleness) of taken at 1 and 4 days post-mortem; OxyMb, - oxymyoglobin (redness) of meat taken at 1 and 4 days post-mortem

Table 4.100 Correlation coefficient between calpain systems and meat colour *m. longissimus dorsi* (pooled data for all goats) (Continues)

	L1	L4	a*1	a*4	b*1	*b4	Chroma 1	Chroma4	Hue angle1	Hue angle4	MetMb 1	MetMb 4	Deoxy Mb 1	DeoxyMb 4	OxyMb 1	OxyMb 4	OxyMb 4
µcap S24	0,22	0,173	-0,343**	-0,075	-0,153	0,103	-0,279*	0,001	0,12	0,224	-0,138	0,051	0,155	-0,182	-0,146	0,224	0,12
Mcalp 15	0,026	0,168**	0,115	0,07	0,073	0,058	0,106	0,071	-0,052	-0,001	0,038	0,019	-0,101	-0,177	0,1	-0,001	-0,052
Mcalp S15	0,293**	0,186	-0,046	-0,015	0,156	0,125	0,041	0,048	0,256*	0,189	-0,152	-0,209	-0,005	-0,132	0,053	0,189	0,256*
Mcalp 1	-0,084	-0,036	0,127	-0,012	0,043	-0,06	0,099	-0,033	-0,096	-0,065	-0,048	0,125	-0,059	-0,042	0,072	-0,065	-0,096
Mcalp S1	0,197	0,02	0,015	0,073	0,169	0,106	0,086	0,095	0,213	0,066	-0,044	-0,134	-0,125	-0,243*	0,154	0,066	0,213
Mcalp 24	-0,054	-0,086	0,049	-0,061	0,057	-0,074	0,058	-0,068	0,003	-0,053	-0,051	-0,135	-0,082	-0,055	0,103	0,109	0,003
Mcalp S24	0,260*	0,133	-0,019	-0,056	0,226	0,076	0,091	0,001	0,325**	0,162	-0,141	-0,239*	-0,123	-0,075	0,181	0,17	0,325**
CalpSt_ µcap 15	0,179	0,102	-0,296**	-0,004	-0,117	0,107	-0,236*	0,045	0,119	0,159	-0,124	-0,107	0,094	-0,067	-0,076	0,159	0,119
CalpSt_ µcap 1	0,121	0,036	-0,063	0,118	0,05	0,18	-0,016	0,153	0,094	0,141	-0,054	0,009	-0,017	-0,133	0,025	0,141	0,094
CalpSt_ µcap 24	0,148	0,109	-0,109	0,021	0,001	0,062	-0,065	0,041	0,089	0,052	0,001	-0,019	0,039	0,062	-0,043	-0,065	0,089
Calp_ Mcalp 15	0,088	0,417*	-0,361**	-0,037	-0,216	0,047	-0,319**	-0,002	0,039	0,101	-0,074	-0,059	0,142	-0,041	-0,149	0,116	0,039
Calp_ Mcalp 1	0,098	0,774*	-0,137	0,084	-0,025	0,145	-0,096	0,117	0,065	0,116	-0,033	0,028	0,033	-0,114	-0,039	0,101	0,065
Calp_ Mcalp 24	0,073	0,032	-0,171	0,016	-0,127	0,034	-0,16	0,025	-0,042	0,018	0,088	0,044	0,069	0,029	-0,106	-0,049	-0,042

µcap S24- Specific µcalpain at 24 hour post-mortem, Mcap 15- m-calpain at 15 minutes post-mortem, Mcap S1- Specific m-calpain at 1 hour post-mortem, Mcap 24- Specific m-calpain at 24 hour post-mortem, Mcap S24- Specific m-calpain at 24 hours post-mortem, CalSt_µcap 15- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S15- Specific calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap 1- calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap S1- Specific calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap 24- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S24- Specific calpastatin/µ-calpain at 24 minutes post-mortem; L* 1 & 4- meat lightness of fresh meat samples taken at 1 day and 4 days post-mortem; a* 1 & 4- meat redness of fresh meat samples taken at 1 day and 4 days post-mortem; b* 1 & 4- meat yellowness of fresh meat samples taken at 1 day and 4 days post-mortem. Chroma 1 & 4 – taken at 1 day and 4 days post-mortem; Hue angle - taken at 1 day and 4 days post-mortem; MetMb 1 & 4 - metmyoglobin (brownness) of meat sample taken at 1day and 4 days post-mortem, DeoxyMb- Deoxymyoglobin (purpleness) of taken at 1 day and 4 days post-mortem; OxyMb, - oxymyoglobin (redness) of meat taken at 1 day and 4 days post-mortem

Table 4.101 The correlation coefficient between calpain systems and meat colour parameters for the *m. semimembranosus* (pooled data of all the goats)

	L1	L4	a*1	a*4	b*1	*b4	Chroma1	Chroma 4	Hue angle1	Hue angle4	MetMb 1	MetMb 4	DeoxyMb 1	Deoxy Mb 4	OxyMb 1	OxyMb_ 4
Mpg15	-0,341**	-0,340**	0,139	-0,010	-0,144	-0,168	0,029	-0,080	-0,391***	-0,264*	0,412***	0,459***	-0,043	-0,133	-0,081	-0,004
Mpg1	-0,317**	-0,363**	0,166	-0,074	-0,078	-0,207	0,074	-0,135	-0,315**	-0,256*	0,447***	0,481***	-0,135	-0,120	0,018	-0,022
Mpg24	-0,459***	-0,380*	0,082	-0,078	-0,177	-0,230	-0,020	-0,147	-0,3831**	-0,306**	0,403***	0,397***	-0,070	-0,085	-0,047	-0,032
CapIn15	-0,237*	-0,250*	-0,109	-0,058	-0,213	-0,148	-0,157	-0,095	-0,259*	-0,227	0,215	0,019	-0,018	0,043	-0,040	-0,058
CapIn S15	-0,020	-0,055	-0,247*	-0,080	-0,208	-0,087	-0,244*	-0,082	-0,092	-0,099	-0,116	-0,151	0,146	0,104	-0,124	-0,073
CapIn1	-0,149	-0,109	-0,106	-0,023	-0,165	-0,038	-0,137	-0,028	-0,175	-0,064	0,281*	0,111	-0,048	-0,014	-0,034	-0,027
CapInS1	0,036	0,058	0,034	0,004	0,078	0,072	0,053	0,036	0,076	0,092	0,071	0,062	-0,107	-0,099	0,101	0,088
CapIn24	-0,118	0,039	-0,203	0,035	-0,248*	0,120	-0,231	0,075	-0,199	0,159	0,013	0,097	0,081	-0,181	-0,088	0,162
CapInS24	-0,006	0,062	-0,167	0,027	-0,149	0,109	-0,168	0,064	-0,083	0,149	0,000	-0,031	0,030	-0,089	-0,028	0,094
µcap 15	-0,257*	-0,250*	-0,060	-0,041	-0,234	-0,138	-0,134	-0,083	-0,347**	-0,195	0,181	0,139	0,085	-0,021	-0,150	-0,022
µcap S15	-0,056	-0,056	-0,168	-0,140	-0,175	-0,109	-0,179	-0,129	-0,129	-0,047	-0,086	-0,076	0,187	0,021	-0,184	0,006
µcap 1	-0,122	-0,137	0,093	0,075	-0,058	-0,023	0,036	0,036	-0,214	-0,113	0,219	0,158	-0,089	-0,036	0,035	-0,012
µcap S1	0,053	0,128	0,095	0,354**	0,088	0,345**	0,097	0,364**	0,041	0,189	0,063	-0,122	-0,106	-0,190	0,103	0,263*
µcap 24	-0,269*	-0,126	-0,165	-0,039	-0,258*	-0,061	-0,210	-0,049	-0,268*	-0,071	0,027	0,009	0,022	0,027	-0,030	-0,039
µcap S24	-0,019	0,156	-0,176	-0,003	-0,101	0,104	-0,154	0,044	-0,005	0,178	-0,131	-0,225	0,035	0,099	0,001	-0,036

Mpt (g) 15- extractable proteins (grams), Mpt (g) 1- extractable proteins 1 hour post-mortem, Mpt (g) 24- extractable protein at 24 hours, CalpIn 15- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S15- Specific calpastatin inhibitor at 15 minutes post-mortem, CalpIn 1- calpastatin inhibitor at 15 minutes post-mortem, CalpIn S1- Specific calpastatin inhibitor at 1hour post-mortem, CalpIn 24- calpastatin inhibitor at 24 minutes post-mortem, CalpIn S24- Specific calpastatin inhibitor at 24 hours post-mortem, µcap 15- µ-calpain at 15 minutes post-mortem, , µcap S15- Specific µ-calpain at 15 minutes post-mortem; µcap 1- µ-calpain at 1 hour post-mortem, , µcap S1- Specific µ-calpain at 1 hour post-mortem, µcap 24- µ-calpain at 24 hours post-mortem, L* 1 & 4- meat lightness of fresh meat samples taken at 1 day and 4 days post-mortem; a* 1 & 4- meat redness of fresh meat samples taken at 1 day and 4 days post-mortem; b* 1 & 4- meat yellowness of fresh meat samples taken at 1 day and 4 days post-mortem. Chroma 1 & 4 – taken at 1 day and 4 days post-mortem; Hue angle - taken at 1 day and 4 days post-mortem; MetMb 1 & 4 - metmyoglobin (brownness) of meat sample taken at 1 day and 4 days post-mortem, DeoxyMb- Deoxymyoglobin (purpleness) of taken at 1 day and 4 days post-mortem; OxyMb, - oxymyoglobin (redness) of meat taken at 1 day and 4 days post-mortem

Table 4.101 The correlation coefficient between calpain systems and meat colour parameters for the *m. semimembranosus* (pooled data of all the goats) (Continues)

	L1	L4	a*1	a*4	b*1	*b4	Chroma1	Chroma4	Hue angle1	Hue angle4	MetMb 1	MetMb 4	DeoxyMb 1	Deoxy Mb 4	OxyMb 1	OxyMb_ 4
Mcalp 15	-0,089	-0,127	0,012	0,069	-0,027	-0,020	-0,003	0,033	-0,069	-0,109	0,094	0,051	-0,090	-0,001	0,070	-0,010
Mcalp S15	0,113	0,117	-0,096	0,035	0,063	0,087	-0,034	0,059	0,192	0,107	-0,285*	-0,268*	0,063	0,108	0,014	-0,021
Mcalp 1	-0,057	-0,186	0,148	0,183	0,088	0,030	0,131	0,123	-0,022	-0,156	0,147	0,049	-0,230	-0,020	0,221	0,004
Mcalp S1	0,157	0,059	0,003	0,108	0,112	0,056	0,047	0,091	0,177	-0,049	-0,187	-0,324**	-0,070	0,158	0,148	-0,086
Mcalp 24	-0,140	-0,064	0,039	0,080	-0,043	0,031	0,008	0,062	-0,115	-0,041	-0,023	0,136	0,047	-0,098	-0,043	0,057
Mcalp S24	0,110	0,092	-0,054	0,016	0,069	0,085	-0,006	0,047	0,171	0,126	-0,312*	-0,146	0,095	0,024	-0,002	0,015
CalpSt_ µcap 15	-0,019	-0,052	-0,037	-0,030	-0,003	-0,046	-0,026	-0,036	0,030	-0,081	0,070	-0,119	-0,093	0,078	0,086	-0,052
CalpSt_ µcap 1	0,009	0,037	-0,116	-0,066	-0,034	0,005	-0,089	-0,036	0,062	0,048	0,131	-0,042	-0,042	0,006	0,004	0,003
CalpSt_ µcap 24	0,018	0,065	-0,083	0,110	-0,089	0,178	-0,090	0,145	-0,053	0,178	0,029	0,100	0,033	-0,235	-0,041	0,225
Calp_ Mcalp 15	-0,120	-0,128	-0,079	-0,055	-0,105	-0,092	-0,095	-0,070	-0,101	-0,138	0,129	-0,073	-0,049	0,065	0,021	-0,053
Calp_ Mcalp 1	-0,034	0,041	-0,131	-0,060	-0,085	0,018	-0,120	-0,026	-0,013	0,065	0,182	0,013	-0,022	-0,027	-0,035	0,022
Calp_ Mcalp 24	-0,009	0,084	-0,133	0,080	-0,147	0,178	-0,146	0,126	-0,101	0,214	-0,011	0,048	0,053	-0,224	-0,051	0,237*

Mcap 15- m-calpain at 15 minutes post-mortem, Mcap S1- Specific m-calpain at 1 hour post-mortem, Mcap 24- Specific m-calpain at 24 hour post-mortem, Mcap S24- Specific m-calpain at 24 hours post-mortem, CalSt_µcap 15- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S15- Specific calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap 1- calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap S1- Specific calpastatin/µ-calpain at 1hour post-mortem, CalSt_µcap 24- calpastatin/µ-calpain at 15 minutes post-mortem, CalSt_µcap S24- Specific calpastatin/µ-calpain at 24 minutes post-mortem. L* 1 & 4- meat lightness of fresh meat samples taken at 1 day and 4 days post-mortem; a* 1 & 4- meat redness of fresh meat samples taken at 1 day and 4 days post-mortem; b* 1 & 4- meat yellowness of fresh meat samples taken at 1 day and 4 days post-mortem. Chroma 1 & 4 – taken at 1 day and 4 days post-mortem; Hue angle - taken at 1 day and 4 days post-mortem; MetMb 1 & 4 - metmyoglobin (brownness) of meat sample taken at 1 day and 4 days post-mortem, DeoxyMb- Deoxymyoglobin (purpleness) of taken at 1 day and 4 days post-mortem; OxyMb, - oxymyoglobin (redness) of meat taken at 1 and 4 days post-mortem

4.8.7 Correlation coefficients between meat quality traits

The correlation between biochemical parameters and calpain system for the LD and SM muscles are presented in Table 4.102 and 4.103.

Table 4.102 Correlation coefficients between meat quality traits the *m. longissimus dorsi*

	pH	Temp	WBSF	CL	TL	SL	MFL1	MFL4	DL	WHCD1	WHCD4	L*1	L*4	a*1	a*4	b*1	b*4	Chroma1	Chroma4	Hue A1	Hue A4	METMb1	METMb4	DEOXYMb1	DEOXYMb4	OXYMb1	OXYMbD4
pH	1																										
Temp	-0,103	1																									
WBSF	-0,001	0,054	1																								
CL	-0,018	0,185	0,4612***	1																							
TL	-0,331**	0,089	0,114	0,174	1																						
SL	0,236*	0,131	-0,048	0,05	-0,233	1																					
MFL1	-0,44	0,156	0,279*	0,163	-0,164	0,146	1																				
MFL4	-0,095	-0,125	0,354*	0,227	-0,135	0,211	0,546***	1																			
DL	-0,440***	-0,041	-0,037	-0,119	0,238	-0,072	-0,370*	-0,320**	1																		
WHCD1	-0,095	0,028	0,087	0,153	-0,044	-0,395**	0,106	0,178	-0,224	1																	
WHCD4	0,186	0,1	-0,142	-0,239	-0,308*	0,223	0,154	0,089	-0,192	0,15	1																
L*1	-0,047	0,217	0,359*	0,277*	0,065	0,084	0,154	0,071	-0,092	-0,1	-0,355*	1															
L*4	-0,207	0,215	0,364*	0,272*	0,239	-0,04	0,095	-0,037	0,062	-0,126	-0,373*	-0,051	1														
a*1	-0,438***	0,309*	-0,185	-0,076	0,187	0,034	-0,043	-0,156	0,269*	-0,099	-0,044	0,039	-0,006	1													
a*4	-0,373**	0,028	0,296**	0,114	0,083	-0,017	0,236	0,147	0,157	0,079	-0,172	0,495**	0,104	0,765**	1												
b*1	-0,23	0,531**	0,267*	0,062	0,186	0,132	0,094	0,042	0,07	-0,137	-0,129	0,529**	0,420**	0,344**	0,346**	1											
b*4	-0,233	0,091	0,494	0,306*	0,209	-0,044	0,263*	0,186	0,067	0,007	-0,34**	0,185	0,62***	0,959***	0,776***	0,503***	1										
Chroma1	-0,371**	0,426**	0,18	-0,02	0,197	0,081	0,018	-0,074	0,198	-0,124	-0,082	0,257**	0,179	0,493***	0,5***	0,916***	0,436***	1									
Chroma4	-0,329**	0,057	0,399***	0,203	0,142	-0,028	0,267*	0,176	0,125	0,049	-0,255*	0,848**	0,337**	0,104	0,96***	0,435	0,921***	0,5***	1								
Hue A1	0,025	0,473**	0,302**	0,194	0,102	0,125	0,182	0,191	-0,188	-0,04	-0,162	0,795**	0,683**	-0,034	-0,021	0,711***	0,44***	0,377**	0,181	1							
Hue A4	-0,014	0,109	0,461***	0,351**	0,259*	-0,079	0,122	0,093	-0,05	-0,048	-0,351**	-0,476**	0,87	0,378**	0,145	0,434	0,733	0,169	0,412	0,412***	1						
METMb1	-0,077	-0,045	-0,085	-0,058	0,06	0,058	0,119	0,09	0,249*	0,105	0,14	-0,246*	-0,430**	0,186	0,43	-0,005	0,039	0,235	0,284**	-0,439***	-0,412**	1					
METMb4	-0,118	-0,178	0,084	0,076	0,162	-0,127	0,163	0,082	0,192	0,194	-0,051	-0,002	-0,215	-0,705	0,556	-0,087	0,322**	0,08	0,488***	-0,326**	-0,109	0,629***	1				
DEOXYMb1	0,240*	-0,382*	-0,157	-0,056	-0,123	-0,135	-0,156	-0,218	-0,18	-0,003	-0,095	-0,1	-0,011	-0,179	-0,499**	-0,661**	-0,351**	-0,732**	-0,464***	-0,235*	-0,011	-0,559***	-0,266*	1			
DEOXYMb4	-0,007	0,171	-0,289**	-0,196	-0,119	0,115	-0,292**	-0,244*	0,024	-0,123	0,102	0,149	-0,111	0,687***	-0,678**	-0,169	-0,723**	-0,189	-0,74***	-0,069	-0,385**	-0,276*	-0,590***	0,309*	1		
OXYMb1	-0,248*	0,460**	0,206	0,087	0,121	0,14	0,137	0,215	0,132	-0,033	0,062	0,187	0,14	0,141	0,427**	0,758***	0,378**	0,764**	0,431***	0,408**	0,135	0,340**	0.109	-0,968***	-0,259*	1	
OXYMb4	0,052	-0,141	0,298**	0,205	0,088	-0,084	0,288*	0,266*	-0,088	0,066	-0,111	0,136	0,186	0,141	0,601**	0,213	0,722	0,184	0,692***	0,174	0,466***	0,125	0,367**	-0,266*	-0,966***	0,264*	1

Table 4.103 Correlation coefficients between meat quality traits the *m. semimembranosus*

	pH	Temp	WBSF	CL	TL	SL	MFL1	MFL4	DL	WHCD1	WHCD4	L*1	L*4	a*1	a*4	b*1	b*4	Chroma1	Chroma4	Hue A1	hue A4	METMb1	METMb4	DEOXYMb1	DEOXYMb4	OXYMb1	OXYMbD4
pH	1																										
Temp	-0,085	1																									
WBSF	0,184	-0,375**	1																								
CL	0,022	0,121	-0,100	1																							
TL	0,123	0,019	0,221	-0,018	1																						
SL	0,229	-0,169	0,319**	-0,146	0,082	1																					
MFL1	0,177	0,136	-0,346**	0,428***	0,082	0,122	1																				
MFL4	-0,127	-0,135	0,136	-0,363**	-0,126	-0,160	-0,304**	1																			
DL	0,113	0,123	-0,057	0,106	0,144	0,128	0,185	0,167	1																		
WHCD1	-0,021	0,034	0,428***	0,077	0,103	0,078	-0,043	-0,034	-0,181	1																	
WHCD4	-0,327**	0,027	-0,057	0,013	-0,357**	-0,271*	-0,086	0,180	-0,308	0,221	1																
L*1	-0,243*	0,441***	-0,381**	0,341**	-0,214	-0,289**	0,245*	-0,381*	-0,221	0,198	0,166	1															
L*4	-0,302**	0,408***	-0,200	0,215	-0,030	-0,282*	0,128	-0,115	-0,190	0,373**	0,271*	0,687***	1														
a*1	-0,537***	0,243*	-0,337**	0,090	-0,106	-0,196	-0,052	0,168	0,047	0,031	0,291**	0,175	0,110	1													
a*4	-0,581***	0,226	-0,184	0,014	0,123	-0,026	0,067	0,070	0,078	0,195	0,236*	0,267*	0,317**	0,634***	1												
b*1	-0,449***	0,529***	-0,493***	0,254*	-0,131	-0,263*	0,103	-0,053	0,000	0,120	0,293**	0,612***	0,411***	0,824***	0,566***	1											
b*4	-0,528***	0,367***	-0,166	0,080	0,080	-0,119	0,108	0,083	-0,010	0,369**	0,338**	0,453***	0,676***	0,476***	0,869***	0,559***	1										
Chroma1	-0,526***	0,372**	-0,417***	0,161	-0,120	-0,231	0,011	0,083	0,029	0,069	0,303**	0,361**	0,238*	0,973***	0,633***	0,933***	0,531***	1									
Chroma4	-0,575***	0,294**	-0,184	0,043	0,110	-0,065	0,089	0,077	0,045	0,274*	0,286*	0,356**	0,481***	0,587***	0,977***	0,582***	0,954***	0,610***	1								
Hue A1	-0,178	0,615***	-0,459***	0,315**	-0,112	-0,238*	0,210	-0,265*	-0,065	0,169	0,185	0,846***	0,574***	0,280*	0,255*	0,772***	0,419***	0,494***	0,334**	1							
Hue A4	-0,328**	0,396***	-0,063	0,109	-0,018	-0,214	0,069	0,099	-0,138	0,460***	0,379**	0,505***	0,865***	0,135	0,399***	0,357**	0,796***	0,232	0,582***	0,458***	1						
METMb1	-0,235	-0,056	-0,091	-0,154	-0,110	0,055	0,046	0,338	0,247*	-0,078	0,019	-0,270*	-0,220	0,46225**	0,312**	0,192	0,140	0,373**	0,249*	-0,208	-0,125	1					
METMb4	-0,155	-0,148	0,143	-0,205	-0,188	-0,189	-0,206	0,311**	-0,021	0,007	0,196	-0,155	-0,041	0,216	0,137	0,023	0,173	0,145	0,157	-0,196	0,174	0,408***	1				
DEOXYMb1	0,335**	-0,241*	0,356**	-0,117	0,020	-0,109	-0,223	-0,031	-0,170	-0,018	-0,146	-0,199	0,004	-0,705***	-0,560***	-0,725***	-0,399***	-0,745***	-0,511***	-0,426***	-0,050	-0,598***	-0,087	1			
DEOXYMb4	0,366	-0,055	-0,051	0,019	0,048	0,103	0,116	-0,275*	-0,017	-0,140	-0,337**	-0,077	-0,227	-0,489***	-0,626***	-0,358**	-0,670***	-0,456***	-0,666***	-0,075	-0,486***	-0,332**	-0,574***	0,336**	1		
OXYMb1	-0,316**	0,287	-0,380	0,188	0,008	0,106	0,234	-0,065	0,111	0,042	0,148	0,311**	0,409***	0,053	0,766***	0,674***	0,508***	0,549***	0,548***	0,775***	0,083	0,390***	-0,288*	-0,030	0,352**	1	
OXYMb4	-0,375**	0,141	-0,002	0,065	0,010	-0,051	-0,054	0,202	0,050	0,159	0,315**	0,156	0,289**	0,497***	0,684***	0,422***	0,726***	0,487***	0,725***	0,174	0,513***	0,238*	0,313**	-0,366**	-0,955***	0,352	1

CHAPTER 5: DISCUSSION

5.1 Evaluation of carcass characteristics and chemical composition of goat ecotypes (South African Boer, Northern Cape Speckled, Eastern Cape Xhosa Lob Ear, Mbusi/Nguni and random Village Type goats), sex and their interactions

Different ecotypes were chosen except for VTV and VT goats which came from the same community, but their production systems and transport conditions before slaughter differed. Thus, VTV and VT goats did not experience the same stress levels in terms of production system and transportation. The different production systems and transportation had an effect on the carcass weights, for example the VTV carcasses on average 1 kg lighter than those of the VT group. Nonetheless, the VT ecotypes as a whole had lighter weights, with lower dry matter content, fat percentage and higher ash percentage. The village type (VT and VTV) goats were similar to those included in the studies of Pophiwa (2017) and Simela (2005) which were regarded as an uncharacterized village ecotype raised by communal farmers from Pella village, North West Province (Table 4.2). The results for these goat ecotypes concur with those of Kadim et al. (2006) who reported warm carcass weight loss of about 1.07–2.00 kg caused by the temperatures during transportation (2 hours). Another possibility of weight loss could be that there was actual muscle wasting due to muscle catabolism and a consequent decrease in muscle glycogen levels (Pethick et al., 1995), which may account for about 1-2% of warm weight loss (Pearson and Young, 1989).

The SAB carcasses were the heaviest compared to the other ecotypes studied, which were expected because it is known that this goat ecotype was developed and bred for meat production purposes hence the moderate (to low) fat and high dry matter percentage. Many studies have focused on the improved South African Boer goats, unlike the three indigenous ecotypes conserved to be the original ecotype and no specific studies were done on them as individual breeds yet.

The Eastern Cape Xhosa Lob Ear (XL), Northern Cape Speckled (NCS) and Mbusi/Nguni (MZ) goats used in this study are specific goat ecotypes that are decedents of original indigenous ecotypes, conserved by farmers specialising in farming with these groups. There is evidence that these goat ecotypes are in danger of extinction because they are being transformed and improved. Therefore, there is a need to study different types of indigenous veld goats to investigate the differences and disseminate the relevant information to farmers,

producers and abattoirs, because indigenous veld goats (ecotypes) have displayed profound characteristics as compared to other breeds (Campbell, 2003).

The XL goat ecotype are to some extent related to the SAB goat ecotype and it is known that a large dabbled lob ear buck was originally used to develop the SAB goat ecotypes (Morrison, 2007) and it is thus expected that this goat ecotype was also good for meat production. Not being an improved goat ecotype, they have moderate body weight, high dry matter, moderate intra muscular fat percentage and high intra muscular protein percentage (Table 4.2). In the present study, keeping in mind that the study worked with kids (0 permanent tooth) live weights of XL goats did not agree with Morrison (2007) that XL goats are medium to large farmed goats and this could have been attributed by the interaction effects of ecotype and sex. The XL does were lighter as compared to the bucks, thus the lighter average weight as a group, which showed that those does had a slower growth rate as compared to the bucks.

The MBZ ecotype has distinct characteristics that is different from the other ecotypes (Morrison, 2007), amongst others the fact that they are small to medium framed that are hardy and utilize efficiently on the available feed resources (Dziba et al., 2003), therefore the resultant carcasses in this study were overall smaller - similar to the VT carcasses (Table 4.2). Other characteristics such as meat quality are similar to the SAB and XL also because they might have shared interconnected genetics between these groups. The MBZ had medium to low percentage of intra muscular fat, high protein and dry matter content (Table 4.2). The live weight of MBZ goats in this study were 2 kg heavier than those reported by Xazela (2010), with live weight of 20.3 kg and this was probably due to the age of the goats used, as the author used goats that were younger (6 months old) to those used in the present study which were 9 months old on average.

The NCS phenotypic characteristics differ completely from the other eco-types (Morrison, 2007), but also displayed acceptable meat quality characteristics. The NCS carcases were slightly lighter than the SAB carcasses (Table 4.2), with low intramuscular fat percentage and the same percentage of dry matter, ash and protein compared to SAB carcasses, which make them acceptable for meat production. The live weight of the NCS and SAB goats corresponds well with live weights between 39.8 kg and 33.7 kg reported by Pophiwa et al. (2017) for the Boer goats and indigenous goats. Generally, the SAB goats have a large frame and possess muscularity, which were specifically developed for meat production (Casey and Webb, 2010).

The goat dressing percentages were similar for all the goat ecotypes (Tables 4.1 & 4.2) and showed to fall in the range of goat dressing percentage of 35-52% as stated by Warmington and Kirton (1990). Several authors also reported no significant differences between different breeds for dressing percentage (Johnson et al., 1995; Santos et al., 2007; Tshabalala et al., 2003; Pophiwa et al., 2017). Nevertheless, Kadim et al. (2003) reported breed differences in dressing percentage that was caused by the degree of gut fill. Nikbin et al. (2016) also reported differences in dressing percentages and concluded that goats transported at high stocking density lose more weight due to high energy utilization. Chilling losses obtained from the present study (Tables 4.1, 4.2 & 4.3) were above the estimated percentage for chevon by Government of Zimbabwe (1995) as cited by Simela (2005). The high variation in chilling loss in this study (Table 4.2) could be ascribed to the overall thin subcutaneous fat cover of goat carcass (Webb et al., 2005). The heavier live weight carcasses in this study showed that lower chilling losses which were negatively correlated (r=-0.268; $p<0.05$) with carcass weight. The latter results are contrary to Kadim et al. (2006) that heavier carcass weight results in higher chilling losses as reported in Jabal Akdhar goats, as well as to that reported by Pophiwa (2017) for Boer goats and indigenous goats. Results from this study could be ascribed by the step-wise chilling procedure followed in comparison with most studies, where carcasses were chilled within 1 hour of post-slaughter.

Ash, protein and fat percentages determined in the *longissimus* muscle in the present study (Tables 4.1, 4.2 & 4.3) corresponds well to Tshabalala et al. (2003) with significant differences between Boer and Indigenous goats. Subsequently, the latter author reported higher fat percentage also representing intra muscular fat (IMF) (10.45% and 7.9%) as compared to those obtained in the present study (between 0.1-0.8%) in Table 4.2. This was because the goats used by latter author were older (over 6 years old). Generally, goats have small carcasses with less subcutaneous fat (Webb et al., 2005). It has also been reported that the subcutaneous fat in goats grow slowly as compared to sheep (Warmington and Kirton, 1990). A high percentage of dry matter was reported by Schönfeldt et al. (1993a) in Angora and Boer goats that ranged between (34.38–35.78%), higher amount of fat (IMF) (4.40-6.24%) and lower ash percentage (0.99–1.8%). However, the latter author found no differences between breeds on the proximate analysis even within the species (sheep and goats). Correspondingly, Johnson et al. (1995) reported higher fat % in the LD of Serbian white and Balkan goats. The ash %, protein % and fat % reported herein in the XL, MBZ and NCS goat carcasses were comparable to those reported by Shija et al. (2013) with percentage values of 4.40%, 23.45% and 2.49%

respectively in Small East African goats. In addition, Invanovic et al. (2014) reported fat % that ranged between 3.55–3.92% close to the ones obtained from XL, MBZ and NCS goats but with lower protein percentage (19.95-20.55%) from the Serbian white and Balkan goats. Whilst the values from the VTV and VT goats are more comparable to that of the Desert goats reported by Babiker et al. (1990) with lower protein, fat and ash percentages (20.8%, 2.8% and 1.23%) respectively. This was supported by the Pearson correlation (r=0.470; $p<0.001$) that suggested that lower weighted goats showed lower fat %.

The bucks in this study as in other studies (Simela et al., 2008) had heavier average than does (Table 4.3), but those authors found higher live weight values in bucks compared to those in the present study, the possible explanation is that those authors used older bucks. Johnson et al. (1995) reported that bucks were heavier than does (20.9 kg *vs* 19.5 kg), that was slightly lower to those obtained in this study and this could be due to breed and age differences. In addition, male goats are generally more masculine, thus heavier weights as compared to females that are more feminine. In agreement, Simela (2005) results also showed that bucks were not significantly heavier (34.46 kg) than does (38.87 kg). Similarly, Bonvillani et al. (2010) in the Criollo Cordobe goat kids, Johnson et al. (1995) in the Nubian×Forida native, Spanish×Florida native and Florida native goats and Simela (2005) in indigenous goats (intact, castrate and females) reported no sex effects. Contrary, Simela et al. (2008) reported that female goats had high chilling loss 3.09% compared to male castrates 2.52%. In addition, Simela et al. (2008) reported higher intramuscular fat (4.07% and 4.03%) in castrate and females, this might have been because the goats used were older (2 years). Similarly, Nirton (1970) also reported that females have higher fat content compared to males.

5.2 Effects of goat ecotypes (South African Boer, Northern Cape Speckled, Eastern Cape Xhosa Lob Ear, Mbusi/Nguni and random Village Type goats), sex and their interactions on muscle pH and muscle energy of *m. longissimus dorsi* and *m. semimembranosus*

The extent and rate of pH decline in muscle plays a vital role in the conversion of muscle to meat (Scheffler and Gerrard, 2007). Muscle pH influence the meat colour, cooking loss, meat tenderness (Dutson, 1983), water holding capacity (juiciness) and flavour (Mushi et al., 2007). To emphasize, ultimate pH is associated with post-mortem rate of glycogen

breakdown and production of lactate (Kadim et al., 2006), according to Pearson correlation ultimate pH is negatively correlated with lactate concentration (r=-0.509, p<0.001). The initial muscle pH values measured at 15 minutes post-mortem in LD and SM (Tables 4.4 & 4.5 and Tables 4.6 & 4.7) were close to those reported by Kannan et al. (2003) in LD of transportation stressed and unstressed castrated Alpine goats (pH 6.7-6.9). Muscle ultimate pH obtained in the present study concurred with Pophiwa et al. (2017) in LD of Boer goats and indigenous goats with pH_u of about 5.76, although, the latter author reported no differences between breeds as post-mortem time proceeded. Normally, after slaughter pH drops from 7.2 to an ultimate pH of 5.3-5.7 (Briskey and Wismer-Pedersen, 1961). Muscle pH declined in both muscles (LD and SM) of goat ecotypes (Tables 4.6 & 4.7) but was slow as compared to those recorded by Pophiwa (2017). However, the ultimate pH values were in the acceptable range to those reported in the LD of different goat breeds (Dhanda et al., 1999; Kadim et al., 2006; Gaviraghi et al., 2007, Shija et al., 2013). Noted that this decline (Tables 4.4 & 4.5, 4.6 & 4.7 and 4.8 & 4.9) did not follow the same pattern than beef, where the muscle pH is normally lower (pH 5.84-5.76) by 3 hours post-mortem as compared to goats (pH>6) as investigated by du Toit (2011).

The lowest ultimate pH and quickest pH decline were observed in the LD of SAB, MBZ and NCS and could have been ascribed by high glycogen concentration at slaughter in the LD muscle (Table 4.6). This was able to accumulate sufficient lactate concentration to reduce that pH level (Pethick et al., 1995). In the present study, the values in both muscles (LD and SM) of VTV, VT and XL goats might have been attributed by stress due to different production systems (feeding), handling (transportation stress) and ante-mortem stress that they experienced (Muchenje et al., 2009). Contra to Kannan et al. (2003) reported no transportation effects on muscle pH in Omani goats. On the other hand, Kadim et al. (2006) reported significant effects of transportation (2 hours) on the ultimate pH (5.78–6.02) in three different muscle of Omani goats. In the present study, ultimate pH above 6 was not recorded indicating towards enough energy available in the muscle. Nonetheless, Xazela (2010) reported higher ultimate pH of 6.1 and 6.2 in the LD of Xhosa lob ear and Nguni respectively. Equally, Simela et al. (2004) reported an ultimate pH of 6.10 and Simela (2005), reported pH 6.03 in non-stimulated *m. longissimus dorsi* of indigenous goats. The ultimate pH of sex did not agree with Santos et al. (2007) and Gaviraghi (2007) found that sex characteristics did not influence ultimate pH and those authors found slightly higher ultimate pH than those found in the present study (Tables 4.8 & 4.9). Simela (2005) on the other hand, found higher ultimate pH with no

differences between sex and this showed that those animals experienced ante-mortem stress. Unlike the results herein ultimate pH might have been improved by the delayed chilling procedure applied. Santos et al. (2007) reported no interaction effects of genotype and sex contra to the results in the SM (Table 4.5) but in agreement with the LD (Table 4.4).

There was a gradual drop in carcass temperature in all goat ecotypes as post-mortem proceeded because after slaughter the carcasses were first hung at 10°C for 6 hours before hanging overnight at 4°C. Temperature is important during early post-mortem due to the risk of rigor shortening that can occur at that time (Huff-Lonergan et al., 2010). Cold shortening is caused by rapid chilling of muscles at temperatures below 10˚C before the onset of rigor mortis thus muscle toughening (Locker and Hagyard, 1963). Moreover, the relationship of pH/temperature at onset of rigor mortis has led to the development of pH/temperature window concept as described by Thompson (2002). As illustrated in Figures 4.1 & 4.2 and Figures 4.3 & 4.4 pH dropped from ~6.7 to 5.7, with 80% temperature decline (38˚C to 8˚C). This showed that by making use of step-wise chilling cold shortening did not occur in the present study. In agreement with Pophiwa et al. (2016), that delayed chilling is an effective way of reducing the risk of cold shortening in Boer and indigenous goats, because goats have small carcasses with less subcutaneous fat covers making them more susceptible to cold shortening (Warmington and Kirton, 1990). Furthermore, the present study agrees that smaller sized goats are more prone to rapid heat dissipation (Gadiyaram et al., 2003), as well as the amount of intramuscular fat (Dhanda et al., 1999). On the hand, it was also observed that SAB had a slow temperature due to the live weights. Correlation analysis showed that heat dissipation from the body was rapid in lighter goat ecotypes ($r= -0.264$; $p<0.05$).

The amount of glycogen in the muscle pre-slaughter plays a significant role as it is converted to glucose, glucose-6-P and then to lactic acid (Immonen and Puolanne, 2000) for achieving ultimate pH around (5.5) to be attained. Glycogen concentration measured at 15 minutes post-mortem (Tables 4.10 & 4.11 and Tables 4.24 & 4.25) was overall lower than the optimal minimum of 50 µmol/g that is required for optimal production of lactic acid in beef according to Monin (1981). This could be that the threshold mentioned by the latter author is more applicable to beef muscles and again the threshold of glycogen concentration for goats has not yet been established. Lower initial glycogen reported herein (Tables 4.24 & 4.25) is associated with the high initial muscle pH (Tables 4.6 & 4.7), which might be caused by the susceptibility of goats to stress, handling, unfamiliar environment and noise. Correlation

analysis indicated that lower glycogen concentration results to high initial pH (r=-0.299; $p<0.05$). In addition, Warriss (1990) indicated (Figure 2.8) that pH decreases with an increase in glycogen concentration.

This concurred with Kannan et al. (2003) that reported lower (~20 µmol/g) glycogen concentration in the LD of younger Alpine goats that were transported over 2 hours as compared to the unstressed goats (~40 µmol/g). Similarly, Nikbin et al. (2016) found higher glycogen concentration in the non-transported goats to those that were transported, while the glycogen concentration in the LD of VT goats might have been improved by nutrition. It's reported that nutrition does not only improve the glycogen level but also reduces the risk of pre-slaughter stress in animals (Immonen et al., 2000 as cited by Simela, 2005). On the other hand, the effect of production system in the SM of VT goats was more sensitive to preslaughter conditions at 1 hour and 3 hours post-mortem (Table 4.24).

In addition, the results of glycogen concentration (Tables 4.12 & Tables 4.24 & 4.25) in this study were within the range of those reported by Kannan et al. (2003) of about 20 µmol/g to 55 µmol/g in LD of the transported stress and unstressed Alpine goats at 15 minutes post-mortem. The latter is comparable to the results of Simela (2004) who found an average glycogen concentration (~32.82 µmol/g) in the LD of South African indigenous goats, but higher than those obtained by Pophiwa (2017) who found glycogen concentration of about 17–22 µmol/g in LD and SM of electrical stimulated and delayed chilled Boer goats and indigenous goats.

Irrespective of the lower muscle glycogen reported by Pophiwa (2017), the rate of glycogen metabolism in the present study was comparable to those reported by the latter author (~78–86%). However, at 24 hours post-mortem, the glycogen concentration was within the range reported by Kannan et al. (2003), but they found no differences in glycogen concentration at 24 hours post-mortem in transported-stressed and unstressed goats (~5 µmol/g to ~15 µmol/g). Furthermore, lower glycogen concentration in the LD of NCS and XL goats could be that the goats had a faster glycogen metabolism, due to the psychological stress on animals that is triggered by epinephrine output (Grandin, 1980). Another possibility could be that the more one selects for growth the more capacity you have for faster glycogen that is being metabolised. A decrease in glycogen concentration with post-mortem has been reported in other species; pigs (Hammelman et al., 2003) and beef (du Toit, 2011).

The goat ecotypes had the ability to convert initial glycogen concentration to glucose, which is broken down from glucose-1-P and finally isomerized to glucose-6-P (Scheffler and Gerrard, 2007). The glucose concentration in this study (Tables 4.26 & 4.27) was within the range of those reported by Pophiwa (2017) of about 0.61-3.39 µmol/g in LD and SM of electrically stimulated and delay chilled Boer goats and indigenous goats. Simela (2005) found an average value of 1.70 µmol/g for glucose concentration that was comparable to the present study. As time proceeded, Pophiwa (2017) equally observed increase in glucose concentration. This might be explained by Immonen and Puloanne (2000) motion that glucose concentration is inversely proportional to the pH, such that when the glucose concentration increases the muscle pH decreases.

Although the values obtained by Pophiwa (2017) at 15 minutes to 3 hours post-mortem were lower to those recorded herein, the latter similarly reported a decrease in glucose-6-P concentration after 15 minutes post-mortem, that could be explained by the imbalance between glycogenolysis and glycolysis bought about by the rate and activity of enzymes (Scheffler and Gerrard, 2007). Thereafter, glucose-6-P concentration increased again at 1 hour post-mortem. Authors reported an increase in glycogen breakdown that is catalysed by *glycogen phosphorylase*, thus the increase in the *phosphofruckinase* thereafter (Hammelman et al., 2003; Scheffler and Gerrard, 2007). Therefore, the occurrence in the present study could be explained by high levels of ATP concentration in muscles, which could have been inhibited by the enzyme called *glycogen phosphorylase* thus the increase (Pophiwa, 2017). Contra to this study, Pophiwa (2017) reported no breed differences at 24 hours post-mortem and with higher glucose-6-P (3.42-4.14 µmol/g) than that obtained from the VTV, VT, NCS and XL goats, but comparable to SM of MBZ and SAB goats and this could merely be due to breed effect.

After slaughter, lactate concentration accumulates together with hydrogen ions and heat that is produced due to anaerobic conditions, as a result metabolic reaction are also ceased (Scheffler and Gerrard, 2007). Lactate concentration observed by Pophiwa (2017) concurred with the present study, with no breed differences in lactate concentration measured in both muscles (LD and SM) at any time post-mortem (Tables 4.30 & 4.31). However, the values recorded herein at 15 minutes were lower than those 35.0-36.0 µmol/g previously reported by Pophiwa (2017). It could be that the goat ecotypes in this study experienced more ante-mortem stress (it is known that the animals of Pophiwa (2017) were fed just before slaughter). Furthermore, Pearson and Young (1989) stated that initial level of lactate concentration falls

within the range of 6-16 µmol/g. Contra to the results obtained in the current study (Tables 4.30 & 4.31), this could be because lactic acid was taken after 15 minutes post-mortem, meaning that it was not the initial lactate concentration level.

The critical threshold for glycolytic potential in small ruminants has not yet been established, consequently it cannot be concluded as to whether the goats were associated with a phenomenon called dark firm dry (DFD) based on the calculated glycolytic potential. Nonetheless, the results obtained herein (Tables 4.32 & 4.33) showed that LD of MBZ and SAB goats were above the threshold level of that used in beef. In accordance with Simela et al. (2004) and (2005) found an average of 101.74 µmol/g for glycolytic potential in *m. longissimus dorsi* of South African indigenous goats. In bovine muscles, the critical threshold of glycolytic potential is 100 µmol/g and anything below that is associated with high ultimate pH, thus meat will be associated with DFD (Wulf et al., 2002). The results obtained herein (82-112 µmol/g) were comparable with Pophiwa (2017) glycolytic potential that ranged between 92.6-101 µmol/g in LD and SM of indigenous and Boer goats at 24 hours post-mortem. The glycolytic potential resulted in ultimate pH between 5.6-5.8. When considering only the goat ecotypes, the glycolytic potential of LD for VTV goats showed that glycolytic potential was indeed affected by transportation stress. The muscle pH at 3 hours post-mortem has been used to determine the rate of glycolysis in muscle, such that muscle pH>6.3 are associated with slow glycolytic rate (Kim et al., 2014). The variation in glycolytic potential is brought about by size, type and number of muscle fibres that makes up the muscle structure (Mlynek et al., 2012). The Pearson coefficient correlation indicated that increased glycolytic potential is strongly associated with lower pH_u (r=-0.484; p<0.001), this was confirmed by the higher glycolytic potential recorded in LD of MBZ and SAB goats (112.5 µmol/g and 108.90 µmol/g) resulting into lower pH_u, while the lower glycolytic potential in the LD of VTV, VT and XL goats resulted into higher pH_u (82.33 µmol/g, 97.78 µmol/g and 90.80 µmol/g).

Creatine phosphate is required for glycolysis metabolism because it's responsible for the maintenance of ATP levels in the muscles at rest. The level of creatine phosphate at rest in beef is between 13.1-23.0 µmol/g (Pearson and Young, 1989). The values measured in this study (Tables 4.20 & 4.21 and Tables 4.34 & 4.35) were lower than those stated by Pearson and Young (1989) that could be ascribed by species differences and size of animals. However, the values of creatine concentration measured were higher than those obtained by Pophiwa (2017) in LD and SM of Boer goats and indigenous goats (1.63–3.67 µmol/g), but close to

those obtained by Simela (2005) with about 3.74 µmol/g in *m. longissimus dorsi* of South African indigenous goats. The ATP production is necessary for muscles to be kept in a relaxed form, however post-mortem muscles are associated with high rate of ATP turnover (Bate-Smith and Bendall, 1949 cited by Scheffler and Gerrard, 2007). Thereafter, at death the production of ATP content is ceased due to anaerobic conditions that are caused by the reduction in energy metabolites and denaturation of enzyme activities during post-mortem (Varnam and Sutherland, 1996 as cited by du Toit, 2011). Thus, ATP content in the muscles herein decreased with post-mortem time. Moreover, the ATP content measured in both muscles at 15 minutes post-mortem (Tables 4.22 & 4.23 and Tables 4.34 & 4.35) compares well with that reported by Pearson and Young (1989) ranging between 5.7–8.1 µmol/g at slaughter. The values of ATP obtained in the LD VTV goats were higher due to less glycogen available to be used thus less ATP content was used, unlike that of the NCS goats. The values of ATP content in this study (Tables 4.22 & 4.23 and Tables 4.34 & 4.35) also compared well to values of 6.89-7.59 µmol/g reported by Pophiwa (2017).

5.3 The effect of ecotype (South African Boer, Northern Cape Speckled, Eastern Cape Xhosa Lob Ear, Mbusi/Nguni and random Village Type goats), sex and their interactions on water holding capacity, drip loss, thawing and cooking loss of *m. longissimus dorsi* and *m. semimembranosus*

Knowledge on the amount of available water in meat is essential because meat is sold based on weight thus it is important to minimize water losses in meat (den Hertog-Meischke et al., 1997). Water content in meat also influences the juiciness or dryness of meat (Schönfeldt et al., 1993a). The highest water holding capacity reported in the present study was in VTV goats (Table 4.45) that might be caused by stress encountered during transportation from the farm to the abattoir and because that goat ecotype was not rested after transportation. However, post-mortem aging eliminated the differences of water holding capacity (WHC) in goat ecotypes. Dissimilarly, Kadim et al. (2006) reported no significant differences of expressed juice in transported and non-transported goats (36.8-42.1) at 1 day post-mortem. Contra to Kannan et al. (2003) with no effects of transportation stress on water holding capacity of goat meat, the results obtained herein were in the range obtained by Pophiwa et al. (2017) in the LD and SM (0.35-0.39) for Boer and indigenous goats respectively as well as in the range of those reported by Kadim et al. (2006) in three different muscles (33.8-41.8) of non-transported

Omani goats. On the contrary, those authors found no breed effects on water holding capacity (Pophiwa et al., 2017; Kannan et al., 2003; Kadim et al., 2003).

Furthermore, Kadim et al. (2008) carried out a study on the influences of seasonal temperature on meat quality characteristics of hot-boned, m. psoas major and minor from goats and sheep, concluded that breed and species differed significantly with water holding capacity. According to Kristensen and Purslow (2001), post-mortem aging is used to increase the amount of water in the meat, due to the breakdown of the cytoskeleton which is made of large connections between the myofibrils and the sarcolemma. The values of water holding capacity herein were in the range of those reported by Kadim et al. (2003) in three different muscles of Omani goats that were aged for 1 day and 6 days.

Drip loss values recorded in the present study (Tables 4.54 & 4.55), were higher compared to those reported in the work of Pophiwa (2017) with drip loss values of (0.24% and 0.54%) and (1.10% and 0.99%) in the LD and SM indigenous goats and Boer goats respectively. Pophiwa (2017) equally reported significant differences in the LD but not the SM, that concurred with the observation obtained herein. In the present study, transportation stress in LD of VTV lowered drip loss, in agreement with Nikbin et al. (2016) found lower drip loss values that were influenced by transportation stress in animals, transported at high stocking density aged for 1-day post-mortem but no differences were obtained over 7 days post-mortem aging in Boer goat carcasses. Nibkin et al. (2016) explained that during transportation, animals tend to loss more water due to stress conditions. Another possibility might have been ascribed by a low percentage of intramuscular fat. A lower drip loss has been equally reported in LD of Angora and Boer goats due to less subcutaneous fat deposit as compared to sheep with large amount of fat which is associated with high drip loss by Schönfeldt et al. (1993a). Correlation analysis indicated that low amount of intramuscular fat results into low drip losses from the meat ($r=0.349$; $p<0.01$).

The mean values for cooking loss obtained herein (Tables 4.52 & 4.53 and Tables 4.54 & 4.55) were lower than those reported by Xazela (2010) in the LD of Boer, Xhosa cross, Xhosa lob eared and Nguni (indigenous goats) of about 32.3-40.5%. In addition, Simela (2005) and Babiker et al. (1990) obtained cooking losses of 32% and 34% in the SM of South African indigenous (non-stimulated) and Desert goats respectively. On the other hand, Ivanovic et al. (2014) reported significantly higher cooking loss (39.41% and 40.60% respectively) between Serbian white and Balkan goats. This could be due to high ultimate pH, time and muscle cut

(Dhanda et al., 2003; 1999; Kadim et al., 2003), breed differences, humidity, velocity and temperature at which the samples were cooked (den Hertog-Meischke et al., 1997).

In addition, averages for cooking loss obtained from the SM were within the range of those reported by Pophiwa et al. (2017) in the SM obtained from Boar and indigenous goats (24.7-25.7%) and Kadim et al. (2006) reported 21.4 - 29.8% in the LD of Dhofari, Batina and Jabal Khaddar (Omani goats). On the other hand, the LD cooking losses obtained in the present study were in the range of those reported by Kadim et al. (2006) in the *m. semitendinosus* of Omani goats (11.5-19.8%). In the present study, cooking loss values were higher in the SM than the LD, in agreement with Kadim et al. (2003), Kannan et al. (2001), Nikbin et al. (2016) and Schönfeldt et al. (1993a). The authors explained that this could have been ascribed by the position of the muscles (SM) because it's more involved in contraction upon standing, hence the high values from the SM.

Transportation stress had an effect on the LD of VTV goats, in agreement with Kadim et al. (2014) that reported higher cooking loss from animals that were transported and non-stimulated. Also, Nikbin et al. (2016) and Kadim et al. (2006) found higher cooking loss values from transported goats. This could be explained by different stress levels (caused by the stocking rates) and duration time as they were transported over 3.5 hours. Contra to Kannan et al. (2003), found no effects of transportation stress on cooking losses. Furthermore, post-mortem aging improves cooking losses in meat, by reducing the amount of cooking losses. However, the initial cooking loss in the present study is not known (see Materials and Methods) to be concluded as to whether there was a decrease or an increase in the percentage cooking loss. A decrease in cooking loss in various muscles of goat meat has been reported to decrease (Kadim et al., 2003; Kannan et al., 2001; Nikbin et al., 2016; Gadiyaram et al., 2008) in goat meat with post-mortem aging. The results in the present study (Tables 4.52 & 4.53) concurred with Santos et al. (2007) that interaction effects of genotype and sex did not have an influence on cooking loss.

5.4 Effect of ecotype (South African Boer, Northern Cape Speckled, Eastern Cape Xhosa Lob Ear, Mbusi/Nguni and random Village Type goats) and sex and their interactions on proteolytic aging and meat tenderness of *m. longissimus dorsi* and *m. semimembranosus*

Myofibril fragment length are associated with post-mortem proteolysis, because during post-mortem storage, proteases weakens myofibrils by causing fragmentation (Kannan et al., 2014; Koohmaraie, 1994). Myofibril fragment length measured at 4 days post-mortem in LD and SM obtained in this study (24.48-29.05 µm; Tables 4.60 & 4.61) were longer compared to those previously reported by Simela (2005) with MFL of 18.20 µm and 16.19 µm, and 17.61 µm and 16.67 µm for *m. longissimus* (LD) *and semimembranosus* (SM) muscles aged for 1 day and 4 days post-mortem respectively in non-stimulated South African indigenous goats. The latter was explained that the short MFL were likely caused by high degree of sacrocyst infection of the muscles at that time. Nonetheless, there is evidence that post-mortem aging causes myofibril to shorten because of proteolytic activities that occurs during storage at the desirable environment for the involved proteolytic enzyme (Kannan et al., 2014). In addition, correlation analysis (r=0.354; $p<0.05$) indicated that the breakdown of myofibril fragment length 4 days post-mortem resulted into lower WBSF, hence the tenderness at 4 days post-mortem.

It is a given that proteolytic activity occurred in this study, and after 24 hours the myofibrils were already degraded and fragmented followed by shorter myofibril lengths (MFL) measured at 4 days post-mortem (Table 4.64). Correlation analysis indicated that decreased calpastatin activities resulted into shortened myofibrillar lengths at 4 days post-mortem (r=0.330; $p<0.01$). Comparatively with beef, du Toit (2011) measured similar MFL only after 14 days post-mortem (26.12 µm to 27.48 µm) indicating that the proteolytic tenderisation process take place much more rapidly in goat muscle compared to that of beef. The MFL values recorded in this study (Tables 4.60 & 4.61) indicated that transportation stress and production system (VTV and VT goats) did not have an effect on the proteolytic activity as measured by MFL. Nor a goat ecotype effect, but from (Tables 4.62 & 4.63) it was clear from the significantly longer MFL measured in bucks compared to does at 1 day post-mortem, that the proteolytic activity was more rapid in does compared to bucks. But having measured the same MFL length and shear force at 4 days post-mortem means that the bucks tenderised more quickly during this time post-mortem and being just as tender as the does at 4 days post-

mortem. This can be explained by the higher significant calpastatin inhibitor measured in bucks compared to does (Table 4.71). Contra to Kadim et al. (2014) reported shorter MFL in the transported goat carcasses. Higher amount of extractable protein indicated that protease was able to breakdown muscle fibres, which resulted to shorter MFL (r=-0.320; $p<0.01$) at 4 days post-mortem.

The decrease in calpastatin activity and µ-calpain with post-mortem time and not with m-calpain results herein was in accordance with Dransfield (1993), Ducastaing et al. (1985), O'Halloran et al. (1997), Zamora et al. (1998), Nagaraj and Santhanam (2006), whilst Gadiyaram et al. (2008) reported a decrease in calpastatin with post-mortem aging from 1 day to 4 days post-mortem. According to Dransfield (1993) calpastatin decreases during rigor development at 24 hours post-mortem, by about 30% in rabbit, lamb and beef. This could therefore be explained by the inhibition of µ-calpain activity that is responsible for the decrease in the calpastatin. In addition, pH influences the decrease in calpastatin and calpains activities (Dransfield, 1993). Optimal activity of calpain system is at pH 7-6.

According to correlation analysis, a decrease in calpastatin activity yielded lower pH (r=0.278; $p<0.001$). This also explains that calpastatin activity worked optimally hence the ideal ultimate pH. Whilst the decrease in the µ-calpain activity was ascribed by an increase in intracellular free calcium ion concentration that indicates that µ-calpain were autolysed (Ducastaing et al., 1984). Correlation analysis indicated that increased µ-calpain activity is associated with high calpastatin inhibitor (r=0.358; $p<0.01$). Similarly, Kouakou et al. (2005) reported that µ-calpain was positively correlated with calpastatin activities ($p<0.05$).

The increase in calcium ion concentration causes tenderization to occur in meat (Dransfield, 1993), by approximately 50% within the first 24 hours post-mortem (Dransfield, 1994). However, this could not be approved in this study because shear force was analysed only at 4 days post-mortem. The percentage decrease of µ-calpain activity of approximately 29.8 to 39.7% and 24.2 to 36.6% recorded in the LD and SM of all goat ecotypes by 24 hours post-mortem (Tables 4.69 & 4.70) were within the range of those found by Dransfield (1993) of about 20 to 70% by 24 hours post-mortem. There was an exception measured in the SM of the VTV goats where a slight activation of µ-calpain (Table 4.70) and no calpastatin inhibition was detected at 1 hour to 24 hours post-mortem. This could be explained by the transportation stress and it was only detected in the SM, because it's involved in contraction as opposed to the LD.

The calpastatin activities in this study were lower than those found by Gadiyaram et al. (2008) with 6.8–7.6 U/g in electrically stimulated and control Spanish goats and their crossbreds that were aged for 1 and 4 days. The values of calpastatin and µ-calpain activities in the present study was within the range of 0.83-2.49 U/g reported by Nagaraj and Santhanam (2006) in four different muscles (*longissimus dorsi*, *biceps femoris*, *semimembranosus* and *semitendinosus*) of goats reported. However, higher values of calpastatin and µ-calpain have been reported in other species such as lambs (Ouali and Talmant, 1990), bovine and pigs, beef (Frylinck et al., 2009 and du Toit, 2011).

The differences in calpastatin activity is brought about by the difference in muscle metabolic and contractile types between species (Ouali and Talmant, 1990). Furthermore, Kemp et al. (2010) stated that high calpastatin levels in the meat reduces calpain activity for proteolysis to occur resulting in less meat tenderization thus poor meat quality. On the other hand, m-calpain activity did not change with post-mortem in the LD and SM of goat ecotypes. Nagaraj and Santhanam (2006) also reported no change in the m-calpain activity. The latter author explained that this was caused by the inadequate level of Ca^{2+} ions to activate m-calpain.

There is limited information on the interaction effects of goat ecotypes and sex on calpain and calpastatin activity. However, extractable protein (gram) reported by Simela (2005) in females and males (castrate and intact) of South African indigenous goats were slightly lower 52.41 mg/g, 54.95 mg/g and 48.73 mg/g compared to those obtained in this study. As well as the calpastatin activity reported by Simela (2005) with about 3.13 U/g and 3.11 U/g in females and males. Kouakou et al. (2005) reported higher calpain and calpastatin activity in the Alpine goat females. It must be kept in mind that the methodologies to measure calpains and calpastatin differ from laboratory to laboratory, and values can thus not be accurately be compared. Only the tendencies between projects can be compared.

Sarcomere lengths are associated with muscle energy at slaughter, they determine muscle contraction and relaxation at post-mortem (Goll et al., 1998). In the present study, both muscles (LD and SM) of goat ecotypes did not show any shortening of the sarcomeres. This was also shown by the pH/temperature window theory graphs (Figures 4.1 and 4.2). Despite the slightly higher WBSF values for SM of VTV goats and the conditions that VTV and VT goats were exposed too, sarcomere length did not shorten, this could have been reduced by the delayed chilling method that prevented the effects of contraction on muscles. Contra to Kadim et al. (2006) reported slightly shorter sarcomere length that ranged between 1.5 to 1.6 µm for

m. longissimus dorsi, 1.5 to 1.6 µm for *m. biceps femoris* and 1.5 to 1.7 µm for *m. semitendinosus* measured at 24 hours post-mortem. Equally, Simela (2005) obtained sarcomere length of 1.77 µm respectively in *longissimus dorsi* of South African indigenous goats at 1-day post-mortem slightly shorter to those obtained in the present study in LD at day 1 post-mortem. However, variation in those values were bought about by the differences in ultimate pH, as latter authors reported higher ultimate pH. In addition, muscles that are heavily contracted led to shorter sarcomere at slaughter due to direct chilling post-slaughter (Nagaraj and Santhanam, 2006). According to correlation analysis in LD indicated that lower ultimate pH yielded longer sarcomere lengths in LD ($r=0.236$; $p<0.05$).

Given that sarcomeres are 2.50 µm at rest (Pearson and Young, 1989), therefore this suggest that sarcomere lengths in both muscles (SM and LD) in the present study have shortened by 21-24% of their normal length. Therefore, this showed that the muscles in all the goat ecotypes were more relaxed. In addition, Ertbjerg and Puolanne (2017) suggests that sarcomere must have shorten by at least 30% of their resting length during shortening. Furthermore, longer sarcomeres have been reported by Pophiwa (2017) 2.10 to 2.09 µm and 2.12 to 2.01 µm from the LD and SM respectively that were delayed chilled in Boer and indigenous goats, which have shortened by 15-20%, showing no toughening. The results herein compare well with Santo et al. (2007) that interaction effects of sex and genotype did not influence sarcomere length.

Tenderness is on top of the list of factors that are highly considered by consumer as they tend to discriminate against meat that is not tender (Maltin et al., 2003). In the present study, WBSF values (Tables 4.58 & 4.59, Table 4.60 & 4.61 and Table 4.62 & 4.63) were comparable to that reported by Johnson et al. (1995), Nikbin et al. (2016), Kadim et al. (2006) and Schönfeldt et al. (1993b) with higher shear force values in SM and lower shear force in LD (Table 2.6). The difference in tenderness between the two muscles could be bought about by differences in sarcomere length, differences in calpain system activity characteristics and increased number of crosslinks in the collagen fibrils, which causes a decrease the solubility of the collagen (determined but not reported as part of thesis) which causes toughness in SM (Schönfeldt et al., 1993b). The differences in tenderness between muscles could be that SM are more involved in heavier contractions as they are located in limbs. The results obtained in the present study compares well with Pophiwa et al. (2017) in the LD of Boer goat and indigenous goats, but the latter author found higher WBSF values 8.06 kg and 8.84 kg in the SM of Boer

goats. Correspondingly, Simela (2005) reported higher shear force values 74.47 N = 7.45 kg in non-stimulated South African indigenous goats. However, this was due to high ultimate pH values because of pre-slaughter stress and because the carcasses were placed in a chiller (4°C) directly post-slaughter and were thus susceptible to cold shortening.

5.5 Effects of ecotypes (South African Boer, Northern Cape Speckled, Eastern Cape Xhosa Lob Ear, Mbusi/Nguni and random Village Type goats), sex and their interactions on meat colour and muscle fibre characteristics of *m. longissimus dorsi* and *m. semimembranosus*

Meat colour is significant parameter in meat quality because abattoirs use it as an indicator for the identification and selection of meat for the acceptability of meat by consumers (Adeyemi and Sazili, 2014). Consumers discriminate against meat that is not cherry bright-red in colour (Troy et al., 2010). The L* values (Tables 4.73 & 4.74, Tables 4.77 & 4.78 and Tables 4.75 & 4.76) of goat ecotypes and the interaction effects of goat ecotype and sex obtained in this study were within the range reported by Pophiwa et al. (2017), Kannan et al. (2003), Kadim et al. (2006), Dhanda et al. (1999) and Thuthuzelwa (2015), but higher than those reported by Xazela (2010), Babiker et al. (1990) and Ivanovic et al. (2014) and lower than those reported by Kannan et al. (2001). The values of L* in LD of VT and VTV goats (39.89 and 39.47 respectively) in this study did not correspond with Kadim et al. (2006) where transportation stress lowered the lightness of the goat meat due to high pH_u. Contra to the results herein, it might be that the pH_u recorded herein on the transported group was not high enough to lower the L* indicating that transportation stress had no effect on the L* value. According to Kadim et al. (2006) L* value is used to determine whether the animals were stressed prior to slaughter. Kannan et al. (2014) found that transportation stress lowered the lightness value of the goat meat in LD of Dhofari goats and caused darker meat. On the other hand, the values obtained from LD of VT goats (Table 4.75) showed that production system increased L* of the meat thus producing lighter meat. According to Moyo et al. (2014) diet has an influence on the L* values which can enhance the lightness of the meat. Moreover, goat ecotype effects were observed herein contra to Kadim et al. (2006) who found no breed effects on the lightness of the goat meat.

The a* values of goat ecotypes and interaction effects of goat ecotypes and sex (Tables 4.22 & 4.23 and Tables 4.34 & 4.35), were within the range of those reported by Kadim et al.

(2014; 2006); Kannan et al. (2003) and comparable to the findings of Pophiwa (2017) and Kannan et al. (2001). Transportation stress in VTV goats did not have an effect on the redness of goat meat, in contrast to Kannan et al. (2003) that transportation stress lowered a* value in goat meat. On the other hand, Kadim et al. (2006; 2014) reported higher values of a* with significant effect of transportation stress. MacDougall (1982) explained that excessive stress caused by transportation causes the depletion of glycogen and high pH_u, that in turn leads a phenomenon called DFD meat (Wulf et al., 2002) and very high a* giving rise to a purplish meat colour. The present study, agreed with Kadim et al. (2001) with higher a* values in the SM in comparison to the LD and contradicted those of Nikbin et al., (2016) with higher a* values in the LD compared to that of the SM. This is explained by the fact that the legs are involved in more contraction upon walking and standing. Lower values of a* (Table 2.5) have been reported in goat meat (Dhanda et al., 1999; Babiker et al., 1990; Gadiyaram et al., 2008) that could have been caused by the method used (D65-lightning), as it gives smaller values as compared to illuminate A and illuminate C. However, illuminate A has been said to be more effective for meat analyses (Colour Guidelines handbook). In addition, variation in meat colour recorded by those authors was ascribed by differences in species, breed, age and sex (Dhanda et al., 1999; Babiker et al., 1990).

However, the b* values in the current study for both LD and SM muscles compares well with that of Pophiwa et al. (2017) but the author reported no differences in breeds. On the other hand, b* values in the present study (Tables 4.75 & 4.76) were higher in comparison to those of Kadim et al. (2003; 2006; 2014), Kannan et al. (2001), Babiker et al. (1990), Gadiyaram et al. (2008), Kannan et al. (2001), Ivanovic et al. (2014) and Nikbin et al. (2016) as indicated in Table 2.5. This might have been attributed by differences in breeds and age of goats used or technology used to measure colour. Transportation stress and production system influenced yellowness in the LD of VTV and VT goats (Table 4.75) that was similar to that of Kadim et al. (2006; 2014) and Nikbin et al. (2016) but the authors reported lower values of b* in different muscles of the transported goats. In the present study, goat ecotypes had an effect on Chroma values but Pophiwa et al. (2017) found no breed effects in LD and SM of Boer goats and indigenous goats. Kannan et al. (2003) equally reported that age of the animal had an effect on Chroma but transportation stress had no effect. The values of Chroma and Hue angle herein (Tables 4.75 & 4.76) were within the range of those reported by Pophiwa et al. (2017), with the exception of hue angle in the LD of VTV and VT goats that were higher (Table 4.75) thus an ecotype effect. Nikbin et al. (2016) reported an increase in stress level caused by

the extend of transportation and resulted to higher hue angle but no change in the Chroma values. According to Tapp III et al. (2011) higher hue angles indicate less redness in meat (Table 2.5). Kannan et al. (2001) reported no hue angle and Chroma differences in the *semimembranosus, triceps brachii and longissimus dorsi* muscles of goat meat.

The effects of ecotypes on the instrumental colour coordinates in LD and SM with post-mortem aging (Table 4.73 & 4.74) agreed with Kouakou et al. (2005) and Kadim et al. (2003). Similarly, Kouakou et al. (2005) reported an increase in L* and b* (control goats) over 13 days post-mortem aging. The pattern recorded herein was in accordance with Nikbin et al. (2016) with an increase in non-transported group and a decrease in the L* with post-mortem time for the transported group equally to the VTV goats for the LD but not for the SM muscle. Further, those authors reported an increase in a*, b*, Chroma and hue angle (Table 2.5) similar to that of the LD values of goat ecotypes in this study (Table 4.75). The increase in lightness is caused by changes in muscle protein denaturation state (MacDougall, 1982). Correlation analyses indicated that a lower amount of extractable protein at 24 hours post-mortem correlates with the increase in lightness at 4 days post-mortem ($r=-0.380$; $p<0.05$). A lower amount of extractable protein is associated with protein denaturation. According to Tshabalala et al. (2003) meat colour is influenced by the post-mortem aging. This can further be explained by Pearson correlation; an increase in hue angle is negatively correlated to metmyoglobin ($r=-0.326$; $p<0.01$). In addition, it has also been reported in other species that the colorimeter colours increase with aging time: Peña et al. (2014) reported that L*, a* and b* increases with aging irrespective of whether the animal is stressed or unstressed in the *longissimus thoracis* of three beef types. External factors alone are not responsible for meat colour, as the surface of meat is greatly attributed by the three states of myoglobin (Kadim et al., 2006). Meat discoloration is caused by conversion of oxymyoglobin to metmyoglobin. The forms of myoglobin are affected by oxygen partial pressure, temperature, muscle pH, meat's reducing activity and microbial growth Mancini and Hunt (2005), partial oxygen pressure and lipid oxidation (Faustman et al., 2010). However, the values of deoxmyoglobin recorded from goat ecotypes and on the interaction effects of goat ecotypes and sex in the LD and SM (Tables 4.80, 4.81 & 4.82) were higher to those reported by Pophiwa et al. (2017) in LD and SM of Boer goats and indigenous goats 56.5-59.7% at 24 hours post-mortem.

Similarly, oxymyoglobin in LD and SM recorded herein at 1 day post-mortem were close to those (21.6-27.1%) reported by Pophiwa et al. (2017). Nonetheless, the latter authors

reported no differences in Boer goats and indigenous goats on all the three forms of myoglobin. According to the values in the present study (Table 4.81), transportation stress and production system did not influence the oxymyoglobin and deoxymyoglobin, with an exception of the SM for VT goats (Table 4.81), that had high levels of deoxymyoglobin (59.1%), which led to a low metmyoglobin (11.8%) and oxymyoglobin (29.0%). Pearson correlation analysis indicated that deoxymyoglobin is negatively correlated with oxymyoglobin (r=-0.966; p<0.001). This could be that the fresh meat was not bloomed enough to allow oxygen to penetrate in the meat (Mancini and Hunt, 2005; Park et al., 2007). MacDougall (1982) explained that blooming of meat increases light scattering, which causes deeper penetration of oxygen into meat thus brighter meat. Kannan et al. (2001) reported higher MetMb levels of 26.5-28.7% on several muscles of the Spanish goats in contrast to the current study. According to the correlation analysis, metmyoglobin is positively correlated with oxymyoglobin (r=0.367; p<0.01) LL and (r=0.313; p<0.01) SM. Similarly, Pophiwa (2017) reported that a reduced percentage of metmyoglobin resulted to reduced oxymyoglobin but an increase in deoxymyoglobin. The results herein were in accordance's with Kannan et al., (2001) that metmyoglobin increased with aging. According to Pearson correlation (Table 4.90) the increase in percentage of red fibres causes an increase in oxymyoglobin hence the red colour of meat (r=0.274; p<0.05). Furthermore, percentage increase of red fibres causes a decrease in deoxymyoglobin (r=-0.274; p<0.05) at 4 days post-mortem.

The knowledge of muscle fibre typing in muscles is of fundamental importance in the study of meat quality (Şirin et al., 2017). However, there is little comparative information on the characteristics of muscles in ruminants especially in indigenous goats. The results obtained herein (Tables 4.84 & 4.85) concurred with Pophiwa (2017) that red fibres had the smallest cross-sectional area, intermediate fibres were of medium size and white fibres had the largest cross-sectional area in the LD and SM. However, the latter author reported higher average values in the cross-sectional area (CSA) of red, intermediate and white (2166 μm^2, 3087 μm^2 and 398 μm^2) in the LD and (2443 μm^2, 3671 μm^2 and 4496 μm^2) in the SM of Boer goats and indigenous goats respectively. The values of CSA for red, intermediate and white fibres (Tables 4.82 & 4.83, Tables 4.84 & 4.85 and Tables 4.86 & 4.87) were within the range of those reported by Simela (2005) except for the VT goats. The latter author obtained cross sectional area (CSA) of red (1630-1958 μm^2), intermediate (2113-2502 μm^2) and white fibres (2881-3243 μm^2) in the LD of conditioned and non-conditioned South African indigenous goats. The percentage of red fibres, intermediate and white fibres herein (Tables 4.86 & 4.87) did not

correspond to those reported by Pophiwa (2017) with values of 49%, 23-26% and 25-28% for the red, intermediate and white in the LD and SM of Boer goats and indigenous goats. This could be the differences in the wide range of goat ecotypes.

The differences in muscle fibre is ascribed by the differences in breed type, sex (Joo et al., 2013), weight/age, nutrition (Waritthitham et al., 2010), physical activity, hormones (Anwer et al., 2013) muscle type and regions within the muscle (Taylor, 2004). Bünger et al. (2009) reported that the differences in breed is brought about by the degree of maturity as carried out on sheep. In the current study, there was a positively moderate relationship (r=0.435; p<0.001), this concluded that an increase in the CSA of muscle fibres (intermediate fibre) yield an increase in live weight. This concurred with the findings of Pophiwa (2017) in the LD of Boer goats and indigenous goats. The results obtained herein indicated that muscles were associated with high percentage of red fibres in agreement with Pophiwa (2017). Muscles that are associated with red fibres are juicier and more flavoursome as compared to type IIB muscle which have a low meat tenderness (Anwer et al., 2013). Furthermore, Choi et al. (2007) stated that the increase in red muscle fibres leads to decrease in the rate and extend of muscle pH, this explains the negative correlation in the red fibres with pH (r=-0.257; p<0.05) in the current study. Equally, Pophiwa (2017) reported a positive correlation between drip loss and cross-sectional area in the LD muscle. This means that large cross-sectional area leads to a large amount of drip loss from the meat. Contra to Waritthitham et al. (2010) with negative correlation between CSA and drip loss. Ryu and Kim (2005) reported no correlation between CSA of muscle fibres with drip loss and this was in accordance with results from the SM muscles but not the LD. The results obtained in this study (Table 4.91) on the LD agreed with Pophiwa (2007), that the percentage of white fibres were negatively correlated (r=-0.34; p<0.05) with shear force in the LD but with a weak correlation (r=-0.273; p<0.05). This could be explained by the fact that white fibres are more susceptible to early proteolytic degradation than the red fibres (Ouali, 1990). Kim et al. (2013) as cited by Joo et al. (2013) reported that the proportion and size of muscle fibres are positively correlated with intramuscular fat, in agreement with the results herein (r=0.288; p<0.05).

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

This study was undertaken to achieve the following aims:

- To investigate muscle energy metabolism and meat colour in different goat ecotypes in South Africa (South African Boer, Northern Cape Speckled, Eastern Cape Lob Ear, Nguni-Mbusi and random Village Type goats) and their sexes (bucks and does).
- To determine the role of the calpain proteolytic enzyme system in post-mortem tenderization of muscle between the different goat ecotypes and sexes (bucks and does).

The indigenous goat ecotypes and sex did not significantly affect the attributes that have an effect on yield and profit like dressing percentage, chilling loss and chemical composition.

This study revealed that there were some physiological, and biochemical differences between indigenous goat ecotypes. By contrast the influence of sex and environmental aspects such as production system and transportation had a greater effect on the animal physiology and meat quality because of the stress responsiveness of these animals to the environment. The post-slaughter goat muscles demonstrated a unique muscle energy metabolism pattern with the early pH dropping slower than that in beef when kept at 10°C until about 6 hours post-mortem, then the pH decreased more rapidly until about normal pH_u values of around pH 5.6. These conditions are ideal for effective operation of calpain enzymes causing tenderisation within the first few hours post-slaughter, followed by relatively small differences in tenderness between 1 day and 4 days post-mortem. The current results provide evidence of short myofragment lengths measured at 1 day and 4 days post-mortem, as well as acceptable Warner Bratzler shear force results. These processes are also supported by the relatively low glycogen levels in the muscle and marginally higher ultimate pH at 24 hours post-mortem. Overall, the muscles also showed that they have a lower glycolytic potential, which is in agreement with previous studies. These goat muscle characteristics were improved by using delayed chilling but may be susceptible to cold shortening if the carcasses are chilled too rapidly with resultant shortened sarcomere lengths and contracted muscle. The avoidance of cold shortening is also advantageous to the calpain action. Structures are relaxed and calpain enzyme has space to move into its target proteins.

The ultimate pH of all the goat ecotypes were within acceptable ranges (pH 5.5 to 5.7), except for VT and VTV goats that had slightly higher pH values - these goat ecotypes might be more susceptible to stress irrespective of the production system and had lower glycolytic potential muscles. The VTV goats were brought in from the village in the morning before slaughter over a long distance in comparison to VT goats that were raised on the ARC-Irene campus and travelled only 3 km to the abattoir. Still both groups gave the same results in most attributes tested. Stress can unfortunately also be caused by other factors such as handling, unfamiliar environment, hunger and noise. Stress could be reduced by the availability of feed and water until slaughter and moving one animal at a time so that another animal cannot see what happens. Meat colour was not affected by goat ecotypes, sex or their interaction, but with post-mortem due to aging. Differences in meat colour were only observed at 1 day post-mortem, but the differences between goat ecotypes disappeared at 4 days post-mortem, giving the meat from all carcasses a more acceptable colour. The differences in the biochemical forms of myoglobin between ecotypes also disappeared at 4 days post-mortem, with an increase in oxymyoglobin giving it a red colour, decreased deoxymyoglobin and steady metmyoglobin. As indicated by most if not all the authors, goat meat has a low amount of fat, which gives the meat a low amount of expressed juice from the meat.

The physiological differences and masculinity of bucks compared to the does on average caused them to be heavier compared to the does, which is also reflected in the calpain system characteristics, where bucks tended to have higher calpastatin levels to promote muscle building. Because the studied animals were still young (kids; around 9 months of age), these differences were not significant and not consistent for all the goat ecotypes. The XL, NCS and VT bucks were heavier than the does, however, this was not true for the SAB and MBZ goats as the does were heavier than the bucks. In addition, the heavier goat ecotypes had the largest sex differences, as compared to light weighted goat ecotypes. The effects of sex showed that bucks were more prone to ante-mortem stress in comparison to does.

The muscles of all the goat ecotypes, sex and interaction effects of ecotype and sex did not show cold shortened muscles, which was facilitated by the application of delayed chilling after slaughter. Therefore, there is significant potential for goat ecotypes to be farmed with because they have characteristics that compare favourably with those of typical meat goats used for meat production. The commercialised goat meat from the different ecotypes is important because they contribute significantly to the total number of goats in South Africa.

However, to ensure that goat meat is of quality there is a need to subject the carcasses to delayed chilling due to its small size and problems associated with ante-mortem stress, preslaughter stress and transportation stress.

6.2 Recommendation

The study revealed that goat ecotypes have similar meat quality characteristics compared to that of other goat breeds used for meat production and have the potential to be farmed with. However, this study recommends that further studies should be done:

- By using similar goat ecotypes but using a larger sample size, to better clarify the interaction effects between goat ecotypes and sex. This was because the results did not always come to a specific conclusion that make sense especially with the biochemical status and it would have helped in giving more interaction between goat ecotypes and sex.
- The determination of WBSF should be measured at 1 day post-mortem in order to correlate the relationship with MFL, because this will give clearer explanation of why meat become tender with aging.
- The determination of calpain activities should be examined over a longer period of post-mortem aging, because it has been suggested that m-calpain works after the μ-calpain can no longer be detected and that normally occurs after 24 hours post-mortem.
- Further sensory analysis (juiciness and flavour) should be carried out, to confirm if goat meat is juicy.
- Safety and preferred slaughter procedures should be an ongoing study and also considering microbiology.
- It is rather difficult to compare different goat research studies because of the variable experimental conditions used in previously published research.

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