Meat characteristics and acceptability of chevon from South African indigenous goats

by

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Abstract

ABSTRACT

Effects of sex, age and pre-slaughter conditioning on the characteristics of South African indigenous goat carcasses (weight, dimensions, and joint and tissue composition) and quality of chevon (pH and temperature profiles, histological, histochemical, metabolic, proteolytic and physical) were determined. Effects of post-mortem ageing and electrical stimulation on the quality of chevon were also investigated. The nutritional quality of chevon in terms of fatty acid and amino acid content was assessed. The acceptability of chevon compared to mutton was tested by a panel of South African consumers.

The goats were large with live weight, carcass weight and carcass dimensions in the range of the large breeds of southern Africa. They had a high lean and low fat content that is typical of most goat breeds. Intact males were suited for high chevon yield because they were heavy, had a high lean and low fat content, and losses during dressing and chilling were reduced by improved nutrition. Goats between two and six teeth yielded heavy carcasses that were comparable to goats in the eight teeth group, and had proportionately more lean. The hind limb appeared to be ideal for high lean and low fat high value cuts but the dorsal trunk was bony and yielded less lean. Pre-slaughter conditioning improved the overall size of the goats and reduced the losses during slaughter and chilling. It also improved the lean/bone and lean and fat/bone indices.

The *M. longissimus thoracis* (LT) had a low glycolytic potential (GP), high initial lactate concentration, low initial pH and high ultimate pH (pHu) values, all of which indicated that peri-mortem handling of goats was a potent stressor. Chevon from carcasses with pHu<5.8 had higher initial GP, glycogen and ATP content. It had longer sarcomeres, low 96-hour shear force values and better colour quality than higher pH meat. Similarly, chevon from the 2-teeth group tended to have lower pHu values than contemporary groups and hence lower 96-hour shear force values and better colour quality. Conversely, mature does tended to have high pHu and hence a high mean 96-hour shear force value and a low mean a* value associated with dark cutting meat. Only up to 20% of the muscle samples had a pHu<5.8. Pre-slaughter conditioning had no effect on GP and pHu but enhanced the rate of pH and temperature decline and resulted in more tender meat with higher a* values.

Generally carcasses with a 3-hour pH (pH_3) of less than 6.1 were heavier, had more carcass fat, maintained a high temperature early post-mortem, had longer sarcomeres, better colour quality and lower 24-hour shear force values than those with a pH_3 of 6.3 or greater. *M. longissimus thoracis* and *M semimembranosus* (SM) samples with pH_3<6.1 constituted less than 22% of the samples.

The LT and SM had different myofibre proportions. Myofibre types were not useful indices of meat quality. The level of immediate post-slaughter calpastatin activity suggests that the proteolytic potential of chevon is not essentially different from that of other meat types.

Ageing and electrical stimulation improved tenderness and colour quality of chevon. Electrical stimulation increased the rate of pH decline to levels outside the risk of cold shortening as well

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as the ageing potential of chevon such that the meat attained tenderness that was within the acceptable limits for four days of ageing.

Chevon had high levels of PUFA, particularly C18:2, which were similar to values reported for ostrich. The high C18:2/C18:3 ratio suggested that the n-6/n-3 fatty acid ratio would be much higher than the recommended ratio of less than four. Most of the fatty acid proportions fell within the ranges that have been reported for chevon and other red meat species. Age and sex of the goats had no significant effect on the fatty acid profile but pre-slaughter conditioning resulted in lower levels of C14:0 and total SFA, and increased levels of C18:1 and hence MUFA. The amino acid proportions suggest that there is no variation in the amino acid profile between *M. longissimus lumborum* muscles from goats of different age or sex classes.

Level of education of the consumers was most important in determining consumer acceptance of the sensory attributes as well as the intended frequency of consumption for chevon and mutton. Population group was a significant factor only when the meats were of more variable acceptability.

Sensory evaluations indicated that chevon and mutton were highly acceptable to the consumers, who were willing to eat any of the meats at least once a week. The study indicated that chevon is acceptable to South African consumers and may be as acceptable as mutton if the meat is from goats of about two years old or younger.

South African indigenous goats may yield high quality chevon, with a low pHu and acceptable colour provided that the meat is from large carcasses (~15kg) with a high fat content (at least 7%) and is not from mature does.

Declaration

I declare that this thesis for the PhD (Animal Science) degree at the University of Pretoria has not been submitted by me for a degree at any other university.

Signed ……..

Langelihle Simela

Summary

Meat characteristics and acceptability of chevon from South African indigenous goats

by

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Experiments were conducted to determine the effects of sex, age and pre-slaughter conditioning on carcass and chevon quality of South African indigenous goats. Effects of post-mortem ageing and electrical stimulation on chevon quality were also investigated. The nutritional quality of chevon in terms of fatty acid and amino acid content was assessed. The acceptability of chevon to South African consumers and in comparison to mutton was tested.

Eight-nine milk- to 8-teeth female and milk- to six-teeth intact male and castrated South African indigenous goats were procured and raised at the experimental farm on a maintenance diet of a pelleted concentrate mix fed at about 3% of total animal weight per pen. Clean water and *Eragrostis curvula* hay were available ad libitum. The goats were slaughtered at a research abattoir after 17 hours in liarage and under conditions similar to those employed in the meat industry in South Africa. All goats were electrically stunned and a subset of four castrates with 4-to-6 permanent incisors and nine 8-teeth does from both the non-conditioned and pre-slaughter conditioned groups were electrically stimulated immediately after exsanguination.

Temperature and pH profiles, sarcomere lengths (SL), myofibrillar fragment lengths (MFL) and myofibre types (MFT) were determined from both the *M. longissimus thoracis et lumborum* (LTL) and the *M. semimembranosus* (SM). Glycolytic potential (GP), ATP and creatine phosphate concentrations, calpastatin activity, fatty acid and amino acid profiles, crude fat and crude protein determinations and sensory analysis were carried out on LTL. Cooking losses, shear force values and colorimetric values of the SM were determined. Separable lean, bone and intermuscular and subcutaneous fat composition of the carcasses were determined from dissections of the right halves.

The goats were large with mean slaughter weights ranging from 27.83±3.81kg to 42.65±3.92kg and cold carcass weights (CCW) ranging from 11.81±2.43 kg to 16.91±2.88kg between the milk-teeth and 8-teeth groups. Chest girth ranged from 71.05±3.44 to 84.09±2.39cm and carcass length from 66.26±3.73 to 74.96±3.22cm between the milk- and 8-teeth groups. Slaughter weight, hot carcass weight (HCW), CCW and carcass dimensions all significantly increased with age of the goats ($P<0.0001$). Intact males and castrates had similar slaughter weight, HCW and CCW that were heavier than those of female goats ($P<0.01$). Intact males had the largest frames

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with mean chest depth and carcass length that were bigger than those of castrates and females (P<0.01). Pre-slaughter conditioning resulted in increased slaughter and carcass weights, carcass dimensions and *M. longissimus thoracis* (LT) area (P<0.05).

Dressing out percentage (DO%) was not affected by sex and age of the goats (P>0.05). Pre-slaughter conditioning resulted in 16% higher DO% and 30% lower chilling losses (P<0.0001). Chilling losses did not vary with the sex of the goats (P>0.05) but were higher for the 2-teeth goats compared to the milk-teeth, 4-to-6 teeth and 8-teeth groups (P<0.05).

Proportionately, carcasses with a higher carcass fat percentage had lower lean percentage. Thus females and castrates had a 6.2% higher carcass fat percentage and 3.2% lower lean percentage than intact males. Similarly, the full-mouthed does had the highest carcass fat percentage of 16.08±8.25 amongst the four age groups and a low lean percentage of 62.13±5.81 (P<0.05). Non-carcass fat content was not affected by sex (P>0.05). There was more of this fat in carcasses of the 8-teeth does than those of younger goats (P<0.001) and in pre-slaughter conditioned than non-conditioned goats (P<0.0001).

Lean/bone and lean and fat/bone indices were not affected by sex and age of the goats (P>0.05). Overall means for the indices were 2.95±0.38 lean/bone and 3.67±0.68 lean-and-fat/bone ratios. Pre-slaughter conditioning resulted in lower percentages of lean and bone (P<0.0001), increased carcass and non-carcass fat content (P<0.0001) and higher lean/bone and lean and fat/bone yield indices (P<0.001).

Amongst the joints of the carcasses, the hind limb had the more ideal composition for high lean and low fat cuts. The dorsal trunk was bony and yielded less lean.

On average the intact males had a significant 2.4% units more weight in the neck and about 1.5% units less weight in the hind limb compared to the females and castrates (P<0.01). Fore limb, dorsal trunk and ventral trunk percentages did not differ significantly amongst the sexes (P>0.05). Overall mean proportions of these joints were 19.08±1.39%, 20.74±1.58% and 18.31± 2.42%, respectively. The proportions of the hind limb and ventral trunk only varied with age. Hind limb percentage was highest in the younger goats and least in the 8-teeth does while ventral trunk proportions were in the reverse order.

Generally the goats had a low initial GP (mean = 101.74±23.21µmol/g), low initial pH (mean = 6.54±0.29), high initial lactate concentration (mean = 30.19±10.57µmol/g) and high pHu (mean = 5.93±0.14), which indicate that they suffered stress during peri-mortem handling. The GP metabolite concentrations, pH and temperature were not affected by the sex of the goats (P>0.05). However mature does had the highest *M. longissimus thoracis* pHu of 6.03±0.19 (P=0.04), the lowest SM a* value of 11.41±3.41 (P=0.002), and hence the lowest chroma value (P=0.003) and tendency to yield tougher chevon (96-hour shear force = 77.39±18.54N). Pre-slaughter conditioning did not improve the response to peri-mortem handling for any of the age and sex groups (P>0.05).

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The average myofibre type ratios (red: intermediate: white) were 26:33:41 in the LTL and 29:37:34 in the SM. Pre-slaughter conditioning resulted in a higher intermediate myofibre percentage (P=0.04) only. Castrated males had a lower proportion of white myofibre than intact males at the 2-teeth stage (P<0.05). Red and intermediate myofibre proportions were not affected by age and sex (P>0.05). Myofibre types were not useful indices of meat quality.

The level of immediate post-slaughter calpastatin activity (mean = 3.18 ± 0.81U/g sample) suggests that the proteolytic potential of chevon is not essentially different from that of other meat types. Calpastatin activity was not affected by the age of the goats (P>0.05) but was significantly higher for pre-slaughter conditioned intact males compares to the non-conditioned ones (P<0.05). Calpastatin activity in the LTL of castrates and females was not affected by pre-slaughter conditioning.

Intact males had a lower 24-hour a*, and hence chroma value than the females and castrates (P<0.05). Pre-slaughter conditioning resulted in lower 96-hour shear force values, more so for castrates than females. Pre-slaughter conditioning reduced the variation of tenderness amongst the different age groups, leading to more uniform and lower 96-hour shear force values. Myofibrillar fragment lengths, cooking losses, L* and b* values of the SM were not affected by sex, age and pre-slaughter conditioning (P>0.05).

The rates of post-mortem glycolysis and carcass chilling and pHu were important determinants of chevon quality. Larger and fatter carcasses were glycolysing fast (pH_3<6.1), maintained high early post-mortem temperature (mean 3-hour LT temperature =16.38±3.48°C) and resulted in significantly better SM colour (24-hour a* = 15.71± 1.99) and longer 24-hour SL (mean = 1.85±0.20µm). The lower values of these traits were associated with muscles with pH_3>6.3. *M. longissimus thoracis* and SM samples with pH_3< 6.1 constituted less than 22% and those with pH_3>6.3 more than 54% of the samples.

On average, carcasses with *M. longissimus thoracis* pHu ≤6.0 had 27.73µmol/g higher GP, 11.5µmol/g more glycogen, 0.52µmol/g more ATP than carcass with a pHu > 6.0 (P<0.05). Carcasses with *M. semimembranosus* pHu<5.8 had the highest a*, b* and chroma (P<0.01) values at both 24- and 96-hours post-mortem. Low pHu chevon also had a mean 96-hour shear force value that was 18N (P=0.005) less than the average 70N of the carcasses with a SM pHu >5.8. Up to 20% of the muscle samples had a pHu<5.8.

Ageing the meat for up to 96 hours improved the tenderness of both muscles. This was expressed in decreased MFL and shear force values of the SM. Ageing also improved colour quality such that differences that occurred at 24 hours post-mortem had disappeared by 96 hours post-mortem.

Electrical stimulation (ES) of chevon improved the rate of pH decline to levels outside the risk of cold shortening (mean *M. longissimus thoracis* pH_3 = 6.37±0.25 for NES vs. 5.90±0.14 for ES carcasses). ES had no effect on LTL sarcomere and myofibrillar lengths. In the SM muscle, ES resulted in more tender meat 24 hours post-mortem (mean 24-hour shear force = 77.97±17.26 N for NES vs. 50.39±10.17N for ES carcasses) and a greater rate of tenderisation to 96 hours post-mortem (Mean 96-hour shear force = 74.47±16.96N for NES and 40.86±8.92N for ES carcasses).

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Electrical stimulation resulted in tenderness levels that were within the acceptable limits as defined for lamb and beef. Electrical stimulation also improved the colour of chevon (mean 24-hour a*= 11.86±3.31 for NES vs. 14.56±1.99 for ES), even after ageing for 96 hours mean 96-hour a* = 13.67±2.23 for NES vs. 15.46± 1.38 for ES carcasses). Colour and tenderness were improved despite the high pHu of chevon.

The polyunsaturated fatty acid (PUFA), particularly C:18:2 content of chevon from the South African indigenous goats was high. The overall mean percentages were 18.35±5.74 PUFA and 17.62±5.45 C18:2. Consequently the PUFA/SFA and C18:2/C18:3 ratios were high and typical of grain-fed ruminants. Age and sex of the goats had no significant effect on the fatty acid profile. However, pre-slaughter conditioning resulted in a lower concentration of C14:0 and total saturated fatty acids (SFA), and increased concentration of C18:1, and hence monounsaturated fatty acids (MUFA). Pre-slaughter conditioning did not affect the PUFA content (P>0.05).

There was little variation in amino acid profile with age-class of the goats. Alanine and tyrosine only were significantly affected by the class of the goats (P<0.05). Both amino acids were least concentrated in LL of 2-to-4 teeth females and most concentrated in LL of mature does.

Level of education was the most important consumer characteristic in determining acceptance of the sensory attributes as well as the intended frequency of consumption for the meats. Consumer age and gender were important factors in some cases but population group was a significant factor in the judgement of meats of more variable sensory attributes.

The sensory evaluations indicate that chevon and mutton were highly acceptable (range of mean overall acceptability = 3.79 to 4.27) to consumers, who were willing to eat any of the meats at least once a week. The study indicated that chevon is acceptable to South African consumers and may be as acceptable as mutton if the meat is from goats of about two years old or younger.

It is concluded that South African indigenous goats belong to the large breed of southern Africa. The goats are highly prone to pre-slaughter stress and hence yield high pH meat with a dark colour. However the goats may yield chevon of acceptable quality with pHu of less than 5.8, high a* values and acceptable tenderness provided that the carcasses are large (~15kg HCW), have a relatively high carcass fat content (≥7%) and are not from old does. Chevon has healthful fatty acid and amino acid profiles regardless of age and sex of the goats. The meat is highly acceptable to South African consumers of diverse backgrounds, especially if it is from goats that are one to two years old.

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LIST OF ACRONYMS

ADP	Adenosine diphosphate
AMP	Adenosine monophosphate
ATP	Adenosine triphosphate
BCFA	Branched chain fatty acids
BF	*M. Biceps femoris*
CCW	Cold carcass weight
DFD	Dark, firm and dry
DO%	Dressing out percentage
EFA	Essential fatty acids
ES	Electrical stimulation
G-6-P	Glucose-6-phosphate
GP	Glycolytic potential
HCW	Hot carcass weight
KKCF	Kidney knob and channel fat
LDH	Lactate dehydrogenase
LL	*M. longissimus lumborum*
LT	*M. longissimus thoracis*
LTL	*M. longissimus thoracis et lumborum*
MCP	Multicatalytic protease
ME	Metabolisable energy
MFI	Myofibrillar fragmentation index
MFL	Myofibrillar fragment length
MFT	Myofibre type/typing
MSA	Meat Standards o Australia
MUFA	Monounsaturated fatty acids
pH_0	Initial pH
pH_3	pH at 3 hours post mortem
pH_6	pH at 6 hours post mortem
pH_{24}	pH at 24 hours post mortem (same as pHu)

List of Acronyms

pHu	Ultimate pH = pH_{24}
PUFA	Polyunsaturated fatty acids
SAMIC	South African Meat Industry Co-operation
SDH	Succinate dehydrogenase
SFA	Saturated fatty acids
SL	Sarcomere length
SM	*M. Semimembranosus*
ST	*M. Semitendonosus*
TAG	Triacylglycerides
TCA	Tricarboxylic acid cycle
UFA	Unsaturated fatty acids
WBS	Warner-Bratzler shear force
WHC	Water holding capacity

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