The quality of South African lamb – carcass, nutrient and sensory attributes

by

Salomina Maria van Heerden

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
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The quality of South African lamb – carcass, nutrient and sensory attributes

by

Salomina Maria van Heerden (née Jerling)

Dissertation submitted to the
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Supervisor: **Prof. H.C. Schönfeldt**

Co-supervisor: **Dr P.E. Strydom**

Co-supervisor: **Dr R. Kruger**

I declare that the thesis herewith submitted for the Ph D degree at the University of Pretoria had not been previously submitted by me for a degree at any other University.

…… **……..**

S.M. van Heerden **Date**

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ABSTRACT

The quality of South African lamb – carcass, nutrient and sensory attributes

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The aim of the study was to determine the quality of South African lamb, particularly the carcass, nutrient and sensory attributes. To this end the cut composition of SA lamb carcasses with different fat scores was determined and cuts suitable for trimming were identified. Sixty four grain fed Dorper lambs were divided randomly into three slaughter groups of 30, 36 and 42 kg, respectively. After slaughter, electrical stimulation (how much/long) and chilling (how long/temp) the carcass sides were subdivided into seven wholesale cuts. Each cut was dissected into meat, bone and subcutaneous fat (SCF) in order to determine the physical composition per cut and for the whole carcass. It was found that the percentages total fat in the carcass increased with 15.5 % in subcutaneous fat over the five fat classes.

In order to determine and compare the raw and cooked nutrient composition of shoulder, loin and leg cuts of Dorper and Merino lamb carcasses of the A age class of fat class 2 (± 7 % SCF) from three main production areas in South Africa were analysed. Samples were analysed both raw (left side cuts) and cooked (right sides) using accredited methodologies for nutrient content namely proximate composition, vitamin B and minerals. There was no significant difference in the iron and zinc values between the cooked cuts. Results showed differences in both trace elements and B vitamins among different cooked cuts, although the differences were not statistically significant. Cooked SA lamb (A age class, fat class 2) contains an average of 60.5 % less total fat and 5.28 % less protein, resulting in 1891 kJ less per 100 g edible portion energy, if compared to the previous values in the food composition tables.

Quantitative descriptive sensory analyses were performed by a trained panel on the *M. longissimus lumborum* (loin) from lambs of the same age. Aroma intensity, initial impression of juiciness, first bite, sustained impression of juiciness, muscle fibre and overall tenderness, amount of connective tissue (residue), overall flavour intensity and off-flavour intensity were measured, as well as cooking related measurements and resistance to shear. With the exception of juiciness, the results in this study showed that contrary to expected carcass fatness (in the same age over five fat classes), as portrayed in the South African Classification system, does not have a significant effect on the sensory qualities of *M. longissimus lumborum* (loin) from lambs of the same age.

This investigation provides important scientific insight into the physical, nutrient and sensory quality of South African lamb. The results obtained show that subcutaneous carcass fat that increased significantly with an increase in fat class can be trimmed to represent leaner cuts to the discerning consumer. This study found unique values for South African lamb cuts, almost 40 % lower in fat content than the previously-believed-to-be-accurate values, as published by the Medical Research Council for health workers. Contrary to expected it was found in this study that increased fatness did not improve lamb tenderness as popularly believed in the United States. Therefore, the study justifies greater scope for further research into all these aspects, as it provides valuable information for the Red Meat Industry.

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Especially to my husband George, my sincere gratitude for your love, encouragement, patience and support through these years.

Finally, I dedicate this study and my career to HIM who made it all possible with the following:

……" Psalm 139"..

…. "U is, omdat U is
Ek is, omdat U daar is.
Alles is deur Hom en vir Hom geskep,
en niks word toevallig ontdek." ……

Kowie Rossouw & Randall Wicomb
2004

ABSTRACT

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The need for information on the quality of South African lamb and mutton to address consumer uncertainties was identified by the Red Meat Producers Organisation (RPO) who requested that the quality of South African lamb be investigated. The aim was to determine the quality of South African lamb, namely the carcass, nutrient and sensory attributes. However, due to financial constraints, only the most often consumed cuts of the most popular grade (A2) were analysed for nutrient content.

In South Africa, sheep carcasses are classified subjectively according to age and amount of fat cover. The consumer is concerned about fat in the diet and consequently certain local meat companies have altered part of their operations to boneless retail cuts that could include trimming of fat off cuts to obtain and market a leaner, more attractive cut for the consumer. The objectives were, firstly to determine the cut composition of SA lamb carcasses with five different fat classs, and secondly to identify certain cuts that are suitable for trimming. The study consisted of 66 pasture-fed Dorper lambs that were divided into three groups and slaughtered at 30, 36 and 42 kg live weight. Chilled carcass sides were subdivided into seven wholesale cuts and dissected into meat bone and subcutaneous fat (SCF) in order to determine the physical composition per cut and

for the whole carcass. The soft tissue of the carcass was analysed for total fat, protein, ash and moisture. According to the result, the percentages total fat in the carcass increased with 15.5 % over the five fat classes, with the largest increase (26 % units) in the loin cut followed by the flank, shoulder and neck cut. The % meat (lean) of the neck, thick rib and breast showed no significant change between fat class 1 to 5, although the % bone decreased significantly (> 6 % units). Meat and bone proportions decreased significantly with increase in fat class for the loin, flank, leg and shoulder cuts. The composition of the loin cut was most affected overall by changes in the fat class. Trimming reduced the boneless SCF level of the loin, leg and shoulder by 12, 6 and 9 % units, respectively, when trimmed from a fat class 5 to a fat class 3. Further trimming to fat class 1, reduced the % SCF by 18, 8 and 5 % units on a boneless level. The SCF of the neck and thick rib could be reduced significantly between 4 and 5 % units from fat class 5 to fat class 3. The neck, thick rib, breast and flank cuts could be trimmed significantly from a fat class 3 to a fat class 1 level by 5 % units. Although trimming could be applied to the over fat carcass and cuts within the fat class, the cost of the process as well as possible profit on the end product should be considered.

The right sides of Dorper and Merino lamb carcasses of the A age class, fat class 2 (± 7 % SCF) from three main production areas in South Africa were used to determine the raw and cooked nutrient composition of three cuts (shoulder, loin and leg). Nutrients showing the greatest differences between raw and cooked treatments, were protein, total fat, cholesterol, C16:0 saturated fatty acids (SFA) and C18:1n9c monounsaturated fatty acid (MUFA). Moisture losses due to cooking resulted in an increase in the protein and cholesterol concentrations of the cooked cuts. Iron content was lower in the cooked loin cut but increased in the cooked leg cut when compared to the corresponding raw cuts. The vitamin B content of all three cooked lamb cuts was lower, although not significantly, than that of the corresponding raw cuts. Therefore, lamb is a good source of protein, iron and the B vitamins, especially vitamin B12 in cooked meat.

The effect of fat class (carcass fatness) on sensory quality, shear force and cooking loss was determined on the M. longissimus lumborum (loin) of Dorper lambs. Quantitative descriptive sensory analysis, were performed by a trained panel, evaluating the meat for aroma intensity, initial impression of juiciness, first bite tenderness, sustained impression of juiciness, muscle fibre and overall tenderness, amount of connective tissue (residue), overall flavour intensity and off-flavour intensity. Two of the eight sensory attributes differed significantly ($p < 0.05$), namely, initial impression of juiciness and sustained juiciness, with a positive correlation existing between initial impression of juiciness and sustained impression of juiciness. A strong positive correlation was found between the amount of connective tissue (residue) and firste bite tenderness as well as between the amount of connective tissue (residue) and tenderness. No significant differences were found for any of the texture attributes between the five fat classes. Total cooking loss had a high positive correlation with total drip loss and fat mass. Cooking losses and juiciness were

influenced by the amount of fat present on the M. longissimus lumborum (loin) cuts however, aroma, flavour and tenderness were not affected by the degree of fatness.

Results of the study indicate great scope for further investigation and research on all cuts of all fat classes that will provide valuable information to the meat industry, health workers and consumers on the physical, nutritional and sensory attributes of South African lamb. However, more research is needed to evaluate consumer acceptance of individual lamb cuts with operations to trim excess fat as a marketing strategy and to positively alter consumer perception of lamb products. The South African consumer will have to be informed about the physical, nutritional and sensory attributes of lamb and therefore the role of marketing in this regard cannot be over-estimated.

OPSOMMING

Die kwaliteit van Suid Afrikaanse lamsvleis – karkas-, voedings- en sintuiglike eienskappe

deur

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Vir die Doktorsgraad in Verbruikerswetenskap

Die behoefte aan inligting ten opsigte van die kwaliteit van Suid Afrikaanse lamsvleis is deur die Rooivleis Produsente Organisasie (RPO) geïdentifiseer met die einddoel om verbruikers onsekerheid aan te spreek en derhalwe versoek dat die kwaliteit van Suid Afrikaanse lamsvleis ondersoek word. Die doel van die studie was om die kwaliteit van Suid Afrikaanse lamsvleis, naamlik die karkas-, voedings- en sintuiglike eienskappe te bepaal. As gevolg van finansiële beperkinge is slegs die A2 klas geanaliseer aangesien dit die mees algemeen verbruik word.

Suid-Afrikaanse skaap karkasse word geklassifiseer volgens ouderdom en vet klasse. Omdat die kwessie van vet in die dieet belangrik is vir die verbruiker, het die plaaslike vleishandelaars reeds gedeeltes van hul produksie aangepas om ontbeende snitte met 'n moontlikheid van vet afranding te bemark met die oog op maerder vleissnit. Die doel vir die karkasevaluering tydens die studie was om die omderskeie snit samestelling vir vyf vetklasse te bepaal en tweedens om snitte te identifiseer vir moontlike afranding van die onderhuidse vetlaag (OHV) van Suid Afrikaanse lamsvleis. Die studie het bestaan uit 66 veld gevoerde Dorper skape wat in drie groepe ingedeel is en geslag is op onderskeidelik 30, 36 en 42 kg. Die verkoelde karkasse is verdeel in sewe

groothandelsnitte waarna elke snit verdeel (gedissekteer) is in vleis, vet en been om sodoende die fisiese snit- en karkassamestelling te bepaal. Chemiese analise is gedoen op die vleis en vet van elke snit. Die resultate toon 'n algemene toename van 15.5 % totale vet oor die vyf vetklasse, met die grootste toename (26 % eenhede) in die lendesnit gevolg deur die lies-, blad- en neksnitte. Daar was geen betekenisvolle verskille tussen die nek-, dikrib- en borssnitte se % vleis toename oor die vyf vetklasse nie, in teenstelling met 'n beduidende afname (6 % eenhede) in die % been. Die verhouding vleis en been het 'n beduidend afname getoon met die toename oor die vet klasse vir die lende-, lies-, boud- en bladsnitte. Die lende snit is die meeste beïnvloed deur die toename in vet klasse. Tydens die afranding van die onderhuidse vet van 'n vetklas 5 na vetklas 3 op die ontbeende lende-, boud- en bladsnitte, het die vet persentasie onderskeidelik met 12, 6 en 9 % afgeneem. Verdere afranding tot 'n vetklas 1 het die onderhuidse vet persentasie onderskeidelik verlaag met 18, 8 en 5 % eenhede. Die onderhuidse vet persentasie van die nek-, en dikribsnitte kon suksesvol verlaag word met 4 - 5 % van 'n vet klas 5 tot 'n vetklas 3. Verder kon die nek-, dikrib-, bors- en liessnitte afgerand word van 'n vetklas 3 tot 'n vetklas 1 met 5 % eenhede. Alhoewel afranding op beide die oorvet karkas asook snit binne dieselfde vetklas gedoen kan word, moet die koste van die proses en die moontlike winste op die eindproduk oorweeg word.

Die regtersye van Dorper en Merino lamkarkasse met 'n A ouderdom en vetklas 2 (± 7 % OHV) van drie hoof produksie areas in Suid Afrika is gebruik om die rou- en gaar voedingswaardeanalise van drie snitte (blad, lende en boud) te bepaal. Die grootste verskil tussen die rou en gaar analise is waargeneem vir die konsentrasie proteïne, totale vet, cholesterol en die hoeveelheid poli- en mono-onversadigde vetsure C16:0, C18:1n9c. Die toename in die konsentrasie proteïen en cholesterol kan toegeskryf word aan vogverlies tydens die gaarmaakproses. Ysterinhoud van die gaar lendesnit was laer as die van die gaar boudsnit. Die vitamine B inhoud van al drie gaar snitte was laer in vergelyking met die van die rou snitte alhoewel nie betekenisvol nie. Lamsvleis kan dus beskou word as 'n goeie bron van proteïene, yster en B-vitamines, veral vitamine B_{12} in gaar lamsvleis.

Die invloed van vetklasse (toename in vetheid) op die sintuiglike eienskappe, sagtheid (snyweerstand) en gaarmaakverlies, van die M. longissimus lumborum (M.LL) is ondersoek. 'n Opgeleide proepaneel is gebruik om die kwaliteits eienskappe te evalueer, naamlik aromaintensiteit, geurintensiteit, aanvanklike- en voortgesette sappigheid, sagtheid, hoeveelheid fibreuse weefselresidu (bindweefsel), algemene geur en die intensiteit van die nasmaak. Slegs twee van die kwaliteits eienskappe het betekenisvol ($p < 0.05$), van mekaar verskil tussen die vetklasse, naamlik, aanvanklike en voortgesette sappigheid. Daar was 'n hoë verwantskap tussen die hoeveelheid fibreuse weefselresidu (bindweefsel) en eerste indruk van sagtheid asook tussen die hoeveelheid fibreuse weefselresidu (bindweefsel) en sagtheid. Geen verskille is waargeneem vir enige tekstuur eienskappe tussen die vyf vetklasse nie. Daar was 'n hoëverwantskap tussen die gaarmaakverlies en die drupverlies asook die vetinhoud van die snitte. Die gaarmaakverlies

en sappigheid hou verband met die hoeveelheid vet teenwoordig in die lende snit M. longissimus lumborum (M.LL), alhoewel die aroma-, geurintensiteit en sagtheid nie beïnvloed is deur die vetheid nie.

Resultate van die studie toon die moontlikheid vir verdere ondersoek en navorsing van al die snitte in al die vetklasse wat waardevolle inligting aan die vleisindustrie , gesondheidswerkers asook aan die verbruiker sal voorsien. Verdere navorsing ten opsigte van verbruikers aanvaarbaarheid en bemarkings strategie is egter nodig ten opsigte van die afranding van ’n oormaat onderhuidse vet vir sekere lamsvleissnitte. Hierdie bemarkings aspek moet nie ligtelik opgeneem word nie aangesien dit belangrik is dat die verbruiker behoorlik ingelig word ten opsigte van die karkas-, voedings en sintuiglike eienskappe van Suid Afrikaanse lamsvleis.

ABBREVIATIONS

AMSA	American Meat Science Association
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
ARC	Agricultural Research Council
ARC-ANPI	Agricultural Research Council-Animal Nutrition and Animal Products Institute
ARC:LBD	Agricultural Research Council-Livestock Business Division
ASTM	American Society for Testing and Materials
CSIR	Council for Scientific and Industrial Research
FAO	Food and Agriculture organization of the United Nations
g	gram
GC	Gas Chromatography
HPLC	High Performance Liquid Chromatography
IC	Ion Chromatography
IMF	Intermuscular fat
INQ	Index of nutritional quality
kJ	kiloJoules
kcal	kilocalories
kg	kilogram
LMY	Lean meat yield
LSD	Least significant difference
MIC	Meat Industry Centre
MLA	Meat and Livestock Australia
M.LL	Muscles longissimus lumborum
MRC	Medical Research Council
mg	milligram
MUFA	Monounsaturated fatty acid
NCD	Non-communicable diseases
NERPO	National Emerging Red Meat Producers Organisation
NRIND	National Research Institute for Nutritional diseases
PC	Principal Component
PCA	Principal Component Analysis
RDA	Recommended Dietary Allowances
pH	The acidity and basicity of solutions is frequently expressed in terms of a function of the Hydrogen $^{+}$ion concentration. Also defined as $pH = -\log_{10}[H^{+}]$
RPO	Red Meat Producers Organisation
PUFA	Polyunsaturated fatty acid

SA	South Africa
SAFCOD	South Africa Food Composition Data
SAMIC	South African Meat Industry Company
SAMM	South African Mutton Merino
SANAS	South African National Accreditation Services
SCF	Subcutaneous fat
SFA	Saturated fatty acid
%	Percentage
UK	United Kingdom
US	Unites States
USA	United States of America
µg	Microgram
WHO	World Health Organization

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Ina van Heerden matriculated in 1980 at Verwoerdburg High School in Centurion. She obtained a HED Home Economics qualification in 1985 from the University of Pretoria. In December 1985 she joined the Agricultural Research Council.-Irene and as Head Agricultural Research Technician at the Agricultural Research Council, her specific project responsibilities include research on the nutrient content and sensory analysis of South African beef and poultry and have been awarded a tender by the Red Meat Research Developing Trust to continue the research on the nutrient content of South African lamb and mutton. She was awarded an M Tech degree in Food and Nutrition in 1999 from Tswane University of Technology and received the ARC Director's merit award for Technician-of-the-Year in 2000.

In her thesis, **The quality of South African lamb - carcass, nutrient and sensory attributes** the promovendus investigated the carcass composition, macro- and micro-nutrient content and sensory profile of South African lamb. The carcass composition data show the variation in subcutaneous fat of the various cuts of the carcass at different fat levels and trimming can be positively implemented to provide a more palatable and leaner product to the consumer. The nutrient analyses found unique values for South African lamb cuts, almost 40 % lower in fat content than the previously-believed-to-be-accurate values, as published by the Medical Research Council for health professionals, consumers and the food industry. Contrary to expected it was found in this study that increased fatness did not improve lamb tenderness as popularly believed in the United States. To date the results of the thesis have been presented at two international and two local conferences, as well as three papers of which one has already been accepted for publication.

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