The Nutrient Content of South African Lamb & Mutton

2012

Compiled by
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Sponsored by the Red Meat Industry of South Africa

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This booklet is a condensed version of the first scientific research studies on the nutrient composition of South African lamb (A2) and mutton (C2).

The Red Meat Research and Development South Africa (RMRDSA), The Federation of Red Meat Producers South Africa and Meat and Livestock Australia (MLA) commissioned and sponsored these studies.

The research was co-performed by researchers and post graduate students from the University of Pretoria and was peformed at the Agricultural Research Council, Irene, South Africa.

About the authors

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Professor Hettie Schönfeldt is a researcher and mentor in the fields of human nutrition and food composition at the University of Pretoria, South Africa. She attained her PhD with a thesis entitled: Effect of Age on Beef Quality. She manages the Red Meat Research and Development programme of South Africa (RMRDSA) as well as the consumer and health professional communication regarding sheep meat under the auspices of Lamb and Mutton South Africa on behalf of the Red Meat Industry. She is a registered Professional Natural Scientist at the South African National Council of Scientific Professionals (SACNASP) and a registered Nutritionist with the British Nutrition Society (BNF).

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Dr SM van Heerden

Doctor Ina van Heerden obtained an HED Home Economics qualification in 1985 from the University of Pretoria, subsequently Ina joined the Agricultural Research Council (ARC) in Irene. She was awarded an M Tech degree in Food and Nutrition in 1999 from Tshwane University of Technology. Ina completed her PhD on 'The quality of South African lamb carcass, nutrient and sensory attributes' at the ARC in collaboration with the University of Pretoria in 2007. She continues her research on determining the nutrient content of South African Foods.

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Introduction

"Knowledge about the chemical composition of foods is the first essential in dietary treatment of disease or in any quantitative study of human nutrition."

(McCance & Widdowson, 1940)

The research studies reported in this booklet are a first attempt to obtain own South African data on the nutrient content of South African lamb and mutton. The previous figures on the composition of mutton available to South Africans were borrowed from the United States Department of Agriculture Food Composition Databank. No values for lamb have been available until now.

The studies were limited to the nutritional analysis of three cuts, namely the shoulder, loin and leg, within a restricted budget. These cuts were selected as they have been found to best represent total carcass composition, while also representing cuts from the hind (leg), middle (loin) and front (shoulder) parts of the carcass, as well as moist (shoulder) and dry heat (loin & leg) cooking methods.

The cuts were dissected into muscle, subcutaneous fat, inter- and intramuscular fat and bone. Nutrient analysis was performed on the different dissected portions. The data obtained was calculated to determine the amount of nutrients present in cuts: i) as slaughtered (meat including all associated fat), ii) lean edible portion (lean meat with subcutaneous fat removed); and iii) lean muscle only (all visible fat removed).

Various studies around the globe reflect the changes in the composition of carcass meat, especially a reduction in the amount of total fat. In South Africa the average fat content of target grade beef has decreased from 32% in 1949 to 18% in 1981 to 13% in 1991 (Naudé, 1994), and a fat content of 11.3% is the most recent South African value obtained for beef (Schönfeldt & Welgemoed, 1996).

The reduction in fat content is directly linked to the increase in consumer demand for leaner red meat products, and a response by the science fraternity by adapting animal diets, breeding techniques, other food science activities post mortem, and preparation techniques. The reduction in fat content over time is presented in Figure 1.

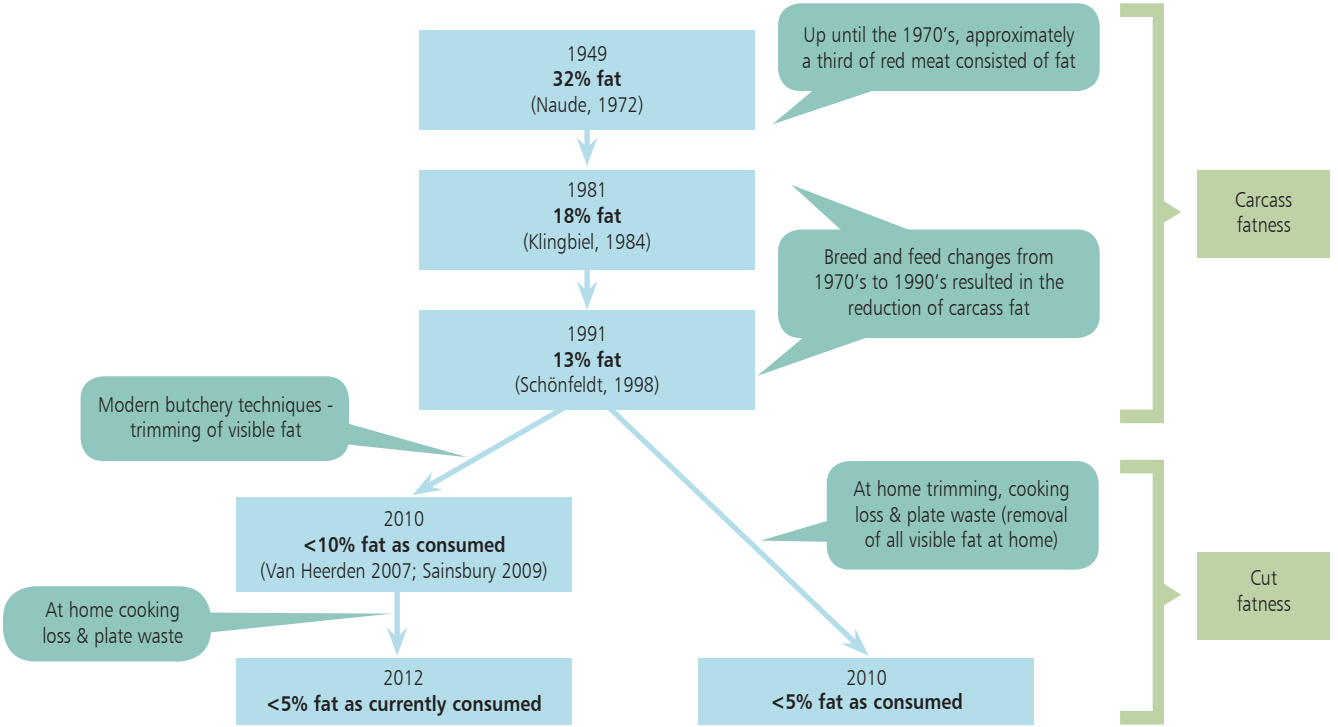

Figure 1: Changes in the fat content of red meat over time

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1. Background

A double burden of nutrition-related diseases is prevalent in many households and communities in South Africa, as both over- and undernutrition are experienced due to rapid urbanization and acculturation. Numerous South Africans suffer from the health-implications of inappropriate diets, with obesity being the most important nutritional disease that contributes many of the major non-communicable diseases such as cardiovascular disease, cancer and diabetes.

Nearly 25% of all deaths in Africa are attributed to non-communicable diseases. In 2003 56% of the South African adult population was recorded as overweight or obese (South African Demographic and Health Survey (SADHS), 2003). In contrast, 1 in 2 children had an energy intake of less than two thirds of their energy needs, and a great number of children consumed a diet with poor nutrient density, not meeting their daily macro- or micronutrient requirements (SADHS, 2003). According to the 1999 National Food Consumption Survey, 1 in 10 children between the ages of 1 and 9 years were underweight, and more than 1 in 5 were stunted (NFCS, 1999). Four years later, mean intakes of calcium, iron, zinc and the vitamins A, D, E, C, B6, B2 and niacin were all recorded as low compared to recommended dietary allowances (RDAs) (SADHS, 2003). Even after the implementation of the mandatory South African food fortification programme in 2003, the 2005 National Food Consumption Survey Fortification Baseline still found that 2 out of 3 children and 1 out of 4 women had poor vitamin A status, 1 out of 5 women and 1 out of 7 children had poor iron status and 45% of children had an inadequate zinc status (NFCS-FB-1, 2008). These findings indicate increases in deficiencies compared to previous nutritional data, regardless of the mandatory fortification of staple foods.

To prevent the negative effects or impact of this massive burden of diet-related disease, consumers need to improve their health through optimized nutrition and a healthy lifestyle.

Promoting healthy lifestyles to reduce the burden of non-communicable disease while improving nutritional status of undernourished individuals requires a broad multi-sectorial approach. This approach needs to involve various sectors of society and promotion of lifestyle changes such as controlled dietary intake and increased physical activity, as well as changes to dietary guidelines, agriculture and health policies and consumer education. The availability of current, accurate scientifically based, nutritional information which the public can relate to, is imperative in promoting healthy lifestyle choices.

Obesity and red meat

Based on epidemiological studies a positive association was observed between obesity and high saturated fat intake from animal products, which has led to the consumption of smaller portions less frequently, in an aim to restrict fat intake. However, red meat such as lamb and mutton, plays an integral role in a healthy diet. The nutrients found in red meat make a significant contribution to the protein, vitamins and minerals requirements of consumers. The South African Food-Based Dietary Guidelines recommend that chicken, fish, milk, meat or eggs can be eaten daily. Various studies also reflect the substantial changes in fat content in red meat over time, including both the reduction in the amount of fat on the carcass at slaughter and after trimming in the shop or at home. Healthier processing and preparation methods also contribute to the increased nutrient density of red meat such lamb and mutton.

Undernutrition and red meat

Animal protein is considered the best quality source of protein, supplying all the essential amino acids in adequate amounts, compared to plant-based proteins which are often limited in amino acids such as lysine, methionine and cysteine. Furthermore, lean red meat, trimmed of excess visible fat, is a nutrient dense source of the B vitamins, and bioavailable iron and zinc. A 90g edible portion of lean South African lamb or mutton, i.e. the meat from about two lamb chops, contributes more than 30% of the RDA for protein, zinc, vitamin B3 and vitamin B12, and more than 10% of the RDA for iron.

The composition of South African lamb and mutton

In this booklet the nutrient composition of South African lamb and mutton, as recently determined by studies at the University of Pretoria in collaboration with the Agricultural Research Council, Irene, is presented.

We developed this booklet to serve as a current scientific reference source for academics, health professionals and the industry on the composition of South African lamb and mutton as purchased and consumed. We hope this booklet will serve as source of valid scientific information for you in your work and daily life.

Lean red meat, like South African lamb and mutton without visible fat, plays a key role in a balanced diet by providing a nourishing package of nutrients, without contributing to excessive fat and kilojoule intake.

2. Research design

2.1. Sample preparation

Correct sampling requires careful attention to ensure that the nutrient data is representative and accurate for the food product in question. Correct sample selection, storage, preparation and analytical procedures are required (Greenfield & Southgate, 2003).

2.1.1. Carcass selection

The sampling of South African lamb and mutton was designed in collaboration with the South African Red Meat Industry, experts from the University of Pretoria and scientists at the Agricultural Research Council according to market share. Dorper and Merino carcasses were selected from two different abattoirs, and they represented three different production regions in South Africa (Karoo, Kalahari and Ermelo districts).

For each age group (lamb (A2) and mutton (C2)), three Merino carcasses and three Dorper carcasses were pooled from each production region. A total of 18 carcasses were obtained per age group. The left side of each carcass was kept raw for analysis, while the right sides were cooked prior to analysis. The three sides from each production region were pooled together for nutritional analysis to keep costs as low as possible, while ensuring representative values in line with the Regulations Relating to the Labelling and Advertising of Foodstuffs (No. R.146 of 1 March 2010 as part of Act 54 of 1972).

The animals were slaughtered and dressed using standard commercial procedures. After selection at each abattoir, the carcasses were weighed, covered with plastic wrap to prevent moisture loss, and transported in a refrigerated truck (4 to 6°C) to the Meat Industry Centre of the ARC Analytical laboratory, Irene. All carcasses were dissected the following day (within three days of slaughter).

Carcasses were sectioned down the vertebral column with a band saw and subdivided into the primal cuts (Figure 2). An experienced deboning team was responsible for the physical dissection of the 18 lamb and 18 mutton carcasses. The shoulder, loin and leg were analysed for nutritional content, as these cuts represent the composition of the whole carcass the best (Schönfeldt, 1998). The shoulder, loin and leg cuts of the left sides were used raw for nutrient analysis, while the shoulder, loin and leg cuts from the right sides were cooked prior to nutrient analysis.

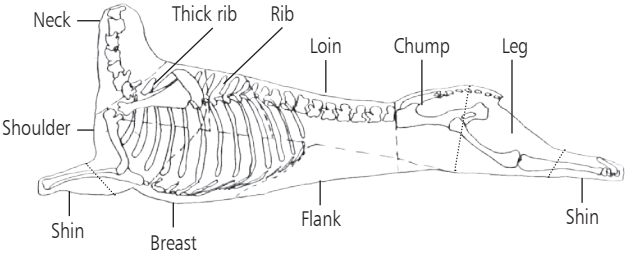


Figure 2: Dissection diagramme

2.1.2. Raw sample preparation

For raw analysis, the three cuts (shoulder, loin and leg) from the left sides were weighed and then dissected by knife into muscle, inter- and intramuscular fat (fat within and between muscles), subcutaneous fat (fat found directly under the skin, also known as back fat) and bone (Refer to Appendix A for dissection form). Dissection took place in an environmentally controlled (10°C) de-boning room. Each dissected fraction was weighed and recorded. The weight of the various tissues (bone (including cartilage), muscle (meat plus sinews), and subcutaneous fat) were then added up to calculate carcass composition as presented in Table 2.1.

For lamb composition, muscle and inter- and intramuscular fat of the three same cuts from each region were combined for composite analyses as the meat portion. Subcutaneous fat from the three similar cuts from each region was sent for analysis as the fat portion. The nutrient content of lamb as slaughtered was calculated as the meat portion plus fat the portion, while the nutrient content of lean lamb (with subcutaneous fat removed) the values obtained from the meat portion were used.

For mutton composition, only the muscle from the same cuts per region was combined for composite analyses as the muscle portion. Inter- and intramuscular fat and the subcutaneous fat from the same cuts per region were sent for analysis representing the fat portion. To calculate the composition of mutton as slaughtered, the muscle portion was combined with the fat portion. To determine the nutrient content of lean mutton (with subcutaneous fat removed) the values obtained from the muscle portion were added to a proportion of the fat portion corresponding to the amount of inter- and intramuscular fat which was present before dissection.

Table 2.1: Physical dissection of raw lamb and mutton (percentage contribution of each to total cut)*

Raw		Muscle (%)	Inter- and intramuscular fat (%)	Subcutaneous fat (%)	Bone (%)
Lamb	Shoulder	73.1	4.22	5.48	17.2
	Loin	63.9	9.06	9.09	17.9
	Leg	76.3	2.54	6.23	15.0
Mutton	Shoulder	70.7	6.63	5.73	17.0
	Loin	65.0	6.89	10.1	18.0
	Leg	76.3	3.89	6.37	13.4

*For nutrient analysis of lamb cuts, inter- and intramuscular fat were combined with the muscle for analysis of the meat portion; for nutrient analysis of mutton cuts, inter- and intramuscular fat was combined with subcutaneous fat for analysis of the fat portion and muscle were analysed separately. Calculations were adjusted accordingly to calculate nutrient content of products, i.e. as slaughtered or purchased (meat + all types of fat + bone), as consumed (meat + all types of fat), and lean edible portion (meat (muscle + inter- and intramuscular fat) only).

2.1.3. Cooked sample preparation

The three cuts from the right sides of the carcasses were vacuum sealed and frozen at -20°C. Prior to cooking, the cuts were thawed and weighed. Each cut was cooked whole according to standardised cooking methods, i.e. shoulder with a moist heat cooking method, and leg and loin cuts with dry heat cooking methods, in identical Miele ovens at 160°C until an internal temperature of 70°C. The internal temperature was measured in the geometrical centre of each cut (Refer to Appendix B and C for cooking forms). The cooked cuts were then physically dissected with a knife into meat, fat and bone.

Table 2.2: Physical dissection of cooked lamb and mutton (percentage contribution of each to total cut)

Cooked		Meat (muscle plus intramuscular fat) (%)	Fat (Subcutaneous and intermuscular fat) (%)	Bone (%)
Lamb	Shoulder	69.8	9.09	21.1
	Loin	57.7	20.1	22.3
	Leg	75.8	6.71	17.5
Mutton	Shoulder	75.5	4.17	20.3
	Loin*	56.8	21.7	21.6
	Leg	76.3	5.45	18.3

*Calculated

2.1.4. Sample handling

Meat and fat portions of the three cuts from the carcasses from the same regions were grouped together for composite sampling. The composite meat and fat portions from the lamb and mutton cuts were cubed, thoroughly mixed and then minced, first through a 5mm and then through a 3mm mesh plate. After mincing, samples of 300g meat, and 300g fat for each composite sample were homogenized and placed in aluminium trays, vacuum sealed, freeze dried and sent for nutritional analyses to the ARC Analytical laboratory.

2.2. Analytical procedures

All analytical procedures were performed on double-blind bases in SANAS (South African National Accreditation Services) accredited laboratories. In Table 2.3 the methods followed are summarized.

Table 2.3: Methods of analysis

Analysis	Method
Moisture	Official Method 935.29 (AOAC, 2005)
Total Nitrogen (N)	Official Method 992.15 (AOAC, 2005) (Dumas method)
Protein	Calculated as N x 6.25
Fat	Soxtec Method. Official Method 960.39 (AOAC, 2005)
Energy	Calculated
Minerals	Inductively Coupled Plasma- Optical Emission Spectrometry - ICP-OES (Varian Liberty 2000 instrument manual)
Vitamins B1 & B2	Wilmalasiri & Wills, 1998
Vitamin B3	Official Method 944.13 (AOAC, 2005)
Vitamin B6	Official Method 961.15 (AOAC, 2005)
Vitamin B12	Official Method 952.20 (AOAC, 2005)
Fatty acid profile	Gas Chromatography (Christopherson & Glass, 1969)
Cholesterol	Dole Extraction. Gas Chromatography (Smuts *et al*., 1992)

2.3. Calculation of nutrient content of South African lamb and mutton

2.3.1. Raw lamb cuts

Raw lamb cuts were divided into meat (muscle and intra- and intermuscular fat) and fat (subcutaneous fat) for analysis. The following calculations were used to calculate the nutrient content of raw lamb cuts:

1. Nutrient content as slaughtered / purchased (meat + fat + bone)

$$= \left(\frac{g\ nutrient\ in\ 100\ g\ meat}{\%\ meat}\right) + \left(\frac{g\ nutrient\ in\ 100\ g\ fat}{\%\ fat}\right) + \left(\frac{0}{\%\ bone}\right)$$

2. Nutrient content of edible portion (meat + fat)

$$= \left(\left(g\ nutrient\ in\ 100\ g\ meat\right)\ x\ \left(\frac{\%\ meat}{\%\ meat + \%\ fat}\right)\right) + \left(g\ nutrient\ in\ 100\ g\ fat\ \ x\ \left(\frac{\%\ fat}{\%\ meat + \%\ fat}\right)\right)$$

3. Nutrient content of lean edible portion (meat only)

$$= \quad g\ nutrient\ in\ 100\ g\ meat$$

2.3.2. Raw mutton cuts

Raw mutton cuts were divided into muscle and fat (subcutaneous and intra- and intermuscular fat) for analysis. The following calculations were used to calculate the nutrient content of raw mutton cuts:

1. Nutrient content as slaughtered / purchased (meat + fat + bone)

$$= \left(\frac{g\ nutrient\ in\ 100\ g\ meat}{\%\ muscle}\right) + \left(\frac{g\ nutrient\ in\ 100\ g\ fat}{\%\ fat}\right) + \left(\frac{0}{\%\ bone}\right)$$

2. Nutrient content of edible portion (meat + fat)

$$= \left(g\ nutrient\ in\ 100\ g\ meat\ x\ \left(\frac{\%\ meat}{\%\ meat + \%\ fat}\right)\right) + \left(g\ nutrient\ in\ 100\ g\ fat\ x\ \left(\frac{\%\ fat}{\%\ meat + \%\ fat}\right)\right)$$

3. Nutrient content of lean edible portion (meat = muscle + intra- and intermuscular fat) =

$$= \quad (g\ nutrient\ in\ 100\ g\ muscle\ x\ ((\ /\ (\%\ muscle\ )\ /\ \%\ muscle\ +\%\ intra\ and\ intermuscular\ fat\ ))\ ) + (g\ nutrient\ in\ 100\ g\ fat\ )$$

4. Nutrient content of muscle only = *g nutrient in 100 g muscle*

2.3.3. Cooked lamb and mutton cuts

Cooked lamb and mutton cuts were divided into meat (muscle and intramuscular fat), fat (subcutaneous and intermuscular fat) and bone. The following calculations were used to determine nutrient content of cooked lamb and mutton cuts:

1. Nutrient content as purchased (meat + fat + bone)

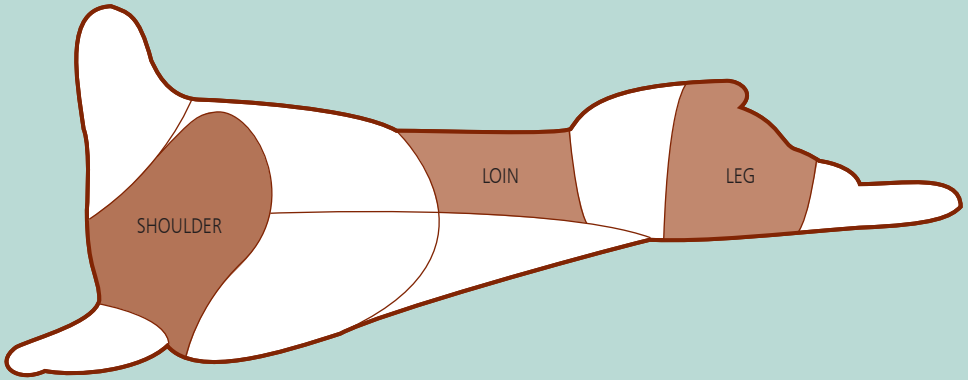
$$= \left(\frac{g\ nutrient\ in\ 100\ g\ meat}{\%\ meat} \right) + \left(\frac{g\ nutrient\ in\ 100\ g\ fat}{\%\ fat} \right) + \left(\frac{0}{\%\ bone} \right)$$

2. Nutrient content of edible portion (meat + fat)

$$= \left(g\ nutrient\ in\ 100\ g\ meat\ x \left(\frac{\%\ meat}{\%\ meat + \%\ fat} \right) \right) + \left(g\ nutrient\ in\ 100\ g\ fat\ x \left(\frac{\%\ fat}{\%\ meat + \%\ fat} \right) \right)$$

3. Nutrient content of lean edible portion (meat only)

$$= g\ nutrient\ in\ 100\ g\ meat$$



3. The nutrient content of South African lamb & mutton

In Table 3.1 to Table 3.7 the nutrient content of South African lamb (A2) and mutton (C2) are presented.

- In Table 3.1 (raw) and Table 3.2 (cooked) the nutrient content of sheep meat as slaughtered (meat + fat + bone) is presented.
- In Table 3.3 (raw) and Table 3.4 (cooked) the nutrient content of the edible portion of South African sheep meat as slaughtered (meat + fat) is presented.
- In Table 3.5 (raw) and Table 3.6 (cooked) the nutrient content of lean edible portion (meat without subcutaneous fat) of South African sheep meat is presented.
- In Table 3.7 the nutrient content of South African mutton muscle only is presented.

Please note that the values marked in red are questionable, as they differ significantly from nutrient values for sheep meat from other countries. Various factors during the analytical process may lead to incorrect results, and it seems from the results that the methods used to determine iron, zinc, and the B-vitamins were inconsistent. All values, whether expected or unexpected, should be subjected to scrutiny. Although the common practice of comparing new information with previously published values for the same food is useful, it can be a source of bias if the analyses are repeated only for deviant values; as there may be a tendency to accept only data that conform to established values. Nonetheless, any samples producing unusually high or low results should be subjected to repeat analyses and specific validation, along with a few foods that yielded the expected values (Greenfield & Southgate, 2011). These results were communicated to the Meat Industry to motivate for more repeats in future to validate the results.

Table 3.1: Nutrient content of 100g raw South African lamb and mutton as slaughtered (meat+fat+bone)

Nutrient	Unit	100g raw as slaughtered (meat + fat + bone)					
		Lamb			Mutton		
		Shoulder	Loin	Leg	Shoulder	Loin	Leg
Moisture	g	56.2	53.5	59.7	55.8	51.3	60.4
Energy	kJ	644	742	580	674	822	633
Total N	g	2.30	2.21	2.45	2.48	2.34	2.64
Protein	g	14.4	13.8	15.3	15.5	14.6	16.5
Cholesterol	mg	54.0	52.6	54.5	42.5	41.1	42.9
Fat	g	10.8	13.7	8.64	11.1	15.5	9.52
Total FA	g	9.97	11.9	7.62	10.4	14.5	8.73
SFA	g	5.28	6.42	3.97	5.67	8.13	4.53
MUFA	g	4.32	5.08	3.37	4.35	5.91	3.87
PUFA	g	0.36	0.42	0.27	0.40	0.48	0.33
Omega 3 (N3)	g	0.06	0.06	0.04	0.11	0.13	0.08
Omega 6 (N6)	g	0.30	0.35	0.23	0.29	0.35	0.24
Omega 9 (N9)	g	3.95	4.62	3.06	4.02	5.46	3.57
Iron	mg	0.93	0.82	1.35	1.81	1.90	2.42
Magnesium	mg	13.4	13.6	17.1	15.5	14.9	17.7
Potassium	mg	155	236	277	189	183	219.4
Sodium	mg	52.5	54.3	55.0	61.4	55.7	58.2
Zinc	mg	1.54	1.08	2.14	3.26	2.10	2.73
Vit B1	mg	0.09	0.07	0.08	0.04	0.02	0.03
Vit B2	mg	0.07	0.03	0.04	0.03	0.02	0.03
Vit B3	mg	0.69	0.74	5.41	1.89	1.23	1.80
Vit B6	mg	0.20	0.23	0.50	3.36	3.36	3.63
Vit B12	mcg	3.11	2.98	5.34	0.12	0.15	0.16

Values in red are questionable

Table 3.2: Nutrient content of 100g cooked South African lamb and mutton as slaughtered (meat+fat+bone)

Nutrient	Unit	100g cooked as slaughtered (meat + fat + bone)					
		Lamb			Mutton		
		Shoulder	Loin	Leg	Shoulder	Loin	Leg
Moisture	g	48.8	42.4	52.0	51.1	40.3	50.1
Energy	kJ	753	909	695	646	1042	685
Total N	g	2.74	2.91	3.18	2.96	2.88	3.57
Protein	g	17.1	18.2	19.9	18.5	18.0	22.3
Cholesterol	mg	67.6	73.0	75.4	45.7	53.4	50.2
Fat	g	12.5	16.2	9.63	8.96	19.9	8.28
Total FA	g	9.61	11.9	8.95	8.30	18.3	7.68
SFA	g	5.32	6.35	4.70	4.45	10.7	3.96
MUFA	g	4.06	5.04	3.87	3.54	6.98	3.42
PUFA	g	0.24	0.55	0.39	0.31	0.60	0.30
Omega 3 (N3)	g	0.03	0.12	0.05	0.07	0.15	0.07
Omega 6 (N6)	g	0.20	0.42	0.33	0.23	0.45	0.22
Omega 9 (N9)	g	3.64	4.57	3.57	3.28	6.45	3.16
Iron	mg	0.02	0.86	2.37	2.07	1.83	2.91
Magnesium	mg	12.5	13.9	17.4	15.9	13.1	18.5
Potassium	mg	182	191	229	198	162	214
Sodium	mg	49.7	48.1	46.9	56.5	44.0	51.9
Zinc	mg	0.03	1.27	2.57	3.50	2.11	3.36
Vit B1	mg	0.06	0.07	0.10	0.02	0.01	0.01
Vit B2	mg	0.07	0.04	0.08	0.05	0.03	0.06
Vit B3	mg	0.95	0.72	1.23	2.59	1.48	2.40
Vit B6	mg	0.05	0.08	0.07	3.69	3.08	3.97
Vit B12	mcg	0.58	0.52	0.80	0.07	0.07	0.08

Values in red are questionable

Table 3.3: Nutrient content of 100g raw edible portion of South African lamb and mutton (meat+fat)

Nutrient	Unit	100g raw edible portion (meat + fat)					
		Lamb			Mutton		
		Shoulder	Loin	Leg	Shoulder	Loin	Leg
Moisture	g	67.9	65.2	70.2	67.2	62.5	69.7
Energy	kJ	777	905	682	813	998	730
Total N	g	2.78	2.69	2.88	2.99	2.84	3.04
Protein	g	17.4	16.8	18.0	18.7	17.7	19.0
Cholesterol	mg	65.2	64.0	64.1	51.2	50.1	49.6
Fat	g	13.0	16.7	10.2	13.4	18.8	11.0
Total FA	g	12.0	14.5	8.96	12.5	17.7	10.1
SFA	g	6.38	7.82	4.67	6.83	9.91	5.23
MUFA	g	5.22	6.19	3.97	5.24	7.21	4.47
PUFA	g	0.44	0.51	0.32	0.48	0.59	0.38
Omega 3 (N3)	g	0.07	0.07	0.05	0.13	0.16	0.10
Omega 6 (N6)	g	0.36	0.43	0.26	0.35	0.42	0.28
Omega 9 (N9)	g	4.77	5.63	3.60	4.84	6.65	4.12
Iron	mg	1.12	1.00	1.59	2.18	2.32	2.80
Magnesium	mg	16.2	16.6	20.1	18.6	18.1	20.5
Potassium	mg	187	287	325	227	224	253
Sodium	mg	63.4	66.1	64.6	74.0	67.9	67.2
Zinc	mg	1.86	1.31	2.51	3.93	2.56	3.15
Vit B1	mg	0.10	0.08	0.09	0.04	0.03	0.04
Vit B2	mg	0.08	0.04	0.04	0.04	0.02	0.04
Vit B3	mg	0.83	0.91	6.36	2.28	1.50	2.07
Vit B6	mg	0.24	0.28	0.59	4.04	4.10	4.20
Vit B12	mcg	3.76	3.64	6.28	0.14	0.18	0.19

Values in red are questionable

Table 3.4: Nutrient content of 100g cooked edible portion of South African lamb and mutton (meat+fat)

Nutrient	Unit	100g cooked edible portion as slaughtered (meat + fat)					
		Lamb			Mutton		
		Shoulder	Loin	Leg	Shoulder	Loin	Leg
Moisture	g	61.9	54.5	63.0	64.1	51.4	61.3
Energy	kJ	953	1171	842	812	1329	838
Total N	g	3.46	3.76	3.86	3.72	3.67	4.36
Protein	g	21.6	23.5	24.1	23.3	22.9	27.2
Cholesterol	mg	85.7	93.9	91.3	57.4	68.1	61.4
Fat	g	15.8	20.9	11.7	11.3	25.4	10.1
Total FA	g	12.2	15.4	10.9	10.4	23.3	9.40
SFA	g	6.74	8.16	5.69	5.59	13.7	4.84
MUFA	g	5.14	6.49	4.69	4.44	8.90	4.19
PUFA	g	0.30	0.71	0.47	0.39	0.77	0.36
Omega 3 (N3)	g	0.04	0.15	0.06	0.09	0.19	0.09
Omega 6 (N6)	g	0.26	0.55	0.40	0.29	0.57	0.27
Omega 9 (N9)	g	4.61	5.88	4.32	4.11	8.23	3.86
Iron	mg	0.03	1.10	2.87	2.60	2.34	3.56
Magnesium	mg	15.9	17.9	21.0	20.0	16.6	22.6
Potassium	mg	231	245.1	278	248	206	262
Sodium	mg	63.0	61.8	56.8	70.9	56.1	63.5
Zinc	mg	0.03	1.63	3.11	4.39	2.69	4.12
Vit B1	mg	0.07	0.09	0.13	0.03	0.02	0.02
Vit B2	mg	0.09	0.05	0.09	0.06	0.04	0.07
Vit B3	mg	1.21	0.93	1.49	3.25	1.88	2.93
Vit B6	mg	0.07	0.10	0.09	4.64	3.93	4.85
Vit B12	mcg	0.73	0.68	0.97	0.08	0.09	0.10

Values in red are questionable

Table 3.5: Nutrient content of 100g raw lean South African lamb and mutton (meat without subcutaneous fat)

Nutrient	Unit	100g raw lean edible portion (meat with subcutaneous fat removed)					
		Lamb			Mutton		
		Shoulder	Loin	Leg	Shoulder	Loin	Leg
Moisture	g	70.8	70.1	73.7	69.8	68.6	72.9
Energy	kJ	662	718	545	703	746	589
Total N	g	2.87	2.84	2.99	3.07	3.07	3.18
Protein	g	18.0	17.8	18.7	19.2	19.2	19.9
Cholesterol	mg	64.0	61.8	62.7	49.8	49.8	47.7
Fat	g	9.63	11.3	6.15	10.2	11.4	6.77
Total FA	g	9.03	9.55	5.36	9.46	10.6	6.08
SFA	g	4.84	5.29	2.82	5.08	5.83	3.05
MUFA	g	3.85	3.90	2.34	4.01	4.40	2.78
PUFA	g	0.34	0.36	0.21	0.37	0.38	0.25
Omega 3 (N3)	g	0.05	0.05	0.03	0.10	0.10	0.07
Omega 6 (N6)	g	0.28	0.30	0.17	0.27	0.27	0.18
Omega 9 (N9)	g	3.53	3.57	2.13	3.71	4.07	2.57
Iron	mg	1.20	1.13	1.71	2.34	2.65	3.02
Magnesium	mg	17.4	18.7	21.6	20.0	20.7	22.1
Potassium	mg	201	323	351	244	255	274
Sodium	mg	67.9	74.4	69.7	79.4	77.5	72.6
Zinc	mg	1.99	1.48	2.71	4.22	2.92	3.40
Vit B1	mg	0.11	0.09	0.10	0.05	0.03	0.04
Vit B2	mg	0.09	0.04	0.05	0.04	0.03	0.04
Vit B3	mg	0.89	1.02	6.87	2.45	1.71	2.24
Vit B6	mg	0.26	0.32	0.64	4.34	4.67	4.53
Vit B12	mcg	4.02	4.09	6.77	0.16	0.21	0.20

Values in red are questionable

Table 3.6: Nutrient content of 100g cooked lean South African lamb and mutton (meat without subcutaneous fat)

Nutrient	Unit	100g cooked lean edible portion (meat with subcutaneous fat removed)					
		Lamb			Mutton		
		Shoulder	Loin	Leg	Shoulder	Loin	Leg
Moisture	g	66.8	63.5	66.0	65.8	62.7	63.4
Energy	kJ	757	761	715	730	810	745
Total N	g	3.69	4.45	4.06	3.83	4.21	4.50
Protein	g	23.1	27.8	25.4	23.9	26.3	28.1
Cholesterol	mg	85.0	95.0	91.7	57.3	69.8	61.6
Fat	g	9.86	7.80	7.67	8.74	9.81	7.20
Total FA	g	6.59	6.85	6.94	8.00	8.97	6.59
SFA	g	3.57	3.60	3.68	4.19	5.00	3.36
MUFA	g	2.84	2.96	2.97	3.49	3.64	2.94
PUFA	g	0.18	0.29	0.29	0.31	0.33	0.29
Omega 3 (N3)	g	0.02	0.05	0.04	0.07	0.08	0.07
Omega 6 (N6)	g	0.16	0.24	0.24	0.24	0.25	0.22
Omega 9 (N9)	g	2.54	2.70	2.73	3.24	3.38	2.72
Iron	mg	0.03	1.49	3.12	2.75	3.23	3.81
Magnesium	mg	18.0	24.2	22.9	21.1	23.0	24.2
Potassium	mg	261	330	303	262	285	280
Sodium	mg	71.2	83.3	61.9	74.8	77.6	68.0
Zinc	mg	0.04	2.20	3.38	4.64	3.72	4.41
Vit B1	mg	0.08	0.12	0.14	0.03	0.03	0.02
Vit B2	mg	0.10	0.07	0.10	0.07	0.05	0.08
Vit B3	mg	1.37	1.25	1.63	3.43	2.60	3.14
Vit B6	mg	0.07	0.13	0.10	4.89	5.43	5.20
Vit B12	mcg	0.83	0.91	1.06	0.09	0.12	0.11

Values in red are questionable

Table 3.7: Nutrient content of 100g raw South African mutton (muscle only)

Nutrient	Unit	100g raw (muscle only)		
		Shoulder	Loin	Leg
Moisture	g	73.3	73.7	75.1
Energy	kJ	552	530	490
Total N	g	3.18	3.26	3.28
Protein	g	19.9	20.4	20.5
Cholesterol	mg	47.8	49.5	46.3
Fat	g	5.80	4.96	3.84
Total FA	g	5.27	4.54	3.31
SFA	g	2.71	2.34	1.54
MUFA	g	2.33	2.00	1.60
PUFA	g	0.23	0.20	0.17
Omega 3 (N3)	g	0.06	0.05	0.04
Omega 6 (N6)	g	0.17	0.15	0.12
Omega 9 (N9)	g	2.17	1.86	1.49
Iron	mg	2.56	2.93	3.17
Magnesium	mg	21.9	22.9	23.2
Potassium	mg	267	282	288
Sodium	mg	86.9	85.7	76.3
Zinc	mg	4.61	3.23	3.57
Vit B1	mg	0.05	0.04	0.04
Vit B2	mg	0.04	0.03	0.04
Vit B3	mcg	2.68	1.89	2.35
Vit B6	mg	4.75	5.17	4.76
Vit B12	mg	0.17	0.23	0.21

Values in red are questionable

Muscle only

4. Retention factors

The amount of nutrients retained in foods after preparation, processing or other treatment depends on several factors such as the specific food matrix, temperature, time, pressure and many other cooking parameters. Furthermore, nutrient content is closely related to changes in fat and moisture. As an example, the more moisture lost during cooking, and the more fat leached out, the higher the density of the remaining nutrients in a 100g portion. Consequently, weight yield factors are included in the experimental determination of nutrient retention factors. This yield factor incorporates the weight changes during cooking. Retention factors were calculated using the following calculations:

$$\text{Yield factor} = \frac{\text{Weight of cooked cut}}{\text{Weight of raw cut}}$$

$$\text{Retention factor} = \frac{\text{Nutrient content per 100 g cooked portion}}{\text{Nutrient content in 100 g raw portion}} \times \text{Yield factor}$$

In Table 4.1 the retention factors of South African lamb and mutton are presented with the retention factors for broiled and roasted lamb reported in the USDA Table of Nutrient Retention Factors, Release 6 (2007). Please note that the shoulder cut was prepared by using a moist heat cooking methods and the loin and leg cuts were prepared using dry heat cooking methods.

Table 4.1: Nutrient retention factors

	Shoulder (moist heat)				Loin (dry heat)				Leg (dry heat)				USDA (2007)	
	Lamb		Mutton		Lamb		Mutton		Lamb		Mutton		Lamb	
	Meat + fat	Lean meat	Meat + fat	Lean meat	Meat + fat	Lean meat	Meat + fat	Lean meat	Meat + fat	Lean meat	Meat + fat	Lean meat	Broiled	Roasted
Moisture	0.78	0.76	0.76	0.77	0.53	0.50	0.62	0.56	0.70	0.70	0.61	0.62	-	-
Protein	1.06	1.04	1.00	1.02	0.89	0.86	0.97	0.84	1.05	1.06	1.00	1.00	-	-
Cholesterol	1.12	1.08	0.90	0.94	0.94	0.85	1.02	0.86	1.11	1.14	0.87	0.92	-	-
Fat	1.03	0.83	0.67	0.70	0.80	0.38	1.01	0.53	0.90	0.97	0.65	0.76	-	-
Iron	0.02	0.02	0.95	0.96	0.70	0.73	0.76	0.74	1.41	1.42	0.89	0.90	0.95	1.00
Magnesium	0.83	0.84	0.86	0.86	0.69	0.71	0.69	0.68	0.82	0.82	0.77	0.78	0.85	0.80
Potassium	1.05	1.05	0.87	0.88	0.55	0.56	0.69	0.68	0.67	0.67	0.72	0.73	0.85	0.75
Sodium	0.85	0.85	0.77	0.77	0.60	0.62	0.62	0.61	0.69	0.69	0.66	0.67	0.85	0.75
Zink	0.02	0.02	0.89	0.90	0.80	0.82	0.79	0.78	0.97	0.97	0.92	0.92	1.00	1.00
Vit B1	0.58	0.58	0.48	0.48	0.68	0.70	0.49	0.48	1.06	1.07	0.30	0.30	0.60	0.60
Vit B2	0.90	0.90	1.43	1.44	0.88	0.91	1.22	1.20	1.67	1.68	1.39	1.40	0.90	0.90
Vit B3	1.23	1.24	1.14	1.15	0.66	0.68	0.94	0.93	0.18	0.18	0.99	1.00	0.80	0.80
Vit B6	0.23	0.23	0.92	0.92	0.22	0.23	0.72	0.71	0.12	0.12	0.81	0.82	0.65	0.75
Vit B12	0.17	0.17	0.45	0.46	0.12	0.12	0.36	0.36	0.12	0.12	0.39	0.39	0.70	0.85

Values in red are questionable

5. Comparison to international data

5.1. New data compared to the data reported in the Medical Research Council Table: Composition of South African foods

The data presented in the Medical Research Council (MRC) tables represent the most accurate and comparative values which were available at the time of print. The nutrient values recorded in the South African Food Composition Data (SAFCoD) Supplement to the MRC Food Composition Tables of 1991 on milk and milk products, eggs, meat and meat products, report on the nutrient content of mutton (raw) and selected mutton cuts (cooked) (Sayed, Frans & Schönfeldt, 1999). These sheep meat values were borrowed from the United States Department of Agriculture (USDA) Nutrient Database for Standard Reference (Release 12, 1998). Lamb dominates the South African sheep meat market with a market share of 85%, but no values for lamb were included in the previous national tables.

The new data which have been generated through the research studies, will provide own South African nutrient data for both lamb and mutton to be used in the national tables for future reference.

The main differences between the findings of the current mutton study, and what is reported in the 1999 national reference table for mutton, include:

- On average, raw South African mutton (meat + fat) contains 33% less fat, 30% less cholesterol and nearly 10% more protein
- South African mutton shoulder (cooked lean edible portion) contains nearly 50% less cholesterol, but 33% more saturated fat
- South African mutton loin (cooked edible portion (meat + fat)) contains more than 30% less cholesterol
- South African mutton leg (cooked edible portion (meat + fat)) contains nearly 40% less fat and cholesterol, and nearly 80% more iron

Table 5.1: The nutrient content of raw South African lamb and mutton (meat + fat) compared to previous reference values for sheep meat in South Africa (Sayed, Frans & Schönfeldt, 1999)

Nutrient	Unit	100g raw edible portion as slaughtered (meat + fat)			
		Lamb	Mutton		
		Current study average	Current study average	MRC	Difference (%)
Moisture	g	67.8	66.5	60.7	↑ 9.51
Energy	kJ	788	847	1087	↓ 22.1
Protein	g	17.4	18.5	16.9	↑ 9.35
Cholesterol	mg	64.5	50.3	72.0	↓ 30.1
Fat	g	13.3	14.4	21.6	↓ 33.3
SFA	g	6.29	7.32	9.47	↓ 22.7
MUFA	g	5.13	5.64	8.86	↓ 36.3
PUFA	g	0.42	0.48	1.70	↓ 71.8
Iron	mg	1.24	2.43	1.60	↑ 51.9
Mag	mg	17.6	19.1	22.0	↓ 13.3
Potassium	mg	266	235	160	↓ 46.7
Sodium	mg	64.7	69.7	58.0	↓ 20.2
Zinc	mg	1.89	3.21	3.33	↓ 3.60
Vit B1	mg	0.09	0.04	0.12	↓ 66.7
Vit B2	mg	0.05	0.03	0.22	↓ 86.4
Vit B3	mg	2.70	1.95	6.10	↓ 68.0
Vit B6	mg	4.56	4.11	0.13	↑ 3061
Vit B12	mcg	0.37	0.17	2.40	↓ 92.9

Values marked in red are questionable

Table 5.2: Nutrient content of cooked South African mutton cuts compared to previous reference values for sheep meat in South Africa (Sayed, Frans & Schönfeldt, 1999)

Nutrient	Unit	Mutton Shoulder (moist heat cooking)			Mutton Loin (dry heat cooking)			Mutton leg (dry heat cooking)		
		Lean meat (subcutaneous fat removed)			Meat + fat			Meat + fat		
		Current study	MRC 1999	Difference (%)	Current study	MRC 1999	Difference (%)	Current study	MRC 1999	Difference (%)
Moisture	g	65.8	56.2	↑ 17.1	51.4	51.6	↓ 0.48	61.3	57.5	↑ 6.52
Energy	kJ	730	899	↓ 18.8	1329	1283	↑ 3.59	838	1046	↓ 19.9
Protein	g	23.9	33.7	↓ 29.0	22.9	25.2	↓ 9.09	27.2	25.6	↑ 6.41
Cholesterol	mg	57.3	108	↓ 46.9	68.1	100	↓ 31.9	61.4	93.0	↓ 34.0
Fat	g	8.74	8.80	↓ 0.681	25.4	23.1	↑ 9.91	10.1	16.5	↓ 38.6
SFA	g	4.19	3.15	↓ 33.0	13.7	9.83	↑ 39.0	4.84	6.89	↓ 29.8
MUFA	g	3.49	3.54	↓ 1.41	8.90	9.70	↓ 8.25	4.19	6.96	↓ 39.8
PUFA	g	0.31	0.81	↓ 61.7	0.77	1.68	↓ 54.2	0.36	1.18	↓ 69.5
Iron	mg	2.75	2.80	↓ 1.79	2.34	1.80	↑ 30.0	3.56	2.00	↑ 78.0
Magnesium	mg	21.1	28.0	↓ 24.6	16.6	24.0	↓ 30.7	22.6	24.0	↓ 5.92
Potassium	mg	262	205	↑ 27.7	206	196	↑ 5.30	262	191	↑ 37.0
Sodium	mg	74.8	70.0	↑ 6.86	56.1	77.0	↓ 27.1	63.5	66.0	↓ 3.86
Zinc	mg	4.64	6.58	↓ 29.5	2.69	3.48	↓ 22.7	4.12	4.40	↓ 6.36
Vit B1	mg	0.03	0.07	↓ 57.1	0.02	0.10	↓ 80.0	0.02	0.10	↓ 80.0
Vit B2	mg	0.07	0.24	↓ 70.8	0.04	0.25	↓ 84.0	0.07	0.27	↓ 74.1
Vit B3	mg	3.43	6.00	↓ 42.8	1.88	7.10	↓ 73.5	2.93	6.60	↓ 55.6
Vit B6	mg	4.89	0.12	↑ 3975	3.93	0.13	↑ 2923	4.85	0.15	↑ 3133
Vit B12	mcg	0.09	2.70	↓ 96.7	0.09	2.50	↓ 96.4	0.10	2.60	↓ 96.2

Values marked in red are questionable

5.2. New data compared to other international reference data values

The United States Department of Agriculture National Nutrient Database for Standard Reference is one of the most comprehensive food composition databases which are freely available. Often, values reported in this database are borrowed to complete other national food composition tables.

Table 5.3: Nutrient content of cooked lean South African lamb compared to values for lean lamb in the USDA National Nutrient Database for Standard Reference (Release 24, 2011)

Nutrient	Unit	100 g cooked lean edible portion (meat with subcutaneous fat removed)								
		Shoulder (moist heat)			Loin (dry heat)			Leg (dry heat)		
		Current study	USDA 2011	Difference (%)	Current study	USDA 2011	Difference (%)	Current study	USDA 2011	Difference (%)
Moisture	g	66.8	62.5	↑ 6.88	63.5	62.8	↑ 1.11	66.0	62.5	↑ 5.60
Energy	kJ	757	883	↓ 14.3	761	845	↓ 9.94	715	854	↓ 16.3
Protein	g	23.1	25.5	↓ 9.41	27.8	26.6	↑ 4.51	25.4	28.4	↓ 10.6
Cholesterol	mg	85.0	91.0	↓ 6.59	95.0	87.0	↑ 9.20	91.7	92.0	↓ 0.33
Fat	g	9.86	11.3	↓ 12.7	7.80	9.76	↓ 20.1	7.67	9.17	↓ 16.4
SFA	g	3.57	4.04	↓ 11.6	3.60	3.72	↓ 3.23	3.68	3.28	↑ 12.2
MUFA	g	2.84	4.96	↓ 42.7	2.96	3.95	↓ 25.1	2.97	4.02	↓ 26.1
PUFA	g	0.18	0.74	↓ 75.7	0.29	0.86	↓ 66.3	0.29	0.60	↓ 51.7
Iron	mg	0.03	1.81	↓ 98.3	1.49	2.44	↓ 38.9	3.12	2.20	↑ 41.8
Mag	mg	18.0	26.0	↓ 30.8	24.2	27.0	↓ 10.4	22.9	25.0	↓ 8.40
Potassium	mg	261	368	↓ 29.1	330	267	↑ 23.6	303	333	↓ 9.01
Sodium	mg	71.2	88.0	↓ 19.1	83.3	66.0	↑ 26.2	61.9	71.0	↓ 12.8
Zinc	mg	0.04	6.48	↓ 99.4	2.20	4.06	↓ 45.8	3.38	4.85	↓ 30.3
Vit B1	mg	0.08	0.10	↓ 20.0	0.12	0.1	↑ 20.0	0.14	0.12	↑ 16.7
Vit B2	mg	0.10	0.26	↓ 61.5	0.07	0.27	↓ 74.1	0.10	0.31	↓ 67.7
Vit B3	mg	1.37	6.07	↓ 77.4	1.25	6.83	↓ 81.7	1.63	6.27	↓ 74.0
Vit B6	mg	0.07	0.17	↓ 58.8	0.13	0.16	↓ 18.8	0.10	0.17	↓ 41.2
Vit B12	mcg	0.83	2.81	↓ 70.5	0.91	2.16	↓ 57.9	1.06	2.58	↓ 58.9

Values marked in red are questionable

6. Summary of findings

6.1. Fat content of South African lamb and mutton

South African lamb and mutton products are often excluded from healthy, balance diets based on the assumption that these products are high in fat. However, the current study found that trimming of visible subcutaneous fat (which is recommended), further reduces the fat content.

- Lean South African lamb and mutton, with subcutaneous fat removed, has a fat percentage of less than 10% (less than 10g fat per 100g edible portion)
- Trimming of the visible subcutaneous fat reduces the amount of fat present in lamb and mutton loin cuts (often used as chops) from more than 20g per 100g, to less than 10g per 100g.
- Food products with a fat value of less than 10g per 100g can be included as part of a healthy, balanced diet.
- Raw mutton (edible portion: meat + fat) contains, on average, 33.3% less fat than the values in the previous national reference tables (Sayed, Frans & Schönfeldt, 1999). No values for lamb were included in the previous national tables.

6.2. Fatty acid profile of South African lamb and mutton

Dietary fat plays an important role in human health, and is considered an essential nutrient which much be supplied by the diet. Essential fatty acids, such as omega-3 and omega-6 fatty acids, play a part in many metabolic processes, and there is evidence that low levels of essential fatty acids, or the wrong balance of types among the essential fatty acids, may be a precursor for a number of illnesses such as increased blood cholesterol, increased risk for developing heart disease and certain types of cancer.

Fatty acids are grouped into three broad categories, namely saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). Despite common reference to animal fats as 'saturated', red meat contains both saturated and unsaturated fats. Although it is generally accepted that saturated fatty acids increase total and low density lipoprotein cholesterol (LDL), and unsaturated fatty acids decrease total cholesterol and increase high density lipoprotein cholesterol (HDL), individual fatty acids within these groups have distinct biological properties. Unfortunately, most of the epidemiological evidence uses broad groupings, which complicates determining the effect of individual fatty acids.

In the case of South African lamb and mutton, the unsaturated fat (cholesterol lowering) content is practically similar to the saturated fat (cholesterol raising) content. The fatty acid profile of meat will also vary depending on the proportions of lean meat and fat present. In Table 6.1 and Table 6.2 the fatty acid composition of South African lamb and mutton is presented.

Table 6.1: Saturated fatty acid (SFA) (g) content of 100g edible portion of raw South African lamb and mutton, as slaughtered (meat+fat), lean meat (subcutaneous fat removed), and as muscle only (all visible fat removed)

	Edible portion as slaughtered (meat+fat)						Lean edible portion (subcutaneous fat removed)						Muscle only		
	Lamb			Mutton			Lamb			Mutton			Mutton		
Cut	Shoulder	Loin	Leg	Shoulder	Loin	Leg	Shoulder	Loin	Leg	Shoulder	Loin	Leg	Shoulder	Loin	Leg
SFA	**6.88**	**8.40**	**5.01**	**7.26**	**10.48**	**5.55**	**5.28**	**5.78**	**3.08**	**5.44**	**6.21**	**3.26**	**2.96**	**2.55**	**1.68**
C4:0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C6:0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C8:0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C10:0	0.026	0.030	0.020	0.020	0.030	0.015	0.019	0.018	0.012	0.014	0.017	0.008	0.006	0.005	0.004
C11:0	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C12:0	0.076	0.111	0.062	0.042	0.027	0.014	0.055	0.078	0.037	0.040	0.017	0.009	0.037	0.009	0.005
C13:0	0.009	0.011	0.005	0.000	0.000	0.000	0.007	0.008	0.003	0.000	0.000	0.000	0.000	0.000	0.000
C14:0	0.836	1.039	0.648	0.390	0.569	0.298	0.618	0.683	0.391	0.289	0.327	0.168	0.151	0.120	0.078
C15:0	0.130	0.149	0.094	0.105	0.168	0.098	0.098	0.097	0.057	0.078	0.097	0.055	0.042	0.035	0.025
C16:0	3.287	3.960	2.445	3.402	4.712	2.608	2.500	2.663	1.501	2.574	2.856	1.561	1.446	1.267	0.835
C17:0	0.262	0.327	0.183	0.316	0.497	0.245	0.203	0.232	0.111	0.228	0.278	0.137	0.108	0.091	0.062
C18:0	2.081	2.570	1.422	2.950	4.403	2.242	1.641	1.858	0.878	2.189	2.578	1.309	1.152	1.014	0.662
C20:0	0.034	0.036	0.019	0.035	0.058	0.029	0.027	0.024	0.010	0.026	0.033	0.016	0.014	0.011	0.008
C21:0	0.114	0.131	0.084	0.000	0.002	0.000	0.087	0.085	0.052	0.000	0.001	0.000	0.000	0.000	0.000
C22:0	0.009	0.015	0.008	0.000	0.015	0.003	0.007	0.012	0.006	0.000	0.007	0.001	0.000	0.000	0.000
C23:0	0.021	0.021	0.021	0.000	0.000	0.000	0.020	0.019	0.019	0.000	0.000	0.000	0.000	0.000	0.000
C24:0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6.2: Monounsaturated fatty acid (MUFA) and Polyunsaturated fatty acid (PUFA) (g) content of 100g edible portion of raw South African lamb and mutton, as slaughtered (meat+fat), lean meat (subcutaneous fat removed), and as muscle only (all visible fat removed) *continued*

	Edible portion as slaughtered (meat+fat)						Lean edible portion (subcutaneous fat removed)						Muscle only		
	Lamb			Mutton			Lamb			Mutton			Mutton		
Cut	Shoulder	Loin	Leg	Shoulder	Loin	Leg	Shoulder	Loin	Leg	Shoulder	Loin	Leg	Shoulder	Loin	Leg
MUFA	**5.63**	**6.64**	**4.25**	**5.58**	**7.63**	**4.75**	**4.20**	**4.26**	**2.55**	**4.30**	**4.70**	**2.98**	**2.55**	**2.18**	**1.75**
C14:1	0.032	0.041	0.027	0.013	0.025	0.013	0.022	0.023	0.015	0.009	0.014	0.007	0.005	0.004	0.003
C15:1	0.001	0.001	0.001	0.046	0.072	0.040	0.000	0.000	0.000	0.033	0.040	0.022	0.015	0.013	0.009
C16:1	0.297	0.357	0.241	0.215	0.285	0.182	0.210	0.212	0.139	0.164	0.173	0.109	0.095	0.078	0.058
C17:1	0.137	0.169	0.107	0.115	0.163	0.112	0.098	0.103	0.060	0.089	0.097	0.066	0.052	0.041	0.035
C18:1n9t	0.437	0.407	0.323	0.276	0.456	0.254	0.326	0.208	0.190	0.192	0.261	0.145	0.077	0.094	0.070
C18:1n9c	4.704	5.639	3.539	4.884	6.587	4.122	3.530	3.694	2.138	3.784	4.085	2.609	2.287	1.941	1.561
C20:1	0.020	0.027	0.016	0.014	0.022	0.013	0.015	0.020	0.010	0.011	0.014	0.009	0.007	0.006	0.007
C22:1n9	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C24:1	0.000	0.000	0.000	0.016	0.020	0.014	0.000	0.000	0.000	0.013	0.014	0.010	0.010	0.008	0.008
PUFA	**0.47**	**0.55**	**0.35**	**0.51**	**0.62**	**0.41**	**0.37**	**0.39**	**0.22**	**0.40**	**0.40**	**0.27**	**0.25**	**0.22**	**0.18**
C18:2n6t	0.031	0.036	0.026	0.058	0.091	0.049	0.023	0.023	0.017	0.042	0.052	0.028	0.022	0.018	0.013
C18:2n6c	0.350	0.411	0.255	0.254	0.276	0.199	0.278	0.291	0.167	0.202	0.189	0.135	0.132	0.114	0.091
C18:3n6	0.011	0.012	0.002	0.044	0.065	0.037	0.010	0.010	0.000	0.032	0.037	0.021	0.016	0.014	0.011
C18:3n3	0.069	0.072	0.047	0.104	0.142	0.071	0.056	0.049	0.031	0.080	0.088	0.048	0.048	0.042	0.032
C20:2	0.007	0.014	0.013	0.004	0.004	0.004	0.004	0.010	0.010	0.004	0.004	0.004	0.004	0.004	0.004
C20:3n6	0.001	0.001	0.001	0.001	0.002	0.001	0.000	0.000	0.000	0.001	0.002	0.001	0.001	0.002	0.001
C20:3n3	0.004	0.004	0.001	0.001	0.000	0.001	0.003	0.003	0.000	0.001	0.000	0.001	0.001	0.000	0.001
C20:4n6	0.000	0.000	0.000	0.015	0.014	0.014	0.000	0.000	0.000	0.014	0.012	0.013	0.012	0.011	0.012
C20:5n3	0.000	0.003	0.000	0.030	0.027	0.029	0.000	0.003	0.000	0.023	0.019	0.020	0.013	0.013	0.014
C22:2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C22:6n3	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.001

Findings of the study have been previously published in the following publications:

- SAINSBURY, J. 2009. Nutrient content and carcass composition of South African mutton with a focus on bioavailability of selected nutrients. Dissertation submitted to the Faculty of Natural and Agricultural Sciences, University of Pretoria as part of the requirements for the degree Master Sciencetia in Nutrition.
- SAINSBURY, J., SCHÖNFELDT, H.C. & VAN HEERDEN, S.M. 2011. The nutritional composition of South African mutton. Journal of Food Composition and Analysis, 24, 720-726.
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- VAN HEERDEN, S.M. & SCHÖNFELDT, H.C. 2007. The Nutrition Content of South African Lamb. Meat Industry Centre. ARC-LBD: Animal Production. ISBN: 978-1-86849-366-1.
- VAN HEERDEN, S.M., STRYDOM, P.E. & SCHÖNFELDT, H.C. 2011. The Carcass Composition of South African Lamb and Mutton as purchased by the South African Consumer. Meat Industry Centre. ARC-LBD: Animal Production Institute. ISBN: 978-1-86849-398-2.

APPENDIX A: PHYSICAL COMPOSITION DATA

ANIMAL: _____ Slaughter date: _____

Number: _____ Freezing date: _____

Mass on arrival: _____kg

Mass of side before cutting: _____

CUT CODE	CUT	STARTING MASS (kg)	BONE (kg)	SUBCU-TANECOUS FAT (kg)	INTER MUSCLE FAT (kg)	MUSCLE (kg)	TOTAL CALCULATED (kg)
	LEG						
	LOIN						
	SHOULDER						

INTERMUSCULAR FAT TO BE PLACED WITH SUBCUTANEOUS FAT FOR ANALYSIS

Appendix B: Dry heat method cooking form

CUT:		DATE:	
SAMPLE CODE:			
THAWING DATA		**Mass (g)**	
Raw sample + thawing loss + bag			
Bag + exudate			
Bag without exudate			
*Mass raw sample**			
*Thawing loss**			
COOKING DATA			
Time in		Start temp (°C)	
Time out		End temp (°C)	
*Cooking time**		*Cooking tempo**	*(°C/g/min)*
Oven temp (°C)		Thermocouple	
WEIGHT		**Mass (g)**	
Pan + rack			
Pan + rack + raw meat			
*Mass raw meat**			
Pan + rack + drip loss + cooked meat			
*Evaporation loss**			
Pan + rack + drip loss			
*Mass total drip loss**			
*Mass cooked meat**			
Pan + rack + residue drip			
*Mass residual drip loss in pan**			
*Total cooking loss**			
CYLINDER READING			
Total drip loss (ml)			
Stock (ml)			
Fat (ml)*			
Mass of fat (g)*			

**calculated*

Appendix C: Moist heat method cooking form

CUT:			DATE:
SAMPLE CODE:			
THAWING DATA			**Mass (g)**
Raw sample + thawing loss + bag			
Bag + exudate			
Bag without exudate			
*Mass raw sample**			
*Thawing loss**			
COOKING DATA			
Time in		Start temp (°C)	
Time out		End temp (°C)	
*Cooking time**		*Cooking tempo**	*(°C/g/min)*
Oven temp (°C)		Thermocouple	
WEIGHT			**Mass (g)**
Pan + rack			
Pan + rack + 100ml distilled water + raw meat			
*Mass raw meat**			
Pan + rack + drip loss + cooked meat			
*Evaporation loss**			
Pan + rack + drip loss			
*Mass total drip loss**			
*Mass cooked meat**			
Pan + rack + residue drip			
*Mass residual drip loss in pan**			
*Total cooking loss**			
CYLINDER READING			
Total drip loss (ml)			
Stock (ml)			
Fat (ml)*			
Mass of fat (g)*			

**calculated*

APPENDIX D

THE SOUTH AFRICAN CARCASS CLASSIFICATION SYSTEM FOR LAMB, MUTTON, BEEF AND GOAT MEAT

South African red meat carcasses are classified according to the South African carcass classification system indicated by roller-marks on the carcass. These coloured roller-marks which are sometimes visible on raw meat are completely harmless, and illustrate the age of the animal before slaughter as well as the fatness of the carcass.

CARCASS AGE

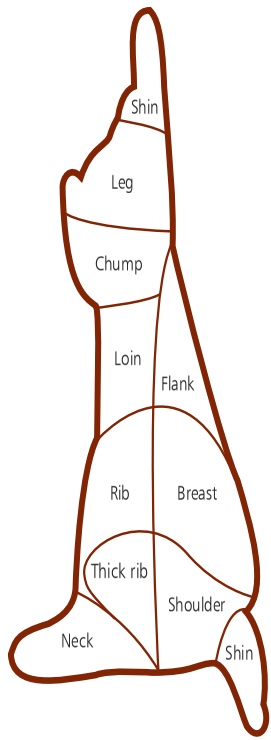
A	(purple AAA roller mark)	– 0 teeth - young animal
AB	(green ABAB roller mark)	– 1 to 2 teeth - slightly older animal
B	(brown BBB roller mark)	– 3 to 6 teeth - older animal
C	(red CCC roller mark)	– More than 6 teeth - old animal

Flavour ↓ Tenderness ↑

CARCASS FATNESS

0 (000 roller mark) - no visible fat
1 (111 roller mark) - very lean
2 (222 roller mark) - lean
3 (333 roller mark) - medium fat
4 (444 roller mark) - fat
5 (555 roller mark) - overfat
6 (666 roller mark) - excessively fat

Leaner product ↑



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This booklet reflects the substantial changes in the nutrient composition of South African lamb and mutton, including a noteworthy reduction in the amount of fat than what was previously thought. With a reduction in fat, both on the carcass itself and after trimming at home, the nutrient density increases. As a nutrient dense food, providing high concentrations of essential nutrients including protein, minerals and vitamins, lean South African lamb and mutton can be included as part of a healthy, balanced diet in line with the South African Food-Based Dietary Guidelines.

Includes:

- Recent findings on the nutrient content of South African lamb and mutton
- Values calculated on analysis to represent nutrient content:
  a) as slaughtered (meat + fat + bone)
  b) edible portion (meat + fat)
  c) lean edible portion (meat without subcutaneous fat)
  d) lean muscle only
- Nutrient retention factors