THE NUTRIENT COMPOSITION OF SOUTH AFRICAN MUTTON

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ABSTRACT

Dorper and Mutton Merino carcasses of the C age group with a fat code 2 (± 7 % SCF) from three main production areas (Karoo, Kalahari and Ermelo) in South Africa were analysed in this study. The physical composition of each cut differed dramatically from the other cuts. The differences between the ten wholesale cuts when comparing the two breeds, are small, and only five cuts differed significantly on one trait. The right sides of the carcasses were used to determine the nutrient and physical (carcass) composition of each raw cut as well as for the whole carcass by calculation. Three cuts (shoulder, loin and leg) from the left side were cooked in order to determine the nutrient composition thereof. Cooking increased the protein and cholesterol concentrations of the cooked cuts. Iron content was higher in the cooked loin and leg but decreased in the cooked shoulder during cooking. According to nutrient density, mutton is a good source of protein, iron and B vitamins and supply more than 25% of RDA/100g of vitamin B12 when cooked.

Key Words: Nutrient composition, South African mutton, Dorper, Merino, Nutrient density

1. INTRODUCTION

Nutrition plays an integral role in the optimal functioning of the body compared to malnutrition (including under nutrition and over nutrition) that is a health impairment resulting from a deficiency, excess or imbalance of nutrients (Robinson, 1978). Most developing countries are faced with the double burden of persisting under nutrition as well as the growing epidemic of obesity and non-communicable diseases such as cancer and heart disease and South Africa is no exception (Labadarios & Oelofse, 2000). Information to link nutrition and chronic diseases is necessary to inform the consumer on healthier food choices as consumers are becoming more health conscious and are increasingly focusing on food safety as well as their eating habits and nutrient intake (Garnier *et al*., 2002). The consumers' involvement influences the whole food chain, agriculture and science (Garnier *et al*., 2002). Food choices can have a positive or negative influence on the person's health status (Kruger *et al*., 2003). Some diseases commonly found in South Africa are related to malnutrition (under- and overnutrition) and thus emphasising the need for greater knowledge on the composition of food (Johnson, 1987). Detailed knowledge on the composition of foods is essential to understand the function of nutrients in the diet. The assessment of dietary exposure is critical for the interpretation of the relationship between nutrition and health (Deharveng *et al*., 1999). Food composition tables give information on the portion, composite sample, collection and analysis of the composition of foods (Miller & Payne, 1961; Southgate, 1998) and can be used to evaluate a person's food intake and compare it to the Recommended Dietary Allowance (RDA) (Whitney & Rolfes, 2002).

Many countries use one national food composition table that contains food commonly eaten in the country. Some of the data analysed in one country is also used in the food composition tables

of other countries. Problems arise where the different countries use different methods to analyse nutritional composition as well as different measuring units and cooking methods. Due to difference in definitions, methods and methods of analysis it is obvious that these food composition tables are not international and it is therefore important that each country has their own food composition tables (Deharveng *et al*., 1999). The first food composition tables for South African foods were compiled by the Research Institute for Nutritional Diseases (NRIND) in 1991 (Langenhoven *et al*., 1993). Current South African food composition tables are compiled by the Medical Research Council (MRC) (Langenhoven *et al*., 1993). However, only 41% of the data in these tables are currently derived from South African foodstuffs (Sayed *et al*., 1999) with the remaining data obtained mainly from American and English composition tables.

Previous nutrition data on mutton for South African food composition tables was borrowed from the UK food composition tables (Langenhoven *et al*., 1993) but the latest update on mutton and lamb that appear in the MRC's food composition tables of 1999 are derived from the United States Department of Agriculture (USDA, 1989) database (Sayed *et al*., 1999). Although sheep in South Africa originated from international breeds the nutritional composition of mutton various greatly between countries (Van Heerden *et al.,* 2007) due to different reasons, for instance meat products are dissected into different primal cuts in each country, thereby influencing the composition of meat cuts (Schönfeldt, 1998). Amino acids for example differ between different parts of the carcasses and different cutting methods may influence the amino acids detected (Lawrie, 1998). Genetic and environmental factors are the main factors affecting the quality and nutrient content of meat (Okeudo & Moss, 2005). Greenfield and Southgate (2003) further states that differences in climate as well as soil content between the countries may also influence the nutrient content of the animals' feed and thus the nutrient content of the

animals' meat. According to Givens (2005) the fatty acid composition of animal products are not fixed and can be altered in response to changes in the diet of the productive animals. Post-mortem factors that differ among countries, such as fat trim levels and cooking can also cause changes in nutrient composition (Jamora & Rhee, 1998). Jamora and Rhee (1998) further explains that cooking lead to moisture loss and thus an increase in concentration of some nutrient and decrease in heat-labile nutrients.

Van Heerden *et al*. (2007) reports that SA lamb contains on average 40% less fat than that published in the National Food Consumption Tables by the Medical Research Council in 1999. The fat content of lamb in the UK has decreased with 10% over the last twenty years. Therefore the need for nutrient composition data of South African (SA) meat was identified by the Red Meat Producers Organisation (RPO) as a priority.

2. MATERIALS AND METHODS

2.1 Sampling

Mutton carcasses from the C age class and fatness level 2 were selected from the meat industry as it represents South African mutton purchased by the consumer. The South African Red Meat Classification System for lamb and sheep uses the main characteristics of beef, mutton, lamb and goat to classify the carcasses in order to make the purchase of red meat as simple as possible for sonumers. The main characteristics used to classify mutton for this study are the age of the animal and the fatness of the carcass. The age classes are known as: A (youngest animals (0 incisors)), AB (older animals (1–2 incisors)), B (even older animals; (3–6 incisors), and C (oldest animals

(7–8 incisors)). The fatness classes are known as class zero (no fat) to class 6 (excessively over fat) (SAMIC s.a.).

The C2 mutton carcasses were obtained through stratified sampling where food is selected, taking into account the most important causes of variation. The meat samples, incorporated in the study, comprised of the two most commonly consumed breeds Dorper ($n = 9$) and Mutton Merino ($n = 9$) carcasses which were obtained from abattoirs that draw mutton from the three main production areas in South Africa namely the Karoo, Kalahari and Ermelo districts. The sheep were slaughtered using standard commercial procedures during four consecutive weeks. The carcasses were classified according to the South African classification system by a qualified classifier at the abattoirs. Selected carcasses were transported in a refrigerated truck (4–6 °C) to the Meat Industry Centre of the then ARC-ANPI, Irene. Upon arrival, all the carcasses were weighed, covered with plastic wrap to prevent moisture loss and chilled at 4 °C overnight and dissected the following day. The mutton carcasses consisted of the skinned, eviscerated body from which the head, feet, kidney and kidney fat were removed.

Three cuts (shoulder, leg and loin from the left side of the carcass), representing the most commonly consumed cuts, were used to determine the cooked proximate analysis, physical composition and nutrient composition. These cuts (leg, loin, shoulder) were cooked according to standardized moist and dry heat cooking methods in identical Mielé ovens at 163 °C to an internal temperature of 73 °C measured in the geometrical centre of the cut (AMSA, 1995). The raw and cooked nutrient data of the three cuts was compared based on the assumption, (Kirton *et al.,* 1962) that the chemical composition of the two sides is similar or almost identical.

2.2 Physical dissection

Carcasses were weighed prior to being divided into the respective wholesale cuts. A trained deboning team were responsible for the physical dissection. Carcasses were sectioned down the vertebral column with a band saw, with each side then subdivided into the following 10 primal cuts: neck, thick rib, flank, shoulder, breast, rib, loin, chump, leg and shanks. For each cut of the right sides of the carcasses, the % meat, subcutaneous fat and bone content were determined, in order to calculate carcass composition. Therefore the cuts were divided into three parts namely meat, bone and subcutaneous fat, in an environmentally controlled abattoir at 6ºC by a trained de-boning team. The wholesale cuts of the left sides of the carcasses were vacuumed packed and frozen till required for cooked analysis.

2.3 Proximate analyses

Proximate analysis (fat, moisture, protein, ash) were done on the 10 raw wholesale cuts. Due to limited funding, proximate analysis was done on only three cooked cuts namely the leg, loin and shoulder cuts. All the raw (n=10 cuts) and cooked (n=3) physical dissected meat (muscle + intramuscular fat) and fat respectively were cubed, thoroughly mixed and then minced first through a 5 mm and then through a 3 mm mesh plate. 300 g sample of meat (muscle + intramuscular fat) and subcutaneous fat respectively were further homogenized with an Ultra Turrax T25 homogenizer after mincing to ensure a proper homogenized sample. Samples were vacuumed packed and frozen, prior to being freeze-dried.

2.4 Nutrient analyses

In order to comply with the new Draft Regulations (2004) relating (http://www.doh.gov.za/department/dir_foodcontr.html), to the Labelling and Advertising of

Foodstuffs as part of the Foodstuffs, Cosmetics and Disinfectants Act, 1972, it is proposed that a composite of three carcasses be pooled and used as a basis of the study. The use of composite samples for analysis rather than individual samples is justified because of funding constraints and has been an accepted approach in food composition studies (Greenfield and Southgate, 2003). Therefore the samples analysed for this purpose are those of the 3 cuts (leg, loin, shoulder) of the C2 class. However, care was taken in the design to ensure statistical reliability of the data.

A composite sample (3 carcasses of 1 age group, 1 fat code, 2 breeds, and 3 cuts), of raw (left sides) and cooked (right sides) meat and subcutaneous fat were analysed for nutrient content. All foods vary in nutrient composition and its contribution of nutrients to the diet, therefore only the nutrients in meat that are known to be a significant source were analysed.

3. STATISTICAL ANALYSIS

The experiment was designed as a completely randomized design (CRD). Analysis of variance (ANOVA) was used to test for differences between mutton from 3 areas and 2 breeds, as well as the area x breed interaction. The data was acceptably normal with homogeneous treatment variances. Treatment means were separated using Fisher's protected t-test least significant difference (LSD) at the 5% level of significance (Snedecor & Cochran, 1980). Data were analysed using the statistical program GenStat (2003).

Sources of variation for all the nutrient data collected were investigated by ANOVA (GenStat, 2003). For any significant difference found for any variate, Bonferroni multiple comparison tests were performed. The Bonferroni test is stricter than the ANOVA test, therefore it is not necessarily true that $p \geq 0,05$ will identify differences between means if tested according to the

Bonferroni test method. A correlation matrix was constructed to test for correlation between the different variables (GenStat, 2003).

4. RESULTS AND DISCUSSION

4.1 Nutrient composition for raw and cooked 100 g meat portion

The mean values of the nutrient composition for raw and cooked 100 g meat portion of South African C2 mutton are presented in Table 1. The nutrient values of cooked mutton are more useful to the consumers than raw values (Ono *et al*., 1984). However, raw values are used to evaluate production and marketing effects on nutrient composition. Cooked values, on the other hand, provide information on what is actually consumed. The differences in the amount of nutrients between raw and cooked meat cuts can be used to calculate nutrient retention in the cuts (Ono *et al*., 1984).

Examining the nutrient differences between raw and cooked South African mutton meat, moisture, sodium, thiamine (B1) and pyridoxine (B6) are the only components that decreased significantly during the cooking process with moisture decreasing with 13 %. The notable decrease in thiamine and pyridoxine are probably due to the fact that these vitamins are water-soluble and were lost in the cooking losses that were not added back to the meat prior to analysis. The nutrient components protein, fat, riboflavin (B2), all fatty acids and cholesterol increased during the cooking process (Table 1). This concentration in nutrients is mainly due to the moisture loss. Jamora and Rhee (1998) emphasises that cooking lead to moisture loss and thus an increase in concentration of some nutrient and decrease in heat-labile nutrients.

Table 1. Mean values of the nutrient composition for raw and cooked 100 g meat portion of South African C2 mutton.

Nutrients analysed	Unit	*p*-value	SEM	Raw (*n* = 18)	Cooked (*n* = 18)
Proximate analysis:					
Moisture	g	<0.001	0.287	73.9	64.0
Protein (Nx6.25)	g	<0.001	0.232	20.2	26.3
Fat	g	<0.001	0.219	4.86	8.58
Ash	g	0.162	0.028	1.18	1.12
Food energy	kJ	<0.001	8.63	524	764
Minerals					
Magnesium (Mg)	mg	0.731	0.22	22.7	22.8
Potassium (K)	mg	0.863	3.76	275	274
Sodium (Na)	mg	<0.001	1.06	83.0	73.5
Zinc (Zn)	mg	0.035	2.17	3.56	4.25
Iron (Fe)	mg	0.095	1.192	2.97	3.26
Vitamins					
Thiamine (B1)	mg	<0.001	0.003	0.04	0.02
Riboflavin (B2)	mg	<0.001	0.003	0.04	0.07
Niacin (B3)	mg	0.192	0.114	4.96	5.17
Pyridoxine (B6)	mg	<0.001	0.015	0.20	0.11
Cyanocobalamin (B12)	µg	0.004	0.150	2.37	3.06
Lipids					
Saturated fatty acids (SFA)					
14:0	g	<0.001	0.007	0.12	0.22
16:0	g	<0.001	0.569	1.22	2.15
18:0	g	<0.001	0.055	0.97	1.91
20:0	g	<0.001	0.001	0.01	0.23
Total saturated fatty acids	g	<0.001	0.125	2.47	4.57
Monounsaturated fatty acids (MUFAs)					
16:1	g	<0.001	0.004	0.08	0.14
18:1n9t	g	<0.001	0.006	0.09	0.20
18:1n9c	g	<0.001	0.082	1.93	3.20
Total monounsaturated fatty acid	g	<0.001	0.094	2.18	3.67
Polyunsaturated fatty acids (PUFAs)					
18:2n6t	g	<0.001	0.001	0.02	0.04
18:2n6c	g	<0.001	0.005	0.11	0.18
Cholesterol	mg	<0.001	2.160	47.9	61.20

Nutrients analysed	Unit	*p*-value	SEM	Raw (*n* = 18)	Cooked (*n* = 18)
CLA		0.185	0.009	0.17	0.26

p-value: *F*-probability to test for significant differences between samples. SEM: Standard Error of Means. The significance of all the variables measured for each sample was tested with split-plot analysis of variance (ANOVA), whereby the main effect of the cuts ($n = 10$ − whole plots) and treatment ($n = 18$ raw and cooked – sub-plots), WAS tested at the 5% level of significance ($p \leq 0.05$).

The mean values of the nutrient composition for the interaction between raw and cooked cuts are presented per 100 g edible portion for South African C2 mutton in Table 2. The nutrients showing the greatest differences between the three cuts (shoulder, leg and loin) for the raw and

Table 2. Mean values of the nutrient composition of three raw and three cooked cuts per 100 g edible portions (meat and fat) of South African C2 mutton.

Nutrients analysed		Raw cuts (*n* = 3)			Cooked cuts (*n* = 3)		
	Unit	Shoulder	Loin	Leg	Shoulder	Loin	Leg
Proximate analysis							
Moisture	g	73.8	74.0	73.7	66.5	63.2	64.0
Protein (Nx6.25)	g	20.4	20.7	20.2	24.9	26.9	28.7
Fat	g	8.85	8.85	9.24	11.69	13.21	9.91
Ash	g	1.19	1.20	1.18	1.25	1.11	1.12
Food energy (calculated)	kJ	667	682	689	860	951	857
Minerals							
Magnesium (Mg)	mg	21.88	23.0	21.9	21.1	23.0	24.2
Potassium (K)	mg	255.77	282	256	262	280	280
Sodium (Na)	mg	86.87	85.7	86.9	74.8	77.6	68.0
Zinc (Zn)	mg	38.78	3.23	3.88	4.64	3.72	4.41
Iron (Fe)	mg	28.01	2.93	2.80	2.75	3.23	3.81
Vitamins							
Thiamine (B1)	mg	0.05	0.04	0.04	0.03	0.03	0.02
Riboflavin (B2)	mg	0.04	0.03	0.04	0.07	0.05	0.08
Niacin (B3)	mg	4.75	5.17	4.95	4.89	5.43	5.20
Pyridoxine (B6)	mg	0.17	0.23	0.21	0.09	0.12	0.11
Cyanocobalamin (B12)	µg	2.68	2.08	2.35	3.43	2.60	3.14
Lipids							

Nutrients analysed		Raw cuts (*n* = 3)			Cooked cuts (*n* = 3)		
	Unit	Shoulder	Loin	Leg	Shoulder	Loin	Leg
Saturated fatty acids (SFAs)							
14:0	g	0.25	0.25	0.26	0.32	0.37	0.27
16:0	g	2.27	2.27	2.33	2.97	3.42	2.49
18:0	g	1.90	1.99	1.94	2.68	3.28	2.07
20:0	g	0.02	0.03	0.02	0.03	0.04	0.03
Monounsaturated fatty acids (MUFAs)							
16:1	g	0.15	0.14	0.16	0.19	0.20	0.18
18:1n9t	g	0.19	0.20	0.21	0.27	0.33	0.24
18:1n9c	g	3.39	3.30	3.58	4.41	4.67	3.88
Polyunsaturated fatty acids (PUFAs)							
18:2n6t	g	0.04	0.04	0.04	0.05	0.06	0.04
18:2n6c	g	0.19	0.17	0.19	0.23	0.24	0.21
Cholesterol	mg	49.94	51.01	50.02	58.75	70.83	57.94

cooked treatments were moisture, protein, fat, sodium, pyridoxine and cholesterol. As expected, moisture losses due to cooking resulted in an increase in the protein and cholesterol concentrations.

4.2 Nutrient composition of three cuts (raw and cooked) per 100 g edible portions

According to the results in Table 2, within the edible portion of the three raw and cooked cuts on average the moisture decreases with up to 15 % during the cooking process. The loin cuts lost a higher percentage of moisture during cooking than the other cuts which may be due to the fact that the loin cut was cooked according to a dry heat cooking method while the other cuts were cooked according to a moist heat cooking method. The subcutaneous fat and intermuscular fat was combined and analysed together in this study and although the amount of fat varies between the different cuts of the animal (Latham, 1997) there are no difference in the fatty acid composition between these tissues (Juarez *et al.,* 2007). The fat content of the loin cut increased

with a severe 49.26 % during cooking. As fat content increased during cooking, the protein content decreased per 100 g portion (Enser et al., 1998).

Of the three raw cuts, the leg had more fat (9.2g) when compared to the shoulder (8.9g) and the loin (8.9g) cuts but had the lowest fat content in edible cooked portion. With the leg containing less than 10g fat per 100 g edible cooked portion it qualifies for the heart foundation. In a study done by Hoke *et al.,* (1999) it was found that there exist an inverse relationship between moisture and fat content. This fact seems to be correct for all three cuts analysed in this study. The edible portion for the cooked leg cut contains less total fat and less saturated fat than the other cuts and contains 18 % less cholesterol than cooked loin cut.

Although the loin cut contained high quantities of potassium, sodium an iron, the zinc content was low when compared to the other cuts. The cooked shoulder cut contained lower amounts of most minerals (magnesium, potassium, and iron) when compared to the other cooked cuts but had high cyanocobalamin content. The cooked shoulder (58.8g) and leg (57.9g) cut contained significantly less cholesterol than the loin cut 70.8g). (Table 2)

4.3 Comparison between current study and MRC food composition tables

Results tabulated in Table 3 demonstrate that meat cuts vary in its contributions to the diet. When comparing the new food composition data for mutton (C2) from the study with the current data included in the South African food composition tales (Sayed *et al*., 1999) there are differences in the nutrient composition of these two sets of data, because previous data were obtained from USA Food Composition Tables. This is an agreement to Greenfield and Southgate (2003) who stated that nutritional composition data varies between different countries.

According to Vandendriessche (2008) the main attributes of meat contributing to the negative health image is the fat level, the sodium level and the fat quality in terms of fatty acid composition with the fat content of meat remaining the biggest problem (Vandendriessche, 2008), but data showing that mutton contains 29.7 % less fat may overcome this problem. Although the CLA content in the current study indicates that mutton is lower in CLA, any amount of CLA present in meat is seen as value added healthful products (Corino *et al.,* 2003)

The vitamin and mineral content of the raw and cooked mutton (C2) from the current study is lower except for potassium, iron and vitamin B12. Cooked South African mutton (data from current study) contains 63 % more iron ((3.26 g – 2 g)/3.6 x 100 %).

Table 3. Comparison of the nutrient composition for raw and cooked 100 g edible portion of lean mutton between the South African 1999 MRC food composition tables and the results of the current study on the C2 mutton.

Nutrients analysed	**Unit**	**Raw**		**Difference between studies[a]**	**Cooked**		**Difference between studies[a]**
		Current study[b]	**1999 MRC tables[c]**		**Current study[b]**	**1999 MRC tables[c]**	
Proximate analysis							
Moisture	g	73.8	60.7	13.1	64.6	57.5	7.06
Protein (Nx6.25)	g	20.5	16.9	3.6	26.8	25.6	1.23
Fat	g	8.98	21.6	−12.62	11.6	16.5	−4.9
Ash	g	1.19	0.9	0.29	1.16	1.0	−.16
Food energy (calculated)	kJ	679	1087	−408	889	1046	157
Minerals							
Magnesium (Mg)	mg	22	22	0	23	24	−1
Potassium (K)	mg	264	230	34	274	313	−39
Sodium (Na)	mg	86.5	58	28.48	73.4	66	7.43
Zinc (Zn)	mg	3.66	3.33	0.33	4.26	4.4	−0.14
Iron (Fe)	mg	2.84	1.6	1.24	3.26	2	1.26

Nutrients analysed	Unit	Raw		Difference between studies[a]	Cooked		Difference between studies[a]
		Current study[b]	1999 MRC tables[c]		Current study[b]	1999 MRC tables[c]	
Vitamins							
Thiamine (B1)	mg	0.04	0.12	−0.08	0.02	0.1	−0.08
Riboflavin (B2)	mg	0.04	0.22	−0.18	0.07	0.27	−0.2
Niacin (B3)	mg	4.96	6.1	−1.14	5.17	6.6	−1.43
Pyridoxine (B6)	mg	0.2	0.13	0.07	0.11	0.15	−0.04
Cyanocobalamin (B12)	µg	2.37	2.4	−0.03	3.06	2.6	0.46
Lipids							
Saturated fatty acids (SFA)	g	4.71	9.47	−4.76	6.07	6.89	−0.82
14:0	g	0.25	0.87	−0.62	0.32	0.64	−0.32
16:0	g	2.42	4.75	−2.33	2.96	3.51	−0.55
18:0	g	1.94	2.98	−1.04	2.67	2.22	0.45
20:0	g	0.10	0	0.1	0.03	0	0.03
Monounsaturated fatty acids (MUFAs)	g	3.77	8.86	−5.09	4.79	6.96	−2.17
16:1	g	0.15	0.63	−0.48	0.19	0.48	−0.29
18:1	g	3.62	7.96	−4.34	4.60	6.32	−1.72
Polyunsaturated fatty acids (PUFAs)	g	0.19	1.7	−1.51	0.28	1.18	−0.9
18:2	g	0.19	1.24	−1.05	0.28	0.9	−0.62
Cholesterol	mg	50.32	72	−21.68	62.51	93	−30.49

Indicates that the current study has less of the particular nutrient than the MRC-tables.

a Difference: calculated on the difference between the values of the current study and that of the 1999 MRC food composition tables (Sayed et al., 1999).
b Data from current study (Table 2).
c Sayed et al. (1999).

4.4 Recommended Dietary Allowances

To evaluate the nutrient contribution of mutton (C2) from this study, the RDA for males, aged 25 - 30 years (Whitney & Rolfes, 2002), were used as the reference point (Table 4). A 100 g portion

Table 4. Contribution of 100 g edible portion of cooked (deboned) meat from three C2 mutton cuts to the nutrient allowances (RDA values) of males, aged 25–50 years.

Nutrients	Unit	RDA males 25–50[a]	Shoulder	Shoulder % contribution	Loin	Loin % contribution	Leg	Leg % contribution	Average % contribution
Proximate analysis									
Moisture	g	–	66.5	–	63.2	–	64.0	–	–
Protein (Nx6.25)	g	63	24.9	39.5	26.9	42.6	28.7	45.6	42.6
Fat	g	–	11.7	–	13.2	–	9.91	–	–
Ash	g	–	1.25	–	1.11	–	1.12	–	–
Food energy (calculated)	kJ	12,180	860	7.06	950	7.80	857	7.04	7.3
Minerals									
Magnesium (Mg)	mg	420	21.1	5.02	23.0	5.47	24.2	5.76	5.42
Potassium (K)	mg	800	261	32.7	280.	35.1	280.	35.1	34.3
Sodium (Na)	mg	–	74.8	–	77.6	–	68.0	–	–
Zinc (Zn)	mg	15	4.64	30.9	3.72	24.8	4.41	29.4	28.4
Iron (Fe)	mg	10	2.75	27.5	3.23	32.3	3.81	38.1	32.6
Vitamins									
Thiamine (B1)	mg	1.2	0.03	2.25	0.03	2.08	0.02	1.42	1.92
Riboflavin (B2)	mg	1.3	0.07	5.15	0.05	4.08	0.08	5.77	5.00
Niacin (B3)	mg	16	4.89	30.6	5.43	33.9	5.20	32.5	32.3
Pyridoxine (B6)	mg	1.7	0.09	5.12	0.12	7.18	0.11	6.47	6.25
Cyanocobalamin (B12)	µg	2.4	3.43	143	2.60	108	3.14	130.	127

– Value not available.

a Whitney and Rolfes (2002), RDA for males 25–50 years.

of cooked shoulder, loin and leg mutton cuts provide on average 42.6 % protein, 34.3 % potassium and 127.4 % vitamin B_{12} of RDA for this group of males. A 100 g portion provides 32.3 % vitamin B_3, 32.6 % iron, 28.4 % zinc, 5.0 % vitamin B2, 6.3 % vitamin B6 and 1.9 % vitamin B1 of the RDA.

Table 5. Indices of the diet quality for cooked, deboned South African C2 mutton cuts.

Nutrients	**100 g edible portion**		
	Nutrient density[a]		
	Loin	**Leg**	**Shoulder**
Protein	5.45	6.47	5.58
Iron	4.26	5.41	3.89
Zinc	3.17	4.18	6.38
Vitamin B12	13.9	18.6	20.2

Nutrient density = ≥1.00: good source.

a Calculated using data from Table 9 and RDA table in Schönfeldt and Welgemoed (1996).

4.5 Nutrient density and the Index of Nutritional Quantity

Nutrient density is used for this purpose as it measures the nutrients a foodstuff provides relative to the energy it provides. The more nutrients present and the fewer kiloJoules, the higher the nutrient density. Nutrient density is calculated as follows:

$$\frac{\text{Amount of micronutrient present in food}}{\text{kJ content of food}} \times \frac{\text{kJ RDA}}{\text{RDA of micronutrient}}.$$

In Table 5 the nutrient density value for all three cooked mutton cuts are above 1, confirming that they supply significant quantities of a range of protein, iron, zinc and vitamin B_{12} for a limited amount of energy.

5. CONCLUSION

It is evident from this study that South African mutton (C2) provides a variety of valuable nutrients. Results indicate that nutrients vary between the raw and the cooked cut. The main cause for this change is the lost in moisture which consecutively lead to higher concentrations of the nutrients. Cooking affected mainly the protein, potassium, zinc and energy values, which were higher in the cooked meat cuts, but in addition differed between the different cooked cuts. Soluble micronutrients can also be lost during the cooking process. Although micronutrients are lost during the cooking process through leaching and solubility, South African mutton (C2) can be regarded as an important dietary source of the B vitamins, iron, and zinc. There was no significant difference in the iron values between the cooked cuts.

Large differences were apparent upon comparing the nutrient composition of a 100g edible portion of the different raw and cooked cuts. During the cooking process moisture decreased in all three cuts while most heat stable nutrients increased. Vitamin B12, B3, B2 and zinc increased in all three cuts during cooking while sodium, vitamin B1 and vitamin B6 decreased in all three cuts.

Upon comparing the current result with the MRC food composition tables of 1999, it is clear that there are significant differences. The current study indicates that cooked South African mutton (C2) contain almost 30 % less fat and 32 % less cholesterol per cooked edible portion. These new results shows that the leg cut of mutton (C2) classifies for the heart foundation mark of approval as it contains less that 10 g fat per 100g edible portion. New results further indicate that South African mutton (C2) are an excellent source of protein, iron, zinc and vitamin B_3 as it

makes a valuable contribution to the RDA of these nutrients for males, aged 25 – 50 years when included as part of a balanced meal plan. Therefore, it can be recommended that lean meat can be consumed in moderation and should be promoted as part of a healthy balanced diet.

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