

# **Sustainable red meat from a nutrition perspective**

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# **Sustainable red meat from a nutrition perspective**

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## DECLARATION

I, Nicolette Hall, declare that the thesis, which I hereby submit for the degree PhD Nutrition at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

SIGNATURE: \_\_\_\_\_

DATE: \_\_\_\_\_

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## ABSTRACT

For any food systems to be sustainable, it needs to contribute to society and economic growth, in addition to being environmentally conscious. Sustainable eating is defined as choosing and consuming *“food to meet current dietary needs while maintaining ecosystems that can also provide food for generations to come with minimal negative impact to the environment”*. Livestock production and the consumption of the red meat produced are often criticised as being unsustainable due to the large carbon footprint attributed to this food commodity. However, what is often excluded from these arguments and debates is the potential beneficial role which animal source foods can play in meeting the dietary requirements of human populations, both in developed and developing countries and communities. The recent Global Nutrition Report (2014) emphasizes nutrition as being central to sustainable development. Within the post-2015 development agenda, improvements in nutritional status could make large contributions to the draft Sustainable Development Goals on poverty, hunger, health, education, gender and employment.

This thesis presents the sustainability of red meat consumption from a nutrition perspective. Forming the scientific foundation for this argument was the analytical determination of the updated nutritional profile of South African beef as currently consumed, as well as a review of the composition of South African lamb and mutton as published in 2007 and 2010 (**Chapter 3**). The data obtained reflects the impact of South Africa’s unique classification and production systems on the composition of locally produced red meat. These animal source foods can be considered good sources of high quantity and quality nutrients, including protein, minerals and essential fatty acids. Trimming of the visible subcutaneous and intermuscular fat deposits from the meat has an even greater impact on nutritional profile (**Chapter 4**). Fat generally

dilutes other essential nutrients, while the beneficial fatty acids (omega 3s and conjugated linoleic acids) are found in the intramuscular fat deposits between muscle cells which are not removed through trimming (**Chapter 5**).

Consequently, red meat products can play a positive role in human nutrition and health. Sustainable food-based interventions to combat under nutrition require the accessibility and availability of nutrient dense foods, and adding even small amounts of red meat could play a significant role in improving the nutritional quality of the starch based staple diets of these individuals. Over nutrition, or the excessive consumption of nutrients and energy, has resulted in a significant rise in the incidence of overweight and obesity globally. In South Africa, more than 65% of women are considered to be overweight or obese, with the incidence in children increasing. Many of these overweight individuals are also suffering from a deficiency of other essential nutrients such as iron. This co-existence of under and over nutrition in the same individual justifies the necessity to promote the consumption of foods higher in nutrients, and lower in energy. Trimmed red meat thus has the potential to play a beneficial role as part of a food-based intervention (**Chapter 6**).

To increase the impact of the findings of the research beyond scientific publications, the results of the analytical study were incorporated into influential outputs, including forming part of the scientific background paper to the Department of Health's revision of the national Food-Based Dietary Guidelines (**Chapter 7**). The arguments of this thesis also feed into the consumer education campaign of Lamb and Mutton South Africa which endeavours to influence social perceptions surrounding the sustainability of red meat consumption (**Chapter 8**). A short communication of the findings was also selected as one of only 28 science writing pieces which was published in the Mail & Guardian newspaper, entitled "*Meatless Mondays might be harmful in South Africa*" (**Addendum 1**).

The South African policy landscape promotes and supports the sustainable production of livestock (**Chapter 2**). Numerous research projects are exploring ways to mitigate greenhouse gas emissions by livestock to improve the environmental impact of the industry. However, as the concerns of sustainable development include economic and social aspects in addition to environmental concerns, the data and arguments generated through this thesis could be used as tools when social concerns within sustainability in particular are voiced. Red meat can play a beneficial role in the nutrition and health of humans by providing high quality nutrients per portion, without necessarily contributing to excessive amounts of fat (and thus energy intake). The updated nutritional profile of South African beef provides evidence for the industry to present the sustainability of red meat consumption from a nutrition perspective.

Recommendations for future research include the extrapolation of the findings into quantitative models to depict the nutrient density of specific food products compared to their carbon footprints. Research on the degree of food waste in the context of sustainable diets could also contribute notably to related arguments in the future, keeping in mind that as meat is the most expensive item in the food basket, waste in this food category is less than in the other food groups.



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## CHAPTER 1: INTRODUCTION

### 1.1 INTRODUCTION

The development of a set of Sustainable Development Goals (SDGs) is currently being discussed on the international agenda as a follow-up for the previous set of Millennium Development Goals (MDGs), which were scheduled to be achieved by 2015. Diets, and more specifically, sustainable eating, i.e. choosing *'healthy food to meet current dietary needs while maintaining ecosystems that can also provide food for generations to come with minimal negative impact to the environment'* (Harmon & Gerald, 2007), are increasingly included in this discussion. As numerous publications (FAO 2006) (Bellarby *et al.*, 2013) (Gerber *et al.*, 2013) continue to report on the carbon footprint and greenhouse gas emissions emitted through animal husbandry, the production and consumption of animal source foods, and especially red meat, has come under the spotlight.

The sustainability of the livestock industry is currently one of the most highly debated issues within food production. It is recognised that livestock provides food together with other economic and social benefits, but the crucial question is whether the consumption of meat is inherently sustainable, or not (Capper, 2013). The red meat industry is currently facing a general demand to increase the volume and production efficiency of animal source foods to meet the growing requirements for high quality protein, and to achieve this goal in a sustainable manner.

The social aspect of sustainability is often the most difficult to address, and includes the argument that if a product is not perceived by the consumer as being sustainable, then there will be no economic benefit (Capper, 2013). Various studies have concluded that price, taste, convenience and health considerations are the most important factors influencing purchasing decisions (Simmons, 2009). However, these factors are dependent on the product being morally and ethically acceptable to the consumer (Vermeir & Verbeke, 2006). The link between health concerns and the sustainability of food choice, in particular for red meat, is unclear. A need was thus identified to explore the sustainability of red meat consumption in South African from a nutrition perspective.

The thesis consists of a series of published papers, which give credibility to the research conducted and enable citation by the international audience. As a starting point, and building the case for the study within the South African context, an overview was conducted on the current policy environment in South Africa as related to sustainable livestock production and consumption. To update the role of red meat as part of nutritious and healthy diets, a research project to determine the nutritional composition of South African beef as currently produced and consumed was funded by Red Meat Research and Development South Africa (RMRDSA) and supported by the National Research Foundation (NRF). The project included the extrapolation of the effect of fat trimming on nutrient composition, and the effect of the different feeding systems in South Africa (grass fed vs. grain fed) on the fatty acid profile. To communicate the findings of the research conducted within the sustainability debate, the essential role which red meat plays in the diet of South Africans was also reviewed in the context of the current double burden of malnutrition (including over- and undernutrition) observed within the country.

Communicating the findings through various channels, including scientific and popular media, furthermore provides guidance for the industry to standardize concepts and processes, e.g. carcass classification, as well as inform consumers to enable better decision making regarding the social sustainability of locally produced red meat. In addition to the publication of scientific papers, results from the study have been presented at both international and national conferences and workshops. In addition to scientific outputs, the study was selected as one of 28 science writing pieces published in the national Mail & Guardian newspaper. The newspaper has a readership of more than 1 million South Africans, including professionals, academics, diplomats, lobbyists and non-governmental groups interested in a critical approach to current affairs. Furthermore, the knowledge gained is being applied within the consumer education campaign of Lamb and Mutton South Africa and communicated to consumers through various popular platforms.

Each chapter in this thesis comprises of a paper with its own introduction, content and discussion, and is formatted (including reference style and language) according to the requirements of the specific journals to which it was submitted for publication. In addition to the

papers, this introductory chapter is included, as well as the concluding chapter summarizing the findings. In **Table 1.1** a summary of the papers comprising the thesis, the journals to which they were submitted as well as their publication status is presented.

**Table 1.1** Summary of papers comprising the thesis

<b>Chapter</b>	<b>Title</b>	<b>Journal name</b>	<b>Publication status</b>
1	Introductory chapter	n/a	n/a
2	The South African policy landscape as related to sustainable livestock production and consumption	International Journal of Sustainable Development	<i>Submitted</i> , under review
3	Update on the composition of South African red meat	South African Journal of Animal Science	<i>Accepted for publication</i>
4	Effect of age and feeding regime on the physical composition of South African beef	Food Chemistry	<i>Accepted for publication</i>
5	Effect of age and feeding regime on the fatty acid profile of South African beef	Meat Science	<i>Submitted</i> , under review
6	The impact of animal source food products on human nutrition and health	South African Journal of Animal Science	<i>Published</i> . 2013: 41:3, p394-412
7	“Fish, chicken, lean meat and eggs can be eaten daily”: a food-based dietary guideline for South Africa	South African Journal of Clinical Nutrition	<i>Published</i> . 2013: 26:3, pS66-S67
8	Consumer education and the health benefits of red meat – a multidisciplinary approach	Food Research International	<i>Published</i> . 2012: 47:2, p152-155
9	Conclusions and Recommendations	n/a	n/a

## 1.2 BACKGROUND

### 1.2.1 Sustainability

The concept of sustainability dates back to the 1960s, when the first sustainability mandate was adopted by the International Union for Conservation of Nature (IUCN) in 1969, and was then used as the key theme of the United Nations Conference on the Human Environment in Stockholm in 1972. The concept of sustainability was coined to suggest that it was possible to achieve economic growth and industrialization without environmental damage. In the following decades, mainstream sustainable development thinking was progressively developed through the World Conservation Strategy (1980), the Brundtland Report (1987), and the United Nations Conference on Environment and Development in Rio (1992), as well as in national government planning and wider engagement from business leaders and non-governmental organizations of all kinds. The World Summit on Sustainable Development in 2002 confirmed that the first decade of the new century would be one of reflection about the demands made by humans on the biosphere. In 2012, the United Nations Conference on Sustainable Development (Rio+20), which took place in Rio de Janeiro, Brazil, developed a political outcome document containing practical measures for implementing sustainable development throughout the globe.

### 1.2.2 Sustainable food systems

Although there is no legal definition of 'sustainable food', a working definition of the World Conservation Unit (IUCN, 2006) is that sustainable food should be *“produced, processed and traded in ways that contribute to thriving local economies and sustainable livelihoods, protect the diversity of both plants and animals, and avoid damaging natural resources and contributing to climate change, and provide social benefits such as good quality food, safe and healthy products, and educational opportunities”*. The American Public Health Association (APHA) defines a sustainable food system as *one “that provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come with minimal negative impact to the environment. A sustainable food system also encourages*

*local production and distribution infrastructures and makes nutritious food available, accessible, and affordable to all."*

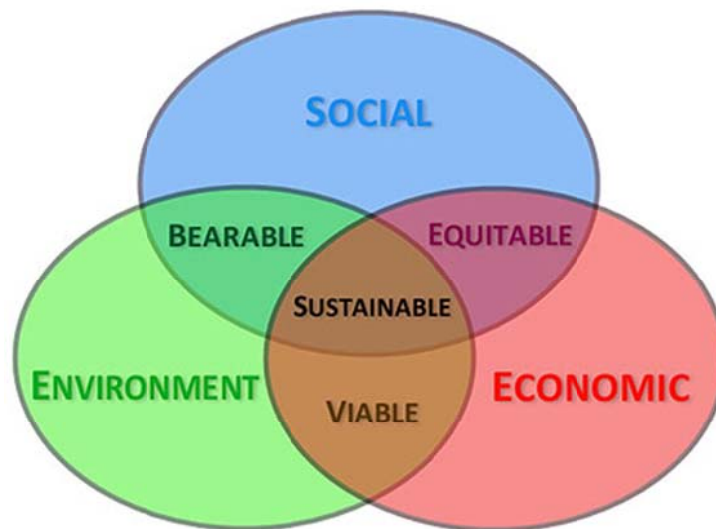
Concerns about the environmental impacts of food production, and the contrasts observed between over- and undernutrition or between and within many countries, has resulted in sustainable eating or consumption of sustainable, yet nutritious, food becoming major components of overall ethical consumerism (IUCN, 2006). In anticipation of the 2014 Second International Conference on Nutrition (ICN2) organized by the United Nations, The Rome Accord (a draft political outcome document incorporating the messages of the political outcome document from Rio+20) recognizes that *"good nutrition requires more sustainable, equitable and resilient food systems. It acknowledges the multiple threats of malnutrition as major challenges to global development, and provides a vision for global action to end all forms of malnutrition and reshaping current food systems to improve people's nutrition in a sustainable way"*. One of the specific draft outcomes acknowledges that *"food systems should produce more nutritious foods, not just more food, and guarantee adequate supply of fruit and vegetables, unsaturated fat and animal source foods while avoiding excess of sugars, saturated and trans fat and salt; food systems should enhance nutrition by providing year-round access to macro- and micronutrients, promoting food safety and balanced diets, and avoiding food processing that reduces or adversely affects nutrition"* (WHO, 2014).

### **1.2.3 Defining sustainability**

Over the past decades, the definition of sustainable development has evolved significantly. Originally, the Brundtland Report (1987) defined sustainable as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. Although this definition was rather ambiguous, it captured two fundamental aspects, the problem of the environmental degradation that commonly accompanies economic growth, while simultaneously acknowledging the need for such growth to alleviate poverty and improve quality of life.



In 2005 the IUCN set out a programme to show where, how and why conservation efforts should simultaneously address environmental, economic as well as social concerns. These three dimensions are often illustrated in a variety of ways and diagrams - as “pillars”, as “concentric circles”, or as “interlocking circles” to illustrate the integration between these three dimensions. The concentric circles model of the IUCN (2009) is illustrated in **Figure 1.1**.



**Figure 1.1** Concentric circle model describing the integration of the different objectives of sustainability (adopted from IUCN Programme 2005-2008, (IUCN 2009))

#### *1.2.3.1 Environmental and economic considerations of livestock sustainability*

In South Africa, both intensive (feedlot) and extensive (pasture) livestock production systems are used. Although there are arguments for and against the sustainability of both these production systems, both systems actually have a pivotal role to play within sustainable livestock production when environmental and economic issues are considered.

It is predicted that by 2050, the planet will support more than 9 billion people, 8 billion of which will be living in the developing world. This population growth will cause a 70% increase in the demand for food by 2050 (FAO, 2012). Unless substantial changes to consumption habits take place, livestock production will have to increase significantly to meet this growth in global

demand. Improving productivity and efficiency are inherently linked to reduced losses throughout the system, and subsequent reduced impact for the amount of product produced (Capper, 2013). This has both a direct effect on environmental strain, but also on economic profitability. As a result, the FAO recommended in their much quoted publication “*Livestock’s Long Shadow*” (FAO, 2006), that sustainable intensification of animal agriculture is required to mitigate the environmental impact, while improving productivity and food security. Intensive (feedlot) production systems adhere to these recommendations and in general produce animals with increasing bodyweight in a shorter period of time. Increased bodyweight increases daily resource use and greenhouse gas emissions per animal, but reduces the impact on the environment per unit of food produced (Capper, 2013). The reduced time required to reach target weight also reduces environmental impact, while adding an economic benefit to this type of system.

In terms of economic viability of extensive production systems, and in particular towards improving food security in developing and poor communities, the South African government has identified the livestock sector as a Key Action Programme from 2014 to 2019 to improve income generation and promote food security. In South Africa, livestock production is an important part of subsistence farming, providing a source of financial security. The availability of animal sources of foods also provides communities with nutrient dense alternatives to often monotonous starch based staple diets.

Furthermore, approximately 12% of South Africa’s surface area can be used for agricultural production (DAFF, 2013). Only 22% of this 12% can be used as “high potential” arable land (optimal for crops), whereas nearly 80% of agricultural land is suitable for extensive livestock farming. The greatest limitation for crops is the availability of water. Livestock production on marginal soils, such as areas in the Karoo (a semi-desert characterised by low rainfall and extremes of heat and cold), positively contributes to food supply, job creation and economic growth in such regions. Sheep farming has long been the backbone of the economy in this region. Livestock is also the largest agricultural sector in South Africa, contributing significantly to employment of mainly unskilled labour.

### 1.2.3.2 *Social considerations of livestock sustainability*

In **Figure 1.1** the three objectives of sustainability as presented. However, sustainability is often defined in general terms and typically related environmental outcomes only. The challenge lies in balancing these environmental considerations with societal and economic concerns. In order to effectively align industry efforts (or food systems) with sustainability, all three of these concerns have to be considered.

Public awareness of environmental issues has increased over time. Consumers do not only know the issues, but tend to feel that the quality of the environment is important both to their own wellbeing and to the common good (IUCN, 2006). Consumers are often caught between the imperatives to raise the living standards of the world as defined by the Millennium Development Goals (MDGs), while living within environmental limits. The challenge of sustainability thus includes these social considerations of limiting environmental harm created by human activity, while reducing the deprivation and suffering caused by poverty and malnutrition, as well as by excesses, e.g. obesity.

When considering social sustainability in the context of red meat consumption, there is increasing concern regarding the intensification of animal industries and the potential damage it can cause to the environment, as well as human health (Montossi *et al.*, 2013). In many cases, concerns such as social values, nutrition and general production practices are important cues in consumer purchasing decisions (Montossi *et al.*, 2013). In order to accurately inform consumers about these cues, up to date and relevant data is required specific to the region or country. Red meat is often seen as high in fat and energy, without recognising its valuable contribution to protein, vitamins and minerals. International studies have shown that the nutritional profile of fresh red meat is predominantly beneficial to human health. Trimming of the visible fat of red meat also further reduces the fat content and subsequently increases the nutrient density of the product per edible portion.

In addition to updated data on the nutritional profile of South African red meat, suitable channels are required to inform consumers about these findings through various means so that

knowledge transfer can take place. In South Africa, the Red Meat Industry Forum (RMIF) is the custodian of a Proportional *Trans* action Statutory Levy in terms of the Marketing of Agricultural Products Act, 1996 (Act No. 47 of 1996) on behalf of the South African government. This levy is applied to various actions, including consumer education about South African red meat. Lamb and Mutton South Africa, and Beef-Up South Africa, are the two current campaigns educating consumers on the role of red meat as part of healthy, sustainable diets. These two campaigns are thus tasked to provide a platform for information sharing regarding the sustainability of South African red meat consumption to influence and guide social perception, and ultimately consumer decision making.

### 1.3 JUSTIFICATION OF THE STUDY

The South African red meat industry has responded to the issue of sustainability through various means, including the launch of a new focus area and subject working group within the Red Meat Research and Development South Africa (RMRDSA) research funding profile, named “Climate Change”. To inform science based discussions, various research studies have been done, and are currently underway, to improve the production efficiency of the South African livestock industry. Interventions to improve production per constant unit (e.g. weaning weight, calving interval and average daily gain), crossbreeding programmes for better feed conversion ratios, and improved residual feed intakes are all being investigated to ultimately reduce the amount of greenhouse gas emissions per unit of product produced (Scholtz *et al.*, 2012) (Meissner, Scholtz & Engelbrecht, 2013). These research interventions provide valuable insights and guidance towards improving environmental and economic sustainability of the livestock industry. Yet, a sustainable food value chain is defined as a *“full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and trans forms them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, does not deplete natural resources, and has broad-based benefits for society”* (FAO, 2014). All beneficial aspects of livestock production, i.e. nutritional quality of the food products produced in addition

to economic incentive, thus need to be further investigated and extrapolated to ensure sustainable development of the industry (**Figure 1.1**).

Despite economic growth, undernutrition in South Africa has not improved when compared to other industrialised nations, while at the same time diet-related non-communicable diseases and obesity have exponentially increased (Shisana *et al.*, 2013). The modern food and agricultural system is often considered the culprit in the health and nutritional status of populations, equally so in developed and developing communities. Good nutrition depends to a large extent on agriculture to provide foods (i.e. cereals, pulses, vegetables, fruit, meats, dairy, etc.) for a balanced diet that meets our needs for energy, protein, vitamins and minerals (Traoré, Thompson & Thomas, 2012). To achieve this goal, stakeholders from agriculture, industry, academia and government will have to collaborate in a productive way to identify and support practical, sustainable interventions to safeguard the health and well-being of populations through the supply of nutrient dense, high quality food options.

Currently, South Africa is classified as a food secure nation at national level, as we procure (produce and import) sufficient food energy per person per day. However, although agricultural and trade policy is often aligned towards amount of food energy made available, the quality or nutrient density of the food that is made available to the consumer should also be considered (especially against the backdrop of the current nutritional status in South Africa, and the South African Food-Based Dietary Guidelines promoting the consumption of a diversity of foods).

Globally, models are being developed to track the environmental impact of foods in the context of the nutritional benefits they offer. One of the first studies to explore such a model was a Swedish study in 2010, which established the Nutrient Density to Climate Impact (NDCI) Index to compare beverages within this broader context of sustainability (Smedman *et al.*, 2010). Those beverages with the highest index value had the highest nutrient density scores in relation to greenhouse gas emissions, and the NDCI for milk from this study was found to be high at 0.54, compared to 0.25 for soy drink and 0.28 for orange juice. Carbonated water, soft drinks and beer all scored zero due to their low nutritional value while red wine scored below 0.1

(Smedman *et al.*, 2010). Although models like these are still mostly in the developmental phases, they will require up-to-date information on the nutritional composition of foods in addition to their environmental impact.

From a local nutrition perspective, accurate information on the nutritional characteristics of livestock products would also enable policy to be more closely aligned with more sustainable food systems. National policy can and should play an instrumental role in improving the health and nutritional status of consumers (FAO, 2014). Based on the global post-2015 development agenda and the particular focus on the livestock industry's environmental responsibility, the policy and programming landscape as related to sustainable livestock production and consumption in South Africa was reviewed as an introduction to the current thesis and submitted for publication (Chapter 2). Furthermore, in order to guide and align current policy frameworks and support the development of nutrient density models in the future, new data on the nutrient composition of South African livestock as currently produced (with the different production systems) and consumed (untrimmed and trimmed), was determined (Chapters 3, 4 and 5). In addition to the generation of new nutrient content data, desktop reviews on the role of red meat as part of healthy, prudent diets were published (Chapters 6 and 7). The use of such findings for consumer education as part of a generic campaign to educate consumers on the role of red meat within healthy, sustainable diets was published as Chapter 8 of this thesis. In Chapter 9, the content of the various articles are summarised to provide a constructive argument that can be referenced when the role of red meat within sustainable diets, specifically within a South African context, is discussed.

## 1.4 AIM AND OBJECTIVES

The aim of the thesis is to investigate the sustainability of red meat consumption in South Africa from a human nutrition perspective.

The objectives are:

1. To review the current policy landscape as related to sustainable livestock production and consumption in South Africa.
2. To determine the changes in the nutritional profile of South African red meat over time.
3. To evaluate the effect of age and trimming on the physical composition of South African beef.
4. To determine the effect of feeding regime on the fatty acid composition of South African beef.
5. To review the role of red meat within a healthy, sustainable human diet.
6. To build a case for extrapolating the information as part of existing consumer education campaigns.

## 1.5 STRUCTURE OF THE THESIS

The structure of the thesis is based on a series of papers submitted for publication.

- Chapter 2 is the first paper and presents a review of the South Africa policy landscape as related to the sustainability of livestock production. It addresses objective 1 as to what policies are currently in place to ensure the sustainability of livestock production and consumption.
- Chapter 3, 4 and 5 present the results obtained from a research project to determine an updated nutritional profile for South African beef as currently produced and consumed. Chapter 3 aims to address objective 2, i.e. how the composition of South African red meat has changed over time. Chapter 4 helps to meet the requirements of objective 3, i.e. what effect age and trimming have on the physical composition of South African beef, and

Chapter 5 addresses objective 4 which is related to determining the effect of a given feeding regime on the fatty acid profile of beef produced with the different production systems currently used in South Africa.

- Chapters 6 and 7 present an overview of the role of red meat as part of healthy, balanced, diets, and addresses objective 5. Chapter 6 was written as part of a special issue for the South African Journal of Animal Science to provide a balanced perspective of animal production, from environmental concerns to human health. The paper presents the nutritional considerations of red meat which need to be taken into account when arguments regarding the sustainable development of livestock are presented. Chapter 7 was submitted as the scientific background document for the revised South African Food-Based Dietary Guideline related to animal product consumption. The South African Food-Based Dietary Guidelines are used as the baseline recommendations by the national Department of Health to guide healthy eating for South Africans.
- Chapter 8 addresses objective 6 and includes an article on the role of consumer education to improve the social perception of red meat, and provides a short case study of the current consumer education campaign of Lamb and Mutton South Africa.
- Chapter 9 summarises the findings of the individual chapters.

This thesis provides scientific information on the consumption of red meat as part of sustainable diets, especially related to fresh South African red meat products and their nutrient contribution to human diets.



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## CHAPTER 2: THE SOUTH AFRICAN POLICY LANDSCAPE AS RELATED TO SUSTAINABLE LIVESTOCK PRODUCTION AND CONSUMPTION

*This paper was submitted to the International Journal of Sustainable Development. The paper presents an overview of the South African policy landscape as related to sustainable livestock production and consumption and serves as an introductory review for the current thesis. The paper is currently under review.*

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### ABSTRACT

Despite economic growth, undernutrition in South Africa has not improved when compared to other industrialised nations, while simultaneously diet-related non-communicable diseases and obesity have exponentially increased. Healthy food is a constitutional right of all South Africans, and to increase food security, the livestock industry has been identified as part of a Key Action Programme to improve income generation and promote food security from 2014 to 2019. The inclusion of sustainably produced, nutrient dense animal source food options (low in fat and kilojoules, high in protein and micronutrients) are promoted as part of healthy, sustainable diets in the national Food-Based Dietary Guidelines and Strategic Plan for the Prevention and Control of Non-Communicable Diseases. Based on the global post-2015 development agenda and the particular focus on the livestock industry's environmental responsibility, the policy and programming landscape as related to sustainable livestock production and consumption in South Africa was reviewed.

### 2.1 INTRODUCTION

The United Nations Millennium Declaration, signed in September 2000, committed world leaders to combat poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women. The eight Millennium Development Goals (MDGs) were derived from this declaration and range from halving extreme poverty rates to providing universal primary education by 2015 (WHO, 2013a). Since the deadline is fast approaching, the United Nations has been working with governments, civil society and other partners to build on the

momentum generated by the MDGs and carry on with an ambitious post-2015 development agenda, in line with the current global focus on sustainable development (United Nations, 2014).

Globalisation and commercialisation have brought significant changes to agriculture and food systems, with subsequent new challenges and solutions. It is estimated that by 2050, global agriculture and food systems will need to be able to produce enough nutritious food to feed nearly 10 billion people, with a high percentage of this global population concentrated in low-income countries (Fan, *et al.*, 2012). Supplying the growing population with sufficient, nutritious food is one of the world's major challenges considering that more than 1.4 billion individuals were overweight or obese in 2008 and increasingly so, while at least 1 billion remain undernourished (WHO, 2013b).

The modern food and agricultural system is often considered the culprit in the health and nutritional status of populations, equally so in developed and developing communities. In South Africa, despite considerable economic growth, undernutrition, and in particular stunting, has not improved in the last couple of decades when compared to other industrialised nations (Shisana, *et al.*, 2013). Simultaneously, diet-related non-communicable diseases and obesity have exponentially increased. In addition, emerging threats such as climatic and demographic changes contribute to the challenge of producing and supplying nutritious food in a sustainable way. The negative impact of climate change on agriculture, food systems and nutrition is increasingly being recognised (Herren, 2010).

In 1972 the United Nations hosted a Conference on the Human Environment, and since then, sustainable development governance has significantly expanded at local, national and global levels. In 1987 the Brundtland Report introduced the concept of integrating economic development, natural resource management and protection and social equity. This report further framed the discussion at the 1992 United Nations Conference on Environment and Development (Earth Summit) held in Rio de Janeiro, Brazil. In 1993 the Commission on Sustainable Development (CSD) was established by the General Assembly. In 2002 the World

Summit on Sustainable Development (Rio+10), held in Johannesburg, South Africa, advanced the mainstreaming of sustainable development in policies through the adoption of the Johannesburg Plan of Implementation (United Nations, 2013).

The Rio+20 conference on sustainable development, which took place in Rio de Janeiro, Brazil in June 2012 was the biggest United Nations conference ever held. During the conference, the international community decided to establish a High-level Political Forum on Sustainable Development to subsequently replace the CSD. One of the further main outcomes of the conference was the agreement by member states to launch a process to develop a set of Sustainable Development Goals (SDGs) which will build upon the Millennium Development Goals (MDGs) and converge with the post-2015 development agenda. At Rio+20 it was decided to establish an *“inclusive and transparent intergovernmental process open to all stakeholders, with a view to developing global sustainable development goals to be agreed by the General Assembly”* (United Nations, 2013).

Some relevant outcomes in the 283 point Resolution adopted by the General Assembly on 27 July 2012, entitled *“The Future We Want”*, include among others the reaffirmation of the necessity to promote, enhance and support more sustainable agriculture, including crops, livestock, forestry, fisheries and aquaculture, that improves food security, eradicates hunger and is economically viable, while conserving land, water, plant and animal genetic resources, biodiversity and ecosystems and enhancing resilience to climate change and natural disasters (United Nations General Assembly, 2012).

According to the Food and Agriculture Organization (FAO, 2012a) there are very strong linkages between the conditions to achieve universal food security and nutrition, responsible environmental stewardship and greater fairness in food management. To emphasise these linkages, the FAO prepared three messages for the RIO+20 summit: 1) Eradicating hunger and improving human nutrition are fundamental to achieving the Rio vision of sustainable development; 2) For healthy people and healthy ecosystems, food consumption and production

must be sustainable and more inclusive; 3) Effective governance for agriculture and food systems is essential to making the policy changes required to achieve the Rio vision.

In anticipation of the 2014 Second International Conference on Nutrition (ICN2) organised by the United Nations, The Rome Accord (a draft political outcome document) recognises that the multiple threats of malnutrition are a major challenge to global development, and provides a vision for global action to end all forms of malnutrition and reshaping current food systems to improve people's nutrition in a sustainable way (WHO, 2014). One of the specific draft outcomes acknowledges that *“food systems should produce more nutritious foods, not just more food, and guarantee adequate supply of fruit and vegetables, unsaturated fat and animal source foods while avoiding excess of sugars, saturated and trans fat and salt; food systems should enhance nutrition by providing year-round access to macro- and micronutrients, promoting food safety and balanced diets, and avoiding food processing that reduces or adversely affects nutrition”*(WHO, 2014).

As a member state of the United Nations, the South African policy environment does not incorporate the multiplicity of concerns related to improving sustainable production and consumption in view of the current double burden of disease observed within this industrialised economy. This paper provides a brief overview of the current South African nutrition situation, and summarises the objectives and possible impacts of some of the recent policies, programmes and interventions promoting sustainable practices, dietary behaviours, food security and other nutrition-related outcomes related to livestock production and consumption at national level. The livestock industry in particular was identified because as populations grow, the emerging middle class can afford to consume higher quantities of more expensive foods, including animal protein. It is projected that nearly 80% more meat will be needed by 2050 (Fan, *et al.*, 2012). Such increased consumption and agricultural production trends and patterns are identified as one of the most important drivers of environmental pressures (FAO, 2012b). As the global consumption and demand of meat, dairy and eggs continues to rise, increasing attention is being paid to the livestock sector's environmental performance.

## 2.2 DOUBLE BURDEN OF DISEASE IN SOUTH AFRICA

Studies to determine the nutritional situation in South Africa at a national level are unfortunately limited as only sporadic nationally representative studies have been performed (Van Heerden, *et al.*, 2012). From these studies, wasting in children, indicating acute or persistent lack of dietary energy, has been generally uncommon. Unfortunately, although still relatively low in comparison to stunting and the increased incidence of obesity, it seems that wasting in children is increasing. In 1994, only 2.6% of children (under 6 years of age) suffer from wasting (South African Vitamin A Consultative Group (SAVACG), 1996), in 1999 this number increased slightly to 3.7% (Labadarios, *et al.*, 1999), and in 2005 4.5% of children were recorded as suffering from wasting (Labadarios, *et al.*, 2008). Labadarios *et al.*, (1999) pointed out that at the national level, stunting was by far the most common nutritional disorder, affecting at that time nearly one in five children. Stunting is indicative of chronic long-term dietary inadequacy but also reflects socioeconomic deprivation, and is used as a measure of nutritional status in children (Vorster, *et al.*, 1997). In the 2013 South African National Health and Nutrition Examination Survey (SANHANES-1) stunting was prevalent in 26.5% of children aged 1-3 years and 11.9% of children aged 4-6. The same study reported a 6.1% prevalence of underweight of children in the age group of 1-3 years, and 4.5% in the age group of 4-6 years (Shisana, *et al.*, 2013).

Furthermore, in 2005, for South African children as a whole, the intakes of energy, calcium, iron, zinc, selenium, vitamins A, D, C and E, riboflavin, niacin, vitamin B6 and folic acid were below two-thirds of the Recommended Dietary Allowances (RDA) (Labadarios, *et al.*, 2008). In 2013, 43.6% of the children under 5 had a vitamin A deficiency. Nearly a third of children between 10 and 14 years had no food to eat at breakfast or lunch (Shisana, *et al.*, 2013).

In addition to underweight, the prevalence of overweight in South Africa is a growing reality, and increasingly so in children. In 1999 nearly 10% of South African children under 9 years were recorded as overweight or obese, with 4% being obese (Labadarios, *et al.*, 1999). In 2005, nearly 5% of children under 5 years of age were recorded as overweight or obese (Labadarios, *et al.*, 2008). Regional and international comparisons with more recent data indicate that South



Africa's preschool children have a major and increasing problem of combined overweight and obesity. Morocco, Swaziland, Botswana, and Nigeria have a prevalence of about 11%, which is about half of South Africa's current prevalence of 22.9% (Shisana, *et al.*, 2013):

Overweight and obesity incidence is also increasing in the adult population. Nearly a third (29%) of men and 55% of women were overweight, and 9% of men and 29% of women were obese in 1998 (Medical Research Council, 1998). By 2003, 56.2% of the total adult population was recorded as overweight or obese (Medical Research Council, 2006) In 2013, the SANHANES-1 found that 20% of men and 68% of women in South Africa had a waist circumference that places them at risk of metabolic complications (Shisana, *et al.*, 2013) When compared to 2003 Demographic Health Survey (SADHS) data, the SANHANES-1 found that underweight decreased, while overweight and obesity increased in adults. Obesity incidence in particular increased substantially in females, from 27% in 2003 to 39.2% in 2013 (Shisana, *et al.*, 2013).

In 2000, the South African Medical Research Council (MRC) performed a comparative risk assessment, and found that eleven of the seventeen most common risk factors for deaths were directly or indirectly related to nutrition, and included among others high blood pressure, excess body weight, high cholesterol, diabetes, low fruit and vegetable intake, vitamin A deficiency and iron deficiency anaemia (Norman, *et al.*, 2006) The rapid increase in NCDs such as diabetes, hypertension and cancers has led to the strengthening of the arguments to focus on dietary quality and is reflected in actions encouraging dietary diversity. Improving nutrition and food utilisation is considered a key tool to ensure sustainable development (FAO, 2012b).

### **2.3 THE SOUTH AFRICAN POLICY ENVIRONMENT - CONSTITUTION AND PRESIDENTIAL OUTCOME ALIGNMENT TOWARDS SUSTAINABLE DEVELOPMENT**

National policies, strategies, and plans play an essential role in defining a country's vision, priorities, budgetary decisions and course of action. In South Africa, the constitutional mandate of the country guides the development of policies and plans at departmental level, i.e. Departments of Health, Agriculture, etc. The Bill of Rights in the Constitution of the Republic of South Africa (Act 108 of 1996) is considered the supreme law of the land and cannot be

superseded by any other governmental action. It provides for interdependence, distinctive but inter-relatedness and spells out principles for cooperative governance to coordinate activities and legislation. The Constitution stipulates in Section 24 that everyone has the right to an environment that is not harmful to their health or well-being, and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development. Furthermore, in Section 28, the Constitution states that everyone has the right to have access to sufficient food and water and that every child has the right to basic nutrition, shelter, basic health care services and social services (South African Government, 1996).

The Medium Term Strategic Framework (MTSF) (2009 to 2014) of South Africa is an electoral mandate, and a statement of intent identifying the development challenges facing South Africa during the electoral period of five years from 2009 to 2014. It outlines the medium-term strategy for improvements in the conditions of the life of South Africans. The document was meant to guide planning and resource allocation, and national and provincial departments developed their own strategic plans and budgets taking the medium-term imperatives reported in this document into account. Priority areas include more inclusive economic growth, decent work and sustainable livelihoods; economic and social infrastructure; rural development, food security and land reform; improved health care; cohesive and sustainable communities; and sustainable resource management and use. Based on the objectives, a set of 12 national outcomes was developed, reflecting the desired development impacts the South African Government seeks to achieve. Each outcome is clearly articulated in terms of measurable outputs and key activities to achieve the outputs. Three outcomes that are relevant to this paper include Outcome 2: *“A long and healthy life for all South Africans”*, Outcome 7: *“Vibrant, equitable and sustainable rural communities with food security for all”*, and Outcome 10: *“Environmental assets and natural resources that are well protected and continually enhanced”*.

The National Development Plan (NDP) Vision 2030 is a broad strategic framework set out by the National Planning Commission to guide the development of the next three electoral presidential cycles' Medium Term Strategic Frameworks. The NDP Vision 2030 acknowledges the social and economic conditions, in addition to medical care, that influence the health of the population and recognises the challenges related to climate change and the transition to an economically viable, low-carbon economy (National Planning Commission, 2011a). The NDP Vision 2030 was based on a Diagnostics Report of the National Planning Commission (NPC) executed in 2010 but embargoed until June 2011 (National Planning Commission, 2011b). The Diagnostics Report identified a failure to implement policies and an absence of broad partnerships as the main reasons for slow progress in South Africa, and set out 9 primary challenges, including high unemployment rates, high disease burden, poor educational outcomes, divided communities, uneven public service performance, crumbling infrastructure, spatial patterns marginalising the poor, corruption and a resource intensive economy. As part of the solution, the NDP Vision 2030 was developed to align future activities of the country at policy level, with the main aims to eliminate poverty and reduce inequality in the next three electoral periods. In summary, the principal indicators of the NDP are to eliminate income poverty by 2030 (reduce the proportion of households with a monthly income below R419 per person (in 2009 prices) from 39% to zero), and reduce inequality (the Gini coefficient should fall from 0.69 to 0.6 by 2030). Apart from increased employment (from 13 million in 2010 to 24 million in 2030), “*affordable access to quality health care*” and “*household food and nutrition security*” are listed as milestones required for enabling the achievement of these indicators (National Planning Commission, 2011a).

According to the FAO, sustainable consumption and production of food “*is a consumer-driven, holistic concept that refers to the integrated implementation of sustainable patterns of food consumption and production, respecting the carrying capacities of natural ecosystems. It requires consideration of all the aspects and phases in the life of a product, from production to consumption, and includes such issues as sustainable lifestyles, sustainable diets, food losses and food waste management and recycling, voluntary sustainability standards, and environmentally friendly behaviours and methods that minimize adverse impacts on the*

*environment and do not jeopardize the needs of present and future generations. Sustainability, climate change, biodiversity, water, food and nutrition security, right to food, and diets are all closely connected”* (FAO, 2014). Various national policies and programmes have been developed under the framework of the South African presidential framework towards sustainable production and consumption encompassing different aspects within the FAO definition of sustainable diets. These policies and programmes specifically relevant to sustainable livestock production and consumption are discussed.

## **2.4 POLICIES AND PROGRAMMES RELATED TO SUSTAINABLE LIVESTOCK PRODUCTION AND CONSUMPTION**

Through sustainable production and consumption, good nutrition can be achieved by means of income generation, availability and access to a diversity of nutrient dense foods, efficient use of natural resources, food waste reduction, and the promotion of sustainable diets through education.

Although livestock production is considered an agricultural activity which can promote food security and income generation potential in line with the South African NDP, livestock, and in particular red meat production, is often criticised as having negative environmental effects, and that it contributes to subsequent undesirable effects on food insecurity, hunger, malnutrition, nutrient deficiencies and excesses (obesity) (FAO, 2012b). The reduction or elimination of animal product consumption is often promoted as a sustainable dietary habit. However, adapting food systems for environmental sustainability while also meeting nutritional demands requires a broader understanding. When considering the measurable impact which various industries have on for example greenhouse gas emissions, the contribution which these foods make to human dietary requirements and livelihoods need to be taken into consideration when aiming for sustainable production and consumption.

#### **2.4.1 Policies and programmes related to sustainable livestock production**

With the purpose of improving food security, the South African Cabinet approved the Integrated Food Security Strategy (IFSS) in 2002 to streamline, harmonise and integrate the diverse food security programmes existing in South Africa. Some successes have been recorded in different priority areas of the Strategy, and South Africa is currently classified as nationally food sufficient (nationally food secure) through a combination of own production and food imports. The General Household Survey (GHS) has also indicated that the food access index has been improving, and the incidence of hunger declining. However, the limitations are that these indicators only report on the availability of energy, without the consideration of other essential nutrients.

The global economic slowdown, increased food price volatility, and the impact of climate change have compelled a review of the IFSS and the development of a comprehensive National Food and Nutrition Security Policy in 2013. The National Food and Nutrition Security Policy aims to target the threats towards food and nutrition security including globalisation, international trade regimes, climate change, and the poor storage and distribution of food. The Policy was developed by the national Department of Social Development and the national Department of Agriculture, Forestry and Fisheries, and focusses on the factors affecting the availability, accessibility, utilisation and stability of food and the food supply. The Policy provides a platform for various strategies which will include targeted public spending in social programmes, efforts to increase food production and distribution, leveraging government food procurement to support community-based food production initiatives and smallholders; and the strategic use of market interventions and trade measures which will promote food security (DAFF DSD, 2013).

It is estimated that nearly 16 million of the 53 million South Africans live in poverty, with 11 million living in rural areas. The 2013 Economic Review of the South African Agriculture states that the primary agricultural sector in South Africa has grown by an average of approximately 11.8% per year since 1970, while the total economy grew by 14.9%, indicating a drop in

agriculture's share of the Gross Domestic Product (GDP) from 7.1% in 1970 to 1.9% in 2011 (DAFF, 2013). Compared to annual data, gross farming income from all agricultural products at the end of June 2013 was 10.1% higher than the previous year, with income from animal products in particular increasing by 11.2%. Animal production increased by 3.2%, mainly as a result of increased production in fresh milk (7.2% higher), more stock slaughtered (6.2%) and more poultry meat (3.1%) produced. The significance for animal production in terms of sustainable livelihoods is not only prevalent in the increase in production, but also when it is considered that prices of poultry meat increased by 13.3%, whereas the average price of slaughter stock actually decreased slightly by 0.7% since June 2012 (DAFF, 2013).

Animal production contributed 46.4% to the total gross value of agricultural production in South Africa for the period June 2012 to June 2013, with the poultry industry making the largest contribution with 17.4%, followed by cattle and livestock at 10.1%. The gross income from animal products in total was 11.2% higher than in the previous year, with income from slaughtered cattle increasing by 3.4%, and from slaughtered sheep increasing by 5.4% (DAFF, 2013).

South Africa is currently a net importer of meat (BFAP, 2013). With 40% of livestock being produced on non-commercial communal farms, and mainly used for traditional purposes, the red meat industry integrated value chain has been identified by the Agricultural Policy Action Plan (APAP) 2014 to 2019 as a Key Action Programme focussed on building South Africa's production capacity and the commercialisation of the livestock system to improve income generation and promote food security.

South Africa is considered a semi-arid country, with only 13% of its land area considered arable land. Only 22% of this being high-potential arable land suitable for crop production. In 2007, approximately 83% of agricultural land was used for grazing (DAFF, 2013). Livestock production provides a unique opportunity within these resource scarce environments to increase food supply through the conversion of grass and other forage into meat and dairy products.

## 2.4.2 Policies and programmes related to sustainable livestock consumption

Since democratisation of the country, several nutrition intervention programmes have been implemented under a comprehensive national nutrition strategy for combating malnutrition, namely the Integrated Nutrition Strategy (INS). The INS was used as the basis for the development of the Integrated Nutrition Programme (INP) which adopted United Nations International Children's Emergency Fund (UNICEF's) Conceptual Framework on malnutrition and targets nutritionally vulnerable communities and groups, including children under 5 years (Iversen, *et al.*, 2012). Depending on the location of the target group and the nature of the intervention the INP is implemented at the level of population, communities, households, health facilities and schools. Apart from various programmes, to specifically address micronutrient status, the INP focussed on fortification of staple foods. Salt iodisation has been mandatory since 1995, and since 2003 it has been mandatory to fortify all maize meal and wheat bread flour with iron, zinc, vitamin A and selected B vitamins. In 2005, the fortification baseline follow-up of the National Food Consumption Survey found that although manufacturers complied with legislation, neither the anthropometric status nor micronutrient status of children had improved, especially as observed in rural communities. Possible reasons could be poor compliance, missed opportunities, incorrect implementation and the instability of added micronutrients (Iversen, *et al.*, 2012).

Despite mandatory fortification and supplementation, nutritional deficiencies were still observed, suggesting the limited ability of nutrient-based approaches to effectively eliminate nutritional deficiencies. In 1994 it was found that 33% of children under 6 years were marginally deficient in vitamin A (serum retinol  $<20\text{mgdL}^{-1}$ ), with the highest rates recorded among children aged 3 to 4 years (South African Vitamin A Consultative Group (SAVACG), 1996). In 1999 it was recorded that one out of two children under the age of 9 years consumed less than half of the recommended levels of energy, vitamin A, vitamin C, riboflavin, niacin, vitamin B6, folate, iron, zinc and calcium. In this national study, diets of children were found to be confined to a narrow range of foods of low micronutrient density. Dietary intakes were particularly inadequate in rural areas (Labadarios, *et al.*, 1999). Despite the mandatory fortification of staple food with a

fortification mix since October 2003, a follow-up national survey in 2005 still found significant nutritional deficiencies in children and women. Nearly 30% of children and women had anaemia, 64% of children and 28% of women had vitamin A deficiency and 45.3% of children had zinc deficiency (Labadarios, *et al.*, 2008).

Sustainable diets are defined by the Food and Agriculture Organization of the United Nations (FAO, 2014) as diets “*that have a low environmental impact; contribute to food and nutrition security and the healthy life for present and future generations; which are protective and respectful of biodiversity and ecosystems; culturally acceptable, accessible, economically fair and affordable; nutritionally adequate; safe and healthy and optimize natural and human resources*”. According to the FAO (FAO, 2012b), directing dietary habits to more sustainable diets includes preserving balanced traditional food systems and promoting food-based approaches for improving nutrition and health as compared to more expensive and non-sustainable supplementary programmes. Nutrients also interact differently when presented as foods within a food matrix. It is also widely admitted that compared to nutrients in supplements, many bioactive compounds in fresh foods are not yet fully understood, further motivating a food-based approach to obtain all required nutrients and bioactive compounds in a sustainable manner.

In 2013 a Roadmap for Nutrition in South Africa (2013-2017) was developed based on recent reviews of the INP as well as a Landscape Analyses on Countries' Readiness to Accelerate Action in Nutrition (WHO, 2010), which seeks to direct nutrition-related activities in the health sector to achieve the focus areas of the Medium Term Strategic Framework for South Africa. The Roadmap for Nutrition in South Africa provides a framework for the repositioning of nutrition and nutrition-related issues and action. Particular reference is made to contribute to increased life expectancy of the entire population by improving the quality, coverage and intensity of specific nutrition interventions that support reduction of mortality rate, especially maternal, neonatal, infant and child mortality. Furthermore, to promote optimal growth of children and prevent overweight and obesity later in life, by focusing on optimal infant and young child nutrition; and to empower families and communities to make informed nutrition-related



decisions, through advocacy regarding household food security, multisectorial collaboration and effective nutrition education (DOH, 2013a).

Many South Africans consume a monotonous diet low in variety, dietary diversity and nutrient content, similar to many other developing countries (FAO, 2012b). In 1999 the National Food Consumption Survey indicated that the five most commonly consumed foods include maize meal porridge, brown bread and tea with small amounts of sugar and milk (Labadarios, *et al.*, 1999). The South African Food-Based Dietary Guidelines were developed to provide an effective tool to eliminate or greatly reduce nutrition-related diseases. The guidelines are food-based rather than nutrient-based and recommend healthy food consumption patterns for all South Africans of five years and older. These guidelines are supported by published peer-reviewed scientific review papers justifying the scientific validity of each guideline. A visual Food Guide which serves to support the messages of the Guidelines for Healthy Eating has also been developed. The Food Guide includes information on the suggested amounts of foods needed daily, from all the food groups. The set of 11 Food-Based Dietary Guidelines are presented in **Table 2.1**. As livestock products, including lean red meat, dairy products and offal contribute significant proportions of essential and highly bioavailable nutrients to the diet, the set of guidelines include one which states that “*fish, chicken, lean meat or eggs can be eaten daily*”, and another which states to “*have milk, maas (cultured milk) or yoghurt every day*”. To limit excess consumption of total and saturated fat, the guidelines recommend the consumption of “*lean*” meat, and include a separate guideline to “*use fats sparingly*”.

Because the obesity epidemic is vividly prevalent in South Africa, the incidence of non-communicable diseases (NCDs) has also increased. In 2011 there was extensive global focus on NCDs culminating in the United Nations General Assembly High Level Meeting of Heads of State and Governments and the adoption of the Political Declaration on the Prevention and Control of NCDs (DOH, 2013b). Leading up to this High Level Meeting a national summit was hosted by the South African Minister and Deputy-Minister of Health. The summit adopted a Declaration and set 10 targets to be reached by 2020, summarised in the Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-17 (DOH, 2013b). One of these

targets is to reduce the percentage of people who are obese and/or overweight by 10% by 2020. According to this Strategic Plan of the Department of Health, the South African population suffers from a double burden of nutrition-related diseases as about a third of children suffer from some form of undernutrition, while more than half of adults are either overweight or obese. Undernourished children develop into adults with an increased risk of overweight, obesity and NCDs when they are exposed to an unhealthy food environment.

Also, many obese individuals are micronutrient-deficient, which further increases their risk of NCDs. Dietary changes that are recommended by the Strategic Plan include consumption of less salt, less fast and fried foods and snacks, consumption of lean meat and low-fat dairy products, inclusion of 2-3 fish dishes per week, consumption of whole grains, fruit, vegetables and legumes, and other traditional foods and dishes, and decreased use and intakes of sweetened (sugary) foods and drinks.

**Table 2.1** The revised South African food-based dietary guidelines (Vorster, *et al.*, 2013)

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**Food-based dietary guidelines for South Africans 5 years and older**

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1. Enjoy a variety of food
  2. Make starchy food part of most meals
  3. Fish, chicken, lean meat or eggs can be eaten daily
  4. Eat plenty of vegetables and fruit every day
  5. Eat dry beans, split-peas, lentils and soya regularly
  6. Have milk, maas or yoghurt everyday
  7. Use salt and food high in salt sparingly
  8. Use fat sparingly; choose vegetable oils rather than hard fats
  9. Use sugar and food and drinks high in sugar sparingly
  10. Drink lots of clean, safe water
  11. Be active!
-

## 2.5 CONCLUSIONS AND RECOMMENDATIONS

Healthy food is a constitutional right of all South Africans. In the context of access and availability to food, the increase in population growth is demanding annually increased food production volumes and income generation potential. As part of the Agricultural Policy Action Plan 2014 to 2019 commercialisation of the South African livestock system has been identified as a Key Action Programme to improve income generation and promote food security. With the majority of South African small stock grazing on semi-arid land where little other food commodities can be procured, this industry in particular could contribute to increased food availability and income generation, while preserving natural resources.

In the context of persistent nutritional deficiencies in South Africa along with the rising incidence of obesity, the inclusion of sustainably produced, nutrient dense animal source food options (low in fat and kilojoules, high in protein and micronutrients) are imperative as part of sustainable diets. When considering the policies and programmes related to consumption, it is clear that the South African policy framework supports the consumption of products from livestock (lean meat, offal and dairy) as part of a healthy, balanced diet to ensure nourished people. Future focus could be placed on implementing programmes and consumer education initiatives targeting the reduction of food waste, nutrient dense food choices within the food group, and adequate portion sizes towards sustainable consumption of livestock products.

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## CHAPTER 3: UPDATE ON THE COMPOSITION OF SOUTH AFRICAN RED MEAT

*The content of the article was presented as an invited lecture at the 12<sup>th</sup> Carcass Classification Symposium held on 7 November 2014. In this paper, result from the research study on South African beef supported by Red Meat Research and Development South Africa (RMRDSA) and the National Research Foundation (NRF) are presented together with a review of recent data on the composition of South African lamb and mutton. This paper was submitted to the South African Journal of Animal Science, and has been accepted for publication.*

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### ABSTRACT

Red meat, being the primary provider of essential nutrients (including protein) to human diets, often evokes a wide array of complex and contradictory arguments. It is viewed as the most expensive component of any diet, supplying many essential nutrients as part of a healthy, prudent eating plan. Yet, red meat is non-homogenous, unique to each country, and continually changing in composition due to breed and feed differences, slaughter practices as well as post-slaughter activities prior to consumption.

It is observed that the amount of fat on red meat carcasses has reduced over time, simultaneously improving nutrient density through feed efficiency. Actions towards this include breed selection, feed manipulation and alterations in animal slaughter age and weight. Further removal of fat through retail and food preparation practices, such as trimming, has resulted in even leaner end products, in line with current nutrition and health recommendations and trends.

The objective of this paper is to present composition data on South African lamb, mutton and beef, and report on the changes observed between local data and international data (for lamb and mutton), as well as changes in the composition of South African beef over time. South African lamb and mutton contain notably less fat and more nutrients per 100g product than international sheep meat produce, rendering a lean product with a higher nutrient density. Compared to previous studies on South African beef, the current data indicates notable

changes in the composition of South African beef over time, specifically related to a reduction in fat content. This reduction in fat content together with changes in carcass weight have resulted in subsequent changes in carcass composition and thus changes in nutrient density. The data attests that in order to align industry processes, as well as legislation and marketing strategies, continued research on physical and nutritional composition needs to be performed for the baseline information to remain relevant and accurate.

### 3.1 INTRODUCTION

There is a continual global demand for high-value animal protein. A global increase in per capita consumption of livestock was observed from 24.2 kg per year in 1964, to 36.4 kg per year in 1999 (Bruinsma 2003). The expected per capita consumption of animal products is predicted to increase to 45.3 kg per year by 2030 (EuroFIR Consortium, 2005). However, in industrial countries (including South Africa), demand for red meat products from livestock is stagnant, or even in a gradual decline (Bureau of Food and Agricultural Policy 2013). Although meat is a food of choice in many diets, the popularity of red meat in South Africa, as in many other countries, is continually declining in favour of white meat and other non-meat proteins (Scholtz, Vorster & Matsego 2001; Department of Agriculture, Forestry and Fisheries 2012). Although the price difference between white and red meat, and animal protein vs. plant protein, is recognised as contributing to this phenomenon, another important possibility is the perceived health risk associated with the consumption of red meat products considered to be high in total and saturated fat, along with product quality issues, environmental issues and animal welfare.

Livestock products are often considered from a health perspective to contain a high fat content, especially of saturated fat. In many studies, consumption of meat and dairy products has been linked to the development of lifestyle-diseases including cancer, diabetes and cardiovascular diseases in both developed and developing countries (Barendse 2014). In contradiction, many current research reviews are questioning the existing hypotheses regarding the role of fat (saturated and unsaturated) in human diets (De Oliveira *et al.* 2012; Chowdhury *et al.* 2014). Yet, regardless of this ongoing (and popular) debate regarding fat, the majority of consumers



have insisted on low fat diets, and continue to do so (Williams & Droulez 2010). As a result, it is observed that the amount of fat on red meat carcasses is continually changing throughout the world, most notably towards less total and saturated fat. Reasons include health considerations, but also increased price offerings for leaner produce (McNeill 2014). Actions towards changes include breed selection, feed manipulation, changes in animal slaughter age and carcass weight. Further removal of fat through retail and food preparation practices, such as trimming, has resulted in even leaner products.

In terms of human health and the role which red meat can play in daily diets, the majority of South African adults, and especially women, are overweight (24.8%) or obese (39.2%) (Sishana *et al.* 2012). The new release of the South African Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-17 highlights the importance of targeting obesity and other non-communicable diseases (DOH 2013). Within the 10 goals set out by the South African Declaration for Prevention and Control of Non-communicable diseases, it is required to reduce by 10% the percentage of people who are obese and/or overweight, to reduce the mean population intake of salt to <5 grams per day, and reduce the prevalence of people with raised blood pressure by 20% by 2020. As the role of red meat is often controversial regarded as related to weight gain and other diet-related health complications, accurate and up to date data on the nutrient content of South African red meat as consumed by our population is needed to accurately implement interventions.

In addition to the statistics on obesity, critical nutrients consistently observed as lacking from the diets of South Africans, include iron and zinc. For South African children, in whom health and nutritional status are fundamentally related in terms of growth and health outcomes, the intakes of energy, iron and zinc was below two-thirds of the Recommended Dietary Allowances (RDA) in 2005 (Labadarios, *et al.* 2008). In 2013, the most comprehensive South African nutrition and health survey ever conducted found that 11% of our children under 5 years of age had iron deficiency anaemia. In the same study, iron deficiency (serum ferritin < 15 ng/mL) was present in 15.3% of women older than 15 years. Iron, as a component of blood, plays an important role in energy metabolism and oxygen transport in the human body. Similarly, protein is essential for

optimal body functioning. Animal-based protein foods (including red meat) are considered the best quality sources of protein as they contain all the essential amino acids in the correct proportions (Rietman *et al.* 2014). Although the production of livestock has increased in developing countries, the consumption of protein is very low in many marginalized communities with people consuming the most limited amounts of animal foods (Steinfeld, Mooney & Schneider 2010).

Since the 1930s, studies on the physical and nutritional composition of South African red meat, together with other research, has assisted in guiding the development of national carcass classification systems over time (Naudé, Klingbiel & Bruwer 1990). In 1970, as reported by Naudé, Klingbiel and Bruwer (1990), more than 70% of South Africans preferred between 3mm and 6mm fat covering on beef roasts (approximately 6% subcutaneous fat, and 18% dissectible carcass fat). A follow-up survey conducted in 1987 found that an even higher proportion (77%) of the population preferred a lower fat cover (Naudé, Klingbiel & Bruwer 1990). Based on these results, in combination with physical and nutritional composition data, the current classification system for South African beef, sheep, lamb and goats was introduced. The Meat Board was dismantled in 1994 and their regular market surveys were terminated, however a study on consumer perception is currently being conducted by the Bureau of Food and Agricultural Policy (BFAP) in collaboration with the South African Red Meat Industry. In addition to consumer perception data, composition studies on South African red meat (sheep and beef) have recently been conducted which could provide insights which could be used for revision of the current classification system.

The results from three different research studies are reported in this article to serve as a background document to the investigation of the current South African carcass classification system, as well as enable future alignment of additional industry processes, e.g. labelling and marketing. The first study investigated the nutritional profile of South African lamb, while the second study investigated the nutritional profile of older aged sheep, i.e. South African mutton. As the nutrient data obtained from these two studies were the first to determine the nutritional profile of locally produced sheep meat, values are compared to nutrient data generated for lamb

and mutton produced and consumed in other parts of the world. The third research study reported in this article investigated the nutritional profile of South African beef, and compares the information obtained from current produce, to previous data generated on the composition of South African beef produced prior to the implementation of the current classification system.

The composition studies on sheep meat were commissioned between 2006 and 2010 in collaboration with the University of Pretoria, the Agricultural Research Council, Irene (ARC) and Meat and Livestock Australia (MLA). The studies included South African lamb from the current age A, fat code 2 class, and mutton from age C, fat code 2 class. Even though lamb is more commonly available on the market (>80% (Van Der Westhuizen, *Personal Communication*, June 2014)) than mutton, the nutrient content data for sheep meat previously referenced in the national food composition databank (Wolmarans *et al.* 2010) was values for mutton meat borrowed from the United States Department of Agriculture's (USDA) Food Composition Database (USDA 1998). These borrowed values report that mutton has the highest fat content of all animal products at 25g fat per 100g edible product, probably explaining the negative health image associated with sheep meat.

The study on the composition of South African beef was commissioned in 2010 by the University of Pretoria in collaboration with the ARC, Irene. The composition of South African beef was last determined in the 1990s, and the new data enables comparison with the previous beef data in order to report changes over time. This article thus presents a summary of the physical and nutrient composition of South Africa lamb, mutton and beef as recently determined, to serve as a background document for the investigation of the current South African carcass classification system.

### **3.2 MATERIALS AND METHODS**

The sampling plans for each of the projects included in this article were developed so that the nutrient data generated is representative and accurate, while considering financial constraints related to nutritional analyses. The sampling plans were designed in collaboration with the

South African Red Meat Industry, experts from the University of Pretoria and scientists at the ARC, Irene.

Fatness code according to the South African carcass classification system (Government Notice No. R. 342 of 19 March 1999) was used as a controllable factor when lamb, mutton and beef carcasses were selected for analyses. Fatness codes are determined by physical evaluation of the subcutaneous fat layer on the beef carcass after slaughter prior to further division into retail cuts. Measurements are taken visually by trained professionals between the 3<sup>rd</sup> and 4<sup>th</sup> lumbar vertebrae of lamb and mutton, and the 10<sup>th</sup> and 11<sup>th</sup> rib of beef. All carcasses selected fell within fatness code 2, meaning they had to contain between 1 and 3mm subcutaneous fat for beef, and 1mm and 4mm subcutaneous fat covering for lamb and mutton (Department of Agriculture 1990).

### **3.2.1 Sheep study**

For lamb and mutton analyses, similar sampling plans were followed. Dorper and Merino carcasses were selected from two different abattoirs, representing the three main production regions in South Africa (Karoo, Kalahari and Ermelo districts). For each age group (lamb (age A; 0 incisors) and mutton (age C; more than 6 incisors), three Mutton Merino carcasses and three Dorper carcasses were pooled from each production region. A total of 18 carcasses were obtained per age group. Slaughtering took place in commercial abattoirs within each region following standard slaughtering procedures. Age was determined by the amount of incisors, and fat codes of the carcasses were assessed according to South African legislation and protocol, based on visual assessment of carcass fat content and fat distribution by a trained qualified meat inspector (Department of Agriculture 1990). The sheep carcasses were *trans*ported to the Agricultural Research Council (ARC), Irene for further sampling procedures within 24 hours after slaughter.

### 3.2.2 Beef study

For beef analyses, 9 Bonsmara carcasses from fat code 2 from each of the four age groups were selected for the study (age A (0 incisors), age AB (1-2 incisors), age B (2-6), and age C (>6 incisors)) and slaughtered at the Agricultural Research Council registered abattoir in Irene. A total of 36 beef carcasses were included in the study. Animal breed was identified as a controllable factor.

The Bonsmara breed was selected as it represents 27% of the national stud herd, with nearly 50% of beef-breeds for slaughtering purposes being cross-breed Bonsmara breeds within feedlots (Van der Westhuizen, *Personal Communication*, May 2014). All animals were slaughtered and dressed using standard commercial procedures. Carcasses were electrically stimulated for 15 seconds (400 V peak, 5 ms pulses at 15 pulses/s) after exsanguination and entered the cold rooms (1–4 °C) 45 minutes after exsanguination. Warm and cold carcass weights were recorded. Carcasses were classified according to the official South African Carcass Classification System for age (by dentition) and fatness (visual appraisal) (Department of Agriculture 1990). Carcasses with the correct age and fatness were identified for each age group, weighed and then chilled at 0–3 °C before being processed the day after slaughter.

### 3.2.3 Physical dissection

All carcasses (sheep and beef) were sectioned down the vertebral column. Cuts from the left side of each carcass were kept raw for nutritional analysis, while the cuts from the right sides were cooked prior to nutritional analysis. The sides were subdivided into the primal carcass cuts according to the London and Home Counties cutting techniques as described by Naudé (1974). For sheep meat, the shoulder, loin and leg and for beef, the shoulder, prime-rib and rump, were analysed for physical and nutritional composition. These cuts were selected as they represent the composition of the carcass the best (Naudé 1974). An experienced deboning team was responsible for the physical dissection of the cuts. Dissection took place in an environmentally controlled de-boning room (10 °C). The cuts were weighed and dissected into visible meat, subcutaneous fat (adipose tissue under the skin), intermuscular fat (adipose tissue between

muscles) and bone. Each fraction was weighed and recorded, in order to estimate carcass composition. After nutrient analysis, the estimate of carcass composition was used to calculate nutrient content.

#### **3.2.4 Cooking**

Cuts (prime rib, rump and shoulder) from the right sides of each carcass (lamb, mutton and beef) were cooked according to standardized moist or dry heat cooking methods in identical ovens at 163°C to an internal temperature of 73°C at the ARC Meat Industry Centre. Internal temperature was measured in the geometrical centre of each cut (American Meat Science Association, 1995). After cooking the cuts were physically dissected into visible meat, subcutaneous fat (adipose tissue under the skin), intermuscular fat (adipose tissue between muscles) and bone. Each fraction was weighed, minced and frozen until nutritional analyses were performed. The dissection procedure replicated the procedure followed for the raw cuts.

#### **3.2.5 Nutritional analyses**

For nutritional analysis, the muscle and fat fractions from three of the same cuts from each species were grouped together as composite samples of muscle and composite samples of fat. These fractions were cubed, minced twice (5 mm, then 3 mm mesh plates), vacuum sealed and frozen. The samples were freeze dried and sent for nutritional analysis to be performed on a double blind basis at the ARC Analytical Laboratory (a South African National Accreditation Service (SANAS) accredited laboratory) for lamb and mutton, and the NutriLab, University of Pretoria, South Africa for beef samples. The NutriLab laboratory used official methods of the Association of Official Analytical Chemists (AOAC). The laboratory is an Agri-Laboratory Association of Southern Africa (AgriLASA) certified laboratory participating in their quality control programme. A control sample was included to monitor validity of all the analyses. The control sample was analysed with every batch of samples. The result of the control samples were within control limits therefore the results of this analyses can be accepted as reliable.

The proximate analyses of the cuts were carried out to determine total moisture (Official method of analysis 934.01, AOAC 2000), fat (ethanol extracted) (Official method of analysis 954.02, AOAC, 2000), nitrogen (Official method of analysis 968.06, AOAC, 2000.) and ash (Official method of analysis 942.05, AOAC, 2000) (AOAC 2005). The conversion factor of 6.25 was used in the calculation of the protein content (Jones, Munsey & Walker 1942). Minerals were determined by Inductively Coupled Plasma- Optical Emission Spectrometry - ICP-OES (Varian Liberty 2000).

As an analysis of full carcass composition is an expensive exercise, many studies have correlated the composition of specific cuts to carcass composition. In the current study, three cuts were identified from the front and hind quarters, which represents the composition of the carcass of each species the best. For lamb and mutton, data from whole carcass dissection are included in this paper as found by Van Heerden, Strydom and Schönfeldt (2011). For beef, Naudé (1972) and Schönfeldt (1998) found that the prime rib cut predicted the fat and muscle content of the beef carcass the best. Data from the prime rib was used as a prediction of total carcass values for beef. For comparison, the same calculations used by Naudé (1972) (namely the method of Carroll and Conniffe (1967) to calculate analytically determined physical composition from chemically analysed moisture, protein, ash and lipids), were used. The analytically determined physical composition (muscle and fat) was calculated using dissection results (weight of bone, meat and fat), as well as the chemically determined composition (moisture, protein, fat and ash) of the deboned tissues (meat and fat) from each cut. Muscle content was calculated by adding moisture, protein and ash together for each portion. The mass of ether extractable lipid was regarded as chemical fat. By means of this calculation, chemically determined physical composition of muscle and fat was calculated.

### **3.2.6 Statistical analyses**

Data for lamb and mutton was statistically analysed using Genstat Software 2003. The significance of variables measured for each sample was tested by means of a one-way factorial analysis of variance (ANOVA). In this paper, only mean values are reported. The data for beef

was analysed with Genstat Software 2013 with Linear mixed models, using the Residual Maximum Likelihood (REML) procedure of GenStat(R). The analysis was used to test for differences between the effects of age per cut. The fixed effect was specified as age and the random effect as the composite sample by age interaction. The residuals were normally distributed and heterogeneity of age variances was accounted for. Fisher's protected least significant differences (FPLSD) test at the 1% level was used to separate means (Payne *et al.* 2013).

### **3.3 RESULTS AND DISCUSSION**

#### **3.3.1 Physical and nutritional composition of South African lamb and mutton**

In **Table 3.1**, the physical composition of South African lamb and mutton are summarized as determined by Van Heerden (2007) and Van Heerden, Strydom and Schönfeldt (2011). For the carcass values, muscle content decreased with animal age, while fat content increased with animal age. Bone content remained relatively constant from age A to age C sheep carcasses. No statistics are reported as the datasets from the two different research studies varied.



**Table 3.1** Percentage contribution of meat, fat (subcutaneous and intermuscular) and bone to composition of lamb (A2) and mutton (C2) cuts (Schönfeldt, Hall & Van Heerden 2012) (Van Heerden, Strydom & Schönfeldt 2011) (Van Heerden 2007)

Cut	Age	Meat (muscle +	Fat		Bone
		intramuscular fat)	Subcutaneous	Intermuscular	
		%	%	%	%
Shoulder	A	73.10	5.48	4.22	17.21
	C	70.68	5.73	6.63	16.95
Loin	A	63.92	9.09	9.06	17.93
	C	65.01	10.14	6.89	17.96
Leg	A	76.27	6.23	2.54	14.96
	C	76.31	6.37	3.89	13.44
Carcass	A	66.2	7.4	5.8	20.2
	C	62.7	9.3	7.7	20.3

In **Table 3.2** the nutrient content of 100g raw edible portion of South African lamb and mutton shoulder, loin and leg cuts are presented (Schönfeldt, Hall & Van Heerden 2012). As the first of its kind study in South Africa, no local and nationally representative nutrient content data was available for sheep meat. The nutrient values recorded in the national reference tables for food composition, report on the nutrient content of mutton (raw) and selected mutton cuts (cooked) (Wolmarans *et al.* 2010). The data presented in the national food composition reference tables represent the most accurate and comparative values which were available at the time. These values were borrowed from the United States Department of Agriculture (USDA) Nutrient Database for Standard Reference (USDA 1998). Although lamb dominates the South African sheep meat market with a market share of 85 %, no values for lamb have ever been included in the national reference tables. The new data which have been generated through the research studies, provides own South African nutrient data for both lamb and mutton to be used in the national tables and food intake studies for future reference.

**Table 3.2** Nutrient content of 100 g raw edible portion of South African lamb and mutton shoulder, loin and leg cuts

Cut	Age	Moisture	Energy	Protein	Cholesterol	Fat	Iron	Magnesium	Potassium	Sodium	Zinc
		g	kJ	g	mg						
Shoulder	Lamb	67.9	777	17.4	65.2	13	1.12	16.2	187	63.4	1.86
	Mutton	67.2	813	18.7	51.2	13.4	2.18	18.6	227	74	3.93
Loin	Lamb	65.2	905	16.8	64	16.7	1	16.6	287	66.1	1.31
	Mutton	62.5	998	17.7	50.1	18.8	2.32	18.1	224	67.9	2.56
Leg	Lamb	70.2	682	18	64.1	10.2	1.59	20.1	325	64.6	2.51
	Mutton	69.7	730	19	49.6	11	2.8	20.5	253	67.2	3.15

In **Table 3.3**, the nutrient content of selected critical nutrients found in cooked untrimmed lamb and mutton leg cuts are compared between countries and with the previous reference values. In **Table 3.4** trimmed cooked lamb and mutton leg values are compared to international values. From the comparisons it can clearly be seen that South African lamb and mutton, as slaughtered and consumed (untrimmed), contain less fat and less saturated fatty acids (SFA) than those reported for lamb and mutton from the United States of America (USDA 2013), or the most recent values found by the Australians (NUTTAB 2010). According to the newest draft of the Regulations Relating to the Labelling and Advertising of Foods: Amendment (R. 429 of 2014) (Department of Health 2014), a foodstuff can be marketed and labelled as a “source of” a selected micronutrient if it contains more than 15 % of the Nutrient Reference Values (NRV) per portion, and can be labelled as “high in” if it contains more than 30% of the NRV of the specific nutrient in question. South African lamb and mutton can thus be marketed as “a source of iron”, and “high in zinc”. Similarly, products which have a protein content higher than 10 % can be labelled and marketed as “high in protein”, and South African lamb and mutton pass this criterion with flying colours, containing between 24 % and 27 % protein per portion. In terms of negative nutrient claims, fresh South African untrimmed lamb and mutton can be marketed as

“low in sodium”, containing less than 120mg sodium per 100g fresh, unsalted product as per the regulation.

**Table 3.3** Selected nutrients found in 100 g cooked edible portion of South African lamb and mutton leg (untrimmed) compared to the national reference values in other countries

Nutrient	Unit	South African <sup>1</sup>		MRC <sup>2</sup>	USDA <sup>3</sup>	Australia		NRV*
		Lamb	Mutton	Mutton	Lamb	Lamb 1987 <sup>4</sup>	Lamb 2013 <sup>5</sup>	
Protein	g	24.1	27.2	25.6	25.55	29.3	29	56
Fat	g	11.7	10.1	16.5	16.48	11.8	13	-
SFA	g	5.69	4.84	6.89	6.89	-	5.5	-
MUFA	g	4.69	4.19	6.96	6.96	-	4.7	-
PUFA	g	0.47	0.36	1.18	1.18	-	0.9	-
Cholesterol	mg	91.3	61.4	93	93	110	83	-
Iron	mg	2.87	3.56	2.00	1.98	2.4	2.3	13
Zinc	mg	3.11	4.12	4.40	4.40	4.5	4.8	10
Sodium	mg	56.8	63.5	66	66	67	52	<2000

<sup>1</sup>Schönfeldt, Hall & Van Heerden, 2012

<sup>2</sup>Wolmarans *et al.*, 2010

<sup>3</sup>USDA, 2013.

<sup>4</sup>Greenfield, 1987.

<sup>5</sup>NUTTAB, 2010.

\*Daily Nutrient Reference Values (NRVs) for the purpose of the Regulations Relating to the Labelling and Advertising of Foods: Amendment (R. 429 of 2014)

When locally produced lamb and mutton are further trimmed of subcutaneous fat, the fat content reduces to less than 10g per 100g product (**Table 3.4**), in line with dietary recommendations and comparable to international values. According to the newest draft of the Regulations Relating to the Labelling and Advertising of Foods: Amendment (R. 429 of 2014) (Department of Health 2014), meat with a fat percentage of between 5 % and 10 % can be labelled as lean or trimmed. South African lamb and mutton leg, when trimmed of subcutaneous fat, can thus be marketed as a “lean meat”. It should be noted that according to legislation that in order for any nutrient content claim to be made on a product label, the nutrient composition values need to be displayed on the label of the product as well. These values need to be either a) analytical data from the supplier, b) chemical data from a reputable laboratory (*as provided in this article*), or c) data from the latest edition of the national food composition tables (which in

the case of lamb and mutton are outdated). Another requirement for the data in the Regulations (R. 429 of 2014) is that the nutritional information needs to be verified every 10 years by analysis and kept on record in order for any nutrient content claims to be permitted.

**Table 3.4** Selected nutrients found in 100 g cooked lean edible portion of South African lamb and mutton leg (trimmed) compared to national reference values in other countries

Nutrient	Unit	South African <sup>1</sup>		USDA <sup>2</sup>	Australia <sup>3</sup>	New Zealand <sup>4</sup>	NRV*
		Lamb	Mutton	Lamb	Lamb	Lamb	
Protein	g	25.4	28.1	28.3	30	23.7	56
Fat	g	7.67	7.20	7.74	9	5.3	-
SFA	g	3.68	3.36	2.76	3.6	-	-
MUFA	g	2.97	2.94	3.39	3.3	-	-
PUFA	g	0.29	0.29	0.51	0.8	-	-
Cholesterol	mg	91.7	61.6	89	80	74.4	-
Iron	mg	3.12	3.81	2.12	2.5	1.7	13
Zinc	mg	3.38	4.41	4.94	5.0	3.2	10
Sodium	mg	61.9	68	68	63	61	<2000

<sup>1</sup> Schönfeldt, Hall & Van Heerden, 2012.

<sup>2</sup> USDA, 2013.

<sup>3</sup> NUTTAB, 2010.

<sup>4</sup> Massey University, 2011.

\*Daily Nutrient Reference Values (NRVs) for the purpose of the Regulations Relating to the Labelling and Advertising of Foods: Amendment (R. 429 of 2014)

### 3.3.2 Physical and nutritional composition of South African beef

In **Table 3.5** the mean weight and percentage contribution of the physically dissected components (meat, fat and bone) from the three cuts over the four age groups of beef are presented. As expected, starting mass and physically determined meat content of the beef cuts varied with age, with a significant decrease in meat from age B to C for prime rib ( $p = 0.23$ ) and in the shoulder cut ( $p = 0.014$ ). Physically dissected bone increased with age in prime rib ( $P = 0.003$ ) and shoulder ( $p < 0.001$ ). Prime rib from age A carcasses contained 17.32 % bone, compared to C age prime rib containing 20.98 % bone on average. Shoulder bone content increased from 6.96 % from age A, to 10.51 % in age C carcasses. Carcasses in the current study had a mass range of 210 kg to 280 kg, whereas in the 1990s carcasses with a mass range of between 190 kg to 240 kg were included (Schönfeldt 1998). In 1981, the Department of

Agriculture and Fisheries (1981) reported carcass weight to be 142 kg. Such data predicts that carcass weights have increased over time.

In 1981 the South African Department of Agriculture and Fisheries published a technical communication on the cuts of a beef carcass as determined by Naudé (1972). According to this technical guideline, the average starting mass of a prime rib cut is 5 kg, comprising 3.5 % of the whole carcass, with 780 g bone. The average starting mass of the prime rib in this study conducted 30 years later indicated comparable, but slightly decreased, prime rib starting weights of between 4.33 kg (age A) and 4.88 kg (age B), containing between 750 g (age A) and 900 g (age C) bone.

The average mass of a shoulder cut was reported in the technical communication of 1981 as 13.32 kg, containing 1.95 kg bone. In the current study starting mass ranged from 11.5 kg (age A) to 13.5 kg (age AB and B), containing between 800 g and 1.24 kg bone. It is assumed that the previous study included the arm bone (humerus) in addition to the blade bone (scapula) during sampling. Only the scapula was dissected with the shoulder cut from the carcass in the current study, possibly explaining the lower bone weight recorded in the current study. No bone was included with the rump cut dissected from the carcass in the current study, which differs from the rump cut reported by the Department of Agriculture and Fisheries (1981) which contained 1.5 kg bone (Department of Agriculture and Fisheries 1981).

As expected, because fat code was used as a controllable factor, no significant difference was found for the dissected subcutaneous fat from the prime rib across the four age groups (**Table 3.5**), confirming that the fatness code was correctly assessed. Similar to previous studies (Jacobson & Fenton 1956), fat generally increased with age from young to older animals.

**Table 3.5** The mean physical composition (kg and percentage (%)) contribution to total cut) of beef cuts (prime rib, rump and shoulder) over four age groups (unpublished results)

Cut	Age class <sup>#</sup>	Starting mass	Meat (muscle + intramuscular fat)			Fat				Bone	
			kg ± SD	kg ± SD	%	Subcutaneous		Intermuscular		kg ± SD	%
			kg ± SD	kg ± SD	%	kg ± SD	%	kg ± SD	%	kg ± SD	%
Prime rib	A	4.33 <sup>a</sup> ±0.07	2.97 <sup>a</sup> ±0.02	68.6	0.23±0.003	5.3	0.39 <sup>a</sup> ±0.12	9.01	0.75 <sup>a</sup> ±0.07	17.3	
	AB	4.25 <sup>a</sup> ±0.31	2.65 <sup>ab</sup> ±0.28	62.4	0.26±0.08	6.12	0.55 <sup>ab</sup> ±0.04	13.0	0.78 <sup>a</sup> ±0.08	18.4	
	B	4.88 <sup>b</sup> ±0.18	3.00 <sup>a</sup> ±0.12	61.5	0.28±0.05	5.74	0.70 <sup>b</sup> ±0.07	14.3	0.89 <sup>b</sup> ±0.10	18.2	
	C	4.29 <sup>ab</sup> ±0.25	2.55 <sup>b</sup> ±0.13	59.4	0.22±0.05	5.13	0.68 <sup>b</sup> ±0.09	15.9	0.90 <sup>b</sup> ±0.11	21.0	
	P-value	0.023	0.23		>0.05		0.002				
Rump	A	6.22±0.44	5.32±0.38	85.5	0.41 <sup>a</sup> ±0.04	6.59	0.52±0.03	8.36	-	-	
	AB	6.33±0.43	5.11±0.22	80.7	0.55 <sup>ab</sup> ±0.09	8.69	0.65±0.14	10.3	-	-	
	B	7.04±0.78	5.67±0.62	80.5	0.67 <sup>b</sup> ±0.08	9.52	0.66±0.24	9.38	-	-	
	C	6.83±0.43	5.57±0.21	81.6	0.50 <sup>ab</sup> ±0.11	7.32	0.75±0.12	11.0	-	-	
	p-value	>0.05	0.244		0.035		0.112				
Shoulder	A	11.5 <sup>a</sup> ±0.60	9.64 <sup>ab</sup> ±0.45	83.9	0.43 <sup>a</sup> ±0.07	3.74	0.66 <sup>a</sup> ±0.12	5.74	0.80 <sup>a</sup> ±0.06	6.96	
	AB	13.5 <sup>b</sup> ±0.58	10.42 <sup>a</sup> ±0.62	77.2	0.73 <sup>b</sup> ±0.18	5.41	1.18 <sup>b</sup> ±0.10	8.74	1.11 <sup>b</sup> ±0.08	8.22	
	B	13.5 <sup>b</sup> ±1.53	10.58 <sup>a</sup> ±0.88	78.4	0.58 <sup>ab</sup> ±0.05	4.30	1.14 <sup>b</sup> ±0.40	8.44	1.24 <sup>b</sup> ±0.24	9.19	
	C	11.7 <sup>a</sup> ±1.08	9.06 <sup>b</sup> ±0.76	77.4	0.43 <sup>a</sup> ±0.10	3.68	0.89 <sup>ab</sup> ±0.09	7.61	1.23 <sup>b</sup> ±0.29	10.5	
	p-value	0.003	0.014		0.016		0.003		<0.01		

<sup>#</sup>Age class was determined according to the South African Carcass Classification System (Department of Agriculture, 1990)

\*SD refers to standard deviation

<sup>a,b,c</sup> Means in the same row per cut, with different superscripts differ significantly (p≤0.05).

<sup>^</sup>Number of samples per age group per cut = 9

In **Table 3.5** it can be seen that no significant difference was found between the subcutaneous fat content of the different age groups in the prime rib cut ( $p > 0.05$ ), but the intermuscular fat content was found to be significantly higher in the age B (14.34%) and age C (15.85%) than in the age A samples (9.01%) ( $p = 0.002$ ). Similarly, no significant difference was observed for intermuscular fat content between the age groups ( $p > 0.05$ ) in the rump cut, but the subcutaneous fat content was significantly more in age B (9.52 %) than in the age A (6.59 %). The shoulder cut age AB (5.41 %) had significantly more subcutaneous fat than both cuts from age A (3.74 %) and age C (3.68 %) ( $p = 0.016$ ), while age AB (8.74 %) and B (8.44 %) had significantly more intermuscular fat than age A (5.74 %) ( $p = 0.003$ ).

In **Table 3.6** the analytically determined physical composition (fat, muscle and bone) as derived from the physical weights reported in **Table 3.5** and chemically analysed proximate composition (moisture, protein, ash and fat), is reported (Carroll & Conniffe 1967). The values are compared to values for South African beef recorded from the 1970s (Naudé 1972), (Klingbiel 1984) (Schönfeldt, Naudé & Boshoff 2010). For this study, the values of the prime rib cut were used to predict carcass composition. In the 1990s the fat range of marketable South African beef carcasses was determined as 18.6g/100g for A age carcasses, 19.9 g per 100 g for AB age carcasses and 20.5 g per 100 g for C age carcasses (Schönfeldt 1998). These values show a decrease in the fat content of marketable beef of 23 % from the 1970s (Naudé 1972).

Although a reduction in chemically determined fat composition is observed over all age groups in the recent study, the fat percentage of South African age A beef has decreased from 19 % since the 1990s to 11 %. As age A carcasses are the most marketable carcasses in the consumer market, it is predicted that consumer demands for lean and tender meat are contributing reasons for the reduction in total fat percentage which is achieved through breeding and feeding practices.

**Table 3.6** Comparison of analytically determined physical composition of marketable South African beef reported over time

Year	1972 <sup>1</sup>	1984 <sup>2</sup>			2010 <sup>3</sup>			Current study (2014)			
Age	-	A	AB	C	A	AB	C	A	AB	B	C
Bone	% 13.7	-	-	-	16.9	16.5	19.2	17.3	18.4	18.3	21.0
Muscle	% 63.5	-	-	-	64.8	62.6	60.6	72.0	65.7	64.6	62.13
Fat	% 22.8	14.0	16.5	16.1	18.6	19.9	20.5	11.0	16.0	17.1	16.2

<sup>1</sup>Naudé, 1972

<sup>2</sup>Klingbiel, 1984

<sup>3</sup>Schönfeldt 1998

#Age class and fat codes were determined according to classification within the South African Carcass Classification System at the time of each study (Government Notice No. 992 of 20 May, 1949; Department of Agriculture, 1990)

In **Table 3.7** the nutrient content of a 100 g raw edible portion of South African beef prime rib, rump and shoulder as slaughtered is presented. As animals age, a general tendency that is observed is a decline in moisture content, along with a decline in protein content, while certain minerals increase significantly, and others decrease. For prime rib, age A carcasses had significantly more protein than age AB, B and C carcasses ( $p = 0.01$ ), and significantly less fat than age B and C carcasses ( $p = 0.04$ ). For rump, age A had significantly more moisture ( $p = 0.02$ ) and less fat ( $p = 0.002$ ) than the other age groups, with no significant difference noted for protein content between ages. Similar to the prime rib, protein content decreased ( $p = 0.04$ ) and fat content increased ( $p = 0.04$ ) with age in the shoulder cut.

In age A prime rib cuts, significantly less iron ( $p=0.002$ ), but more phosphorus ( $<0.001$ ) and potassium ( $p < 0.001$ ) was found than in the other age groups. Similarly, age A shoulder cuts had significantly more phosphorus, but less iron, than the other age groups. Age A rump cuts contained more phosphorus than any of the other rump cuts from the other age groups, but no significant difference was found in the iron content of rump between age A, age B or age C animals. Rump from age AB animals however had more iron per edible portion than age A.

The selenium content in all cuts as significantly higher in age AB and age B carcasses which were grass fed, compared to age A and age C animals which were rounded off on grain-based diets. Selenium is a unique mineral currently receiving considerable global attention as research



is uncovering its role in human health related to immune function, and reproduction (Rayman 2012). Selenium is also being researched as a possible element to assist in combating HIV/AIDS (Sudfeld *et al.* 2014).

As previously mentioned, in order to make any nutrient content claim in marketing or consumer education activities, analytical data needs to be verified at least every 10 years according to the Regulations Relating to the Labelling and Advertising of Foods: Amendment (R. 429 of 2014). In this paper, selected nutrients of raw, target grade (age A and AB) South African beef are compared with the nutrient content determined in target grade beef in the 1990s. When compared to the previous beef data (**Table 3.8**) on the nutritional content of beef (Schönfeldt 1998), it is clear that nutritional fat content decreased notably in target grade beef (age A) from nearly 20 g per 100 g in the 1990s, to less than 13 g per 100 g in the current study. Fat content further varied between the different carcass cuts. Less notable differences are observed in the fat content of beef within the other age groups, probably indicating the role which industry has played in adjusting target class beef as dictated by price and demand.

When considering the Regulations Relating to the Labelling and Advertising of Foods: Amendment (R. 429 of 2014), South African prime rib, rump and shoulder can be labelled as “a source of zinc, iron, phosphorus and selenium”, while being “high in copper”, and “low in sodium” (providing less than 120 mg sodium per 100 g product). When trimmed of all visible fat, South African beef from age A, AB and B contain less than 5 % fat, and can thus be classified as extra lean according to these Regulations (R. 429 of 2014).

**Table 3.7** Nutrient content of 100 g edible portion of raw prime rib, rump and shoulder of South African beef (untrimmed) from four age groups

Cut	Age	Moisture	Protein	Fat	Calcium	Phosphorus	Magnesium	Copper	Iron	Zinc	Sodium	Potassium	Selenium
		g	g	g	mg	mg	mg	mg	mg	mcg	mg	mg	mcg
Prime rib	A	66.1	20.0 <sup>a</sup>	13.3 <sup>a</sup>	51.2	183 <sup>a</sup>	21.7	0.45 <sup>a</sup>	1.31 <sup>a</sup>	2.65	48.2	324 <sup>a</sup>	5.75 <sup>a</sup>
	AB	61.3	18.4 <sup>b</sup>	19.6 <sup>ab</sup>	52.0	138 <sup>b</sup>	19.3	0.24 <sup>c</sup>	1.71 <sup>b</sup>	2.97	53.7	273 <sup>b</sup>	8.28 <sup>b</sup>
	B	59.7	18.5 <sup>b</sup>	21.0 <sup>b</sup>	44.7	137 <sup>b</sup>	25.8	0.33 <sup>bc</sup>	1.77 <sup>b</sup>	3.00	48.4	255 <sup>b</sup>	7.67 <sup>b</sup>
	C	60.9	17.7 <sup>b</sup>	20.6 <sup>b</sup>	52.1	138 <sup>b</sup>	17.3	0.39 <sup>ab</sup>	1.69 <sup>b</sup>	2.85	51.6	271 <sup>b</sup>	4.07 <sup>a</sup>
	p-value	0.08	0.01	0.04	0.70	<0.001	0.2	0.002	0.002	0.17	0.57	<0.001	<0.001
Rump	A	68.5 <sup>a</sup>	19.9	10.7 <sup>a</sup>	34.0	197 <sup>a</sup>	23.4 <sup>a</sup>	0.57	1.31 <sup>a</sup>	2.13	44.4 <sup>ab</sup>	338 <sup>a</sup>	6.30 <sup>a</sup>
	AB	63.7 <sup>b</sup>	19.2	16.1 <sup>b</sup>	31.3	167 <sup>b</sup>	22.3 <sup>a</sup>	0.56	2.73 <sup>b</sup>	2.63	46.8 <sup>ab</sup>	326 <sup>ab</sup>	11.4 <sup>b</sup>
	B	63.1 <sup>b</sup>	18.5	17.4 <sup>b</sup>	27.2	158 <sup>b</sup>	37.7 <sup>b</sup>	0.53	2.07 <sup>ab</sup>	2.45	42.3 <sup>b</sup>	297 <sup>b</sup>	9.49 <sup>b</sup>
	C	65.0 <sup>ab</sup>	19.0	14.9 <sup>b</sup>	36.0	170 <sup>b</sup>	25.1 <sup>a</sup>	0.68	2.08 <sup>ab</sup>	2.75	55.6 <sup>a</sup>	301 <sup>b</sup>	5.79 <sup>a</sup>
	p-value	0.02	0.39	0.002	0.58	0.01	0.01	0.09	0.01	0.06	0.04	0.01	0.001
Shoulder	A	71.3	20.5 <sup>a</sup>	7.56 <sup>a</sup>	40.9	195 <sup>a</sup>	23.1	0.61	1.46 <sup>a</sup>	3.01 <sup>a</sup>	52.9 <sup>a</sup>	337 <sup>a</sup>	6.22 <sup>a</sup>
	AB	68.0	18.6 <sup>b</sup>	12.7 <sup>b</sup>	36.7	147 <sup>b</sup>	19.1	0.57	1.81 <sup>b</sup>	3.40 <sup>ab</sup>	62.5 <sup>b</sup>	279 <sup>b</sup>	10.8 <sup>c</sup>
	B	68.8	18.9 <sup>ab</sup>	11.6 <sup>ab</sup>	34.9	150 <sup>b</sup>	19.6	0.63	1.88 <sup>b</sup>	3.29 <sup>ab</sup>	58.4 <sup>bc</sup>	277 <sup>b</sup>	8.93 <sup>b</sup>
	C	68.8	19.5 <sup>ab</sup>	10.7 <sup>ab</sup>	42.7	166 <sup>b</sup>	23.1	0.72	1.90 <sup>b</sup>	3.67 <sup>b</sup>	69.8 <sup>c</sup>	294 <sup>ab</sup>	4.86 <sup>a</sup>
	p-value	0.06	0.04	0.04	0.46	0.006	0.22	0.1	0.001	0.05	<0.001	0.02	<0.001

<sup>a,b,c</sup> Means in the same row per cut, with different superscripts differ significantly ( $p \leq 0.05$ ).

^Number of samples per age group per cut = 9

**Table 3.8** Selected nutrients found in South African untrimmed and trimmed, raw beef cuts (prime rib, rump and shoulder) compared to carcass data determined in the 1990s and the current NRVs for South Africans older than 37 months.

Nutrient	Age	Current study <sup>#</sup>								1990s <sup>1</sup>						NRV*	
		Untrimmed				Trimmed				Lean muscle only				Untrimmed			
		A	AB	B	C	A	AB	B	C	A	AB	B	C	A	B		C
Protein	g	20.0	18.4	18.5	17.7	20.7	19.4	19.5	18.3	22.3	22.1	22.4	21.0	18.2	18.7	18.4	56
Fat	g	13.3	19.6	21.0	20.6	10.0	15.4	17.2	17.8	3.37	3.82	4.87	5.62	19.8	19.9	20.1	-
Calcium	mg	51.2	52.0	44.7	52.1	54.8	56.2	48.2	55.3	61.8	68.0	59.4	69.5	13.7	14.8	14.3	1300
Phosphorus	mg	180	140	140	140	195	149	148	147	220	180	182	185	160	167	158	1250
Magnesium	mg	21.7	19.3	25.8	17.3	23.2	20.8	27.8	18.4	26.2	25.2	34.3	23.2	18.2	19.0	20.0	365
Copper	mg	0.45	0.24	0.33	0.39	0.48	0.26	0.36	0.41	0.55	0.31	0.44	0.52	0.23	0.17	0.14	0.90
Iron	mg	1.31	1.71	1.77	1.69	1.41	1.84	1.90	1.80	1.59	2.23	2.35	2.27	0.94	1.08	1.94	13
Zinc	mcg	2.65	2.97	3.00	2.85	2.84	3.22	3.24	3.04	3.20	3.89	3.99	3.82	3.28	3.59	3.53	10
Sodium	mg	48	53	48	52	52	58	52	55	58	70	64	69	88	100	95	<2000
Potassium	mg	324	273	255	271	346	295	275	288	391	356	339	362	272	293	278	>4700
Selenium	mcg	5.75	8.28	7.67	4.07	6.14	8.95	8.27	4.33	6.94	10.8	10.2	5.47	-	-	-	55

<sup>1</sup>Schönfeldt, Naudé & Boshoff 2010

\*Daily Nutrient Reference Values (NRVs) for the purpose of the Regulations Relating to the Labelling and Advertising of Foods: Amendment (R. 429 of 2014)

<sup>#</sup>Nutritional analysis of the prime rib cut has been used as it was determined that this cut predicts the composition of the carcass the best (Naudé 1972) (Schönfeldt 1998)

### **3.4 CONCLUSIONS AND RECOMMENDATIONS**

This article presents data generated through three recent compositional studies on South African red meat. The information on lamb and mutton provides the first set of own datasets on the nutritional and compositional quality of South African lamb and mutton. Previously, data used by health professionals as well as policy makers and academia were borrowed values from the USDA as reported in the South African national food composition tables. Notable differences include that South African lamb and mutton contain significantly less fat, and subsequently a higher profile of other essential nutrients such as protein, iron and zinc. In the context of the current South African nutrition landscape, with high incidence of overweight and obesity in the midst of nutritional deficiencies, locally produced lamb and mutton could thus have a beneficial role in diets of the population, contrary to previous popular belief of this species to be too high in fat.

South African beef has also changed notably in the past centuries. Especially young carcasses, which comprise the majority of product offering on the market, has decreased notably in total fat content when untrimmed. Additional trimming (prior to consumption) furthermore decreases the fat content of South African beef to as little as 3.4% fat, which can be positively compared to lean white meat product offerings. In addition, the leaner the meat product consumed, the higher the nutrient density (amount of nutrients) per unit of energy supplied.

The data reported in this paper thus enables the South African red meat industry to better position locally produced red meat within the current global sustainable debate. Furthermore, the updated information could assist in guiding industry processes, including carcass classification which is currently under investigation.

### **3.5 ACKNOWLEDGEMENTS**

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## CHAPTER 4: EFFECT OF ANIMAL AGE AND TRIMMING PRACTICES ON THE PHYSICAL COMPOSITION OF BONSMARA BEEF

*This paper was submitted to the Journal of Chemistry and has been accepted for publication. The paper was presented at the International Food Database Conference in Granada, Spain, September 2014 and was awarded best poster presentation at the conference. The paper reports on some of the findings from the research study supported by Red Meat Research and Development South Africa (RMRDSA) and the National Research Foundation (NRF). The content provides valuable updated information on the nutrient quality of South African beef to be used by policy makers, industry and consumer education programmes.*

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### ABSTRACT

Increased economic incentive for producing young and leaner carcasses, as well as demand for lean meat from progressively health conscious consumers, are considered drivers for change in carcass composition over time. Furthermore, many retailers trim visible fat from meat to various degrees and consumers increasingly remove visible fat from meat prior to, or after, cooking.

The objective of this study was to determine the composition of South African Bonsmara beef from four age groups from different production systems, as well as to extrapolate the effect of fat trimming on physical composition. Fat content of marketable beef has decreased notably since the 1930s, and beef from the South African Bonsmara breed contains less than 10g lipid per 100g after trimming of subcutaneous fat, irrespective of age. Removal of all visible fat reduces the lipid content to less than 5g per 100g, comparing favourably with other lean animal products.

### 4.1 INTRODUCTION

Carcass classification or grading systems are developed to describe the quality and yield of a carcass to inform all the role players in the production chain with the final purpose of a satisfied consumer (Strydom, 2011). According to AHDB Industry Consulting (2008), as summarized by Strydom, (2011), general aims of such a classification system include the provision of a

common language for livestock trade, to enable the use of premiums for desirable characteristics and allow yield monitoring of various classes. Since 1932 a beef description system was put in place in South Africa, with the age of the animal used as a characteristic to grade carcasses since 1936 (Government Notice No. 1548 of 16 October, 1936). In 1949, the amount of permanent incisors was implemented as the measurement to determine animal age (Government Notice No. 992 of 20 May, 1949) (Strydom, 2011). In 1992 the current South African Carcass Classification System was implemented as a compulsory classification tool used for marketing and trade of South African red meat carcasses, including beef, veal, sheep and goat meat. The classification system was based on findings regarding changes in the quality characteristics as well as physical and nutrient composition of South African beef carcasses due to age (by dentition) and degree of fatness (Naudé, 1974) (Klingbiel, 1984) (Department of Agriculture, 1990) (Schönfeldt, 1998) (Government Notice No. R. 342 of 19 March, 1999). However, since implementation, the composition and nutritional profile of beef carcasses over the four different age groups has not been evaluated again to assess the validity of the current system in terms of physical and nutrition composition of current marketable beef meat.

Meat quality describes the attractiveness of meat for consumers (Wood, *et al.*, 1999), with many quality characteristics, i.e. flavour, tenderness, juiciness and health characteristics, influenced through animal nutrition and breed manipulation (among others). These quality characteristics are principally influenced through variation in the type and amount of lipid content present in the final meat product (Wood, *et al.*, 1999).

Nutritional and health considerations for leanness are increasingly influencing food choice. In the USA, health considerations are considered the most important factor influencing changes in consumer demand for meat and meat products (Resurreccion, 2003). Similar to international food consumption patterns (McAfee, *et al.*, 2010), South African consumers are consuming more white meat today instead of red meat (BFAP, 2011), possibly due to health considerations. With obesity incidence being a significant risk factor for non-communicable diseases and death, the fat content of food products from animal origin has been under the spotlight. Based on epidemiological studies, obesity has a positive association with high

saturated fat intake from foods from animal origin (Wyness, *et al.*, 2011). Although meat is recognized as a primary dietary component and forms an important part of a balanced and varied diet, red meat is often seen as a culprit in weight gain and obesity (Millward, 1999). The nutritional contribution which red meat makes to global diets, including those from critical nutrients such as protein, vitamin A and iron, as well as total and saturated fats, has been well documented over time (Johnson, 1987) (Wyness, *et al.*, 2011). In order to reflect true composition, scientific data should continually be updated as various studies around the globe reflect the changes in the composition of red meat, especially a reduction in the amount of total fat in the end product (Schönfeldt & Hall, 2008). Reasons for the change in composition include breed and age selection, feed manipulation, and retail and food preparation practices, such as trimming (Schönfeldt & Hall, 2008).

Previous studies have shown that in South Africa the average fat content of target grade beef has decreased from 32% in 1949 (Naude, 1972) to 18% in 1981 (Klingbiel, 1984) to 13% in 1991 (Schönfeldt, 1998). Further reduction in fat content through trimming has, in global studies, reflected fat (lipid) content values of less than 10% (Schönfeldt & Hall, 2008) (Gerber, Scheeder, & Wenk, 2009). Limiting the consumption of all visible fat through trimming, cooking loss and plate waste, has showed that lean red meat can contain less than 5% fat (lipid) (Williams, 2007). The composition of South African beef with subcutaneous fat removed has never been determined before. The aim of the current study was to determine the physical composition of beef from the current predominant breed in South Africa, namely Bonsmara, from four age groups and production systems (according to the carcass classification system), with and without subcutaneous fat.

## **4.2 MATERIALS AND METHODS**

### **4.2.1 Sampling and sample preparation**

#### *4.2.1.1 Factors considered*

The South African market classification for beef, sheep and goats classify these carcasses into four age groups depending on the number of erupted incisors. Nine carcasses for each of the, four age groups of beef in the South African carcass classification system, were included in the

study. It included carcasses from age A (0 incisors), age AB (1-2 incisors), age B (2-6 incisors), and age C (>6 incisors) (Department of Agriculture, 1990).

In South Africa, more than 85% of age A carcasses are produced on feedlots with grain-based feeding systems, whereas age AB and age B carcasses are mainly produced on grass-based feeding systems. Age C carcasses found on the market are normally culled cows, mainly produced on the veld (grass-based feeding system), but rounded off to the optimal fatness in a feedlot (grain-based feeding system) (Van der Westhuizen, 2014, Personal Communication).

Animal breed was identified as a controllable factor, as breed influences physical composition (Warren, *et al.*, 2008). The South African Bonsmara breed was selected as it represents 27% of the national stud herd, with nearly 50% of beef breeds for slaughtering purposes being cross-breed Bonsmara breeds in feedlots (Van der Westhuizen, 2014, Personal Communication).

Fatness code was used as the second controllable factor, and only carcasses with a fat code 2 were included. Within the South African market, age and fat code determine the market price, with fat code 2 reaching the highest reward. Subsequently more than 75% of meat sold on the market is classified within the fat code 2 class (Van der Westhuizen, 2014, Personal Communication).

Fat code was identified according to South African legislation and protocol, based on visual assessment of carcass fat content and fat distribution by a qualified meat inspector. According to the classification system, fat code 2 carcasses should contain 4.1% subcutaneous fat, and 1 to 3 mm subcutaneous fat on the prime rib (Department of Agriculture, 1990).

#### *4.2.1.2 Slaughtering procedure*

All animals were slaughtered and dressed using standard commercial procedures at the experimental facility of the Agricultural Research Council's Irene campus (Gauteng, Johannesburg). Carcasses were electrically stimulated for 15 seconds (400 V peak, 5 ms pulses at 15 pulses/s) after exsanguination and entered the cold rooms (1–4 °C) 45 minutes after exsanguination. Warm and cold carcass weights were recorded. Carcasses were classified

according to the official South African Carcass Classification System for age (by dentition) and fatness (visual appraisal). Nine carcasses with the correct age and fatness were identified for each age group, weighed and then chilled at 0–3 °C before being processed the following day after slaughter. Carcasses were sectioned down the vertebral column, and subdivided into the primal prime rib, rump and shoulder carcass cuts according to the London and Home Counties cutting techniques as described by Naudé (1974). An experienced deboning team was responsible for the removal of the cuts as well as the physical dissection of each of these cuts into visible meat, subcutaneous fat (adipose tissue under the skin), intermuscular fat (adipose tissue between muscles) and bone. Three cuts (prime rib, rump and shoulder) were selected for the study as they represent the composition of the carcass the best when raw and cooked (Naude, 1972) (Schönfeldt, 1998).

#### *4.2.1.3 Physical and chemical analyses*

Physical dissection took place in an environmentally controlled de-boning room (10°C). The cuts were weighed and dissected into muscle, intermuscular fat, subcutaneous fat, and bone. Each fraction was weighed and recorded, in order to calculate physical carcass composition, as well as the physical composition of different edible portions.

For chemical analysis, the muscle and fat fractions from three of the same cuts were grouped together as composite samples of muscle and composite samples of fat. These fractions were cubed, minced twice (5mm, then 3mm mesh plates), vacuum sealed and frozen. The samples were freeze dried and sent for chemical analysis (moisture, protein, ash and fat) at the Agricultural Research Council (ARC) Analytical Laboratory and the NutriLab Laboratory at the University of Pretoria. The physical dissection weights and chemical analysis were used to calculate the composition of the various portions of the three cuts. These include the 'as slaughtered' portion constituting bone, muscle, intermuscular fat and subcutaneous fat; the 'edible' portion constituting muscle, intermuscular fat and subcutaneous fat; the 'lean edible' portion constituting muscle and intermuscular fat, and the 'muscle only' portion constituting only the muscle fraction. The 'as slaughtered' data from the prime rib was used to predict carcass composition (Naude, 1972).

## 4.2.2 Analytical procedures

### 4.2.2.1 Analytical methodology

The proximate analyses of the cuts were carried out to determine total moisture (Official method of analysis 934.01, AOAC 2000), fat (Official method of analysis 954.02, AOAC, 2000.), nitrogen (Official method of analysis 968.06, AOAC, 2000.) and ash (Official method of analysis 942.05, AOAC, 2000.). The conversion factor of 6.25 was used in the calculation of the protein content (Jones, Munsey, & Walker, 1942).

### 4.2.2.2 Analytical quality control

Analyses were performed on a double blind basis at Nutrilab, University of Pretoria, South Africa. The laboratory used official methods of the Association of Official Analytical Chemists (AOAC). The laboratory is an Agri-Laboratory Association of Southern Africa (AgriLASA) certified laboratory participating in their quality control programme. A control sample was included to monitor validity of all the analyses. The control samples were analysed with every batch of samples. The result of the control samples were within control limits therefore the results of this analyses can be accepted as reliable.

### 4.2.2.3 Calculating physical composition of each cut from analytical values

Analytically determined physical composition (muscle and fat) was calculated using dissection results (weight of bone, meat and fat), as well as the chemically determined composition (moisture, protein, lipid and ash) of the deboned tissues (meat and fat) from each cut. Analytically determined muscle content was calculated by adding moisture, protein and ash together for each portion. The mass of ether extractable lipid was regarded as chemical fat. By means of this calculation, chemically determined physical composition of muscle and fat was calculated, and together with dissected bone comprised the total cut.

#### 4.2.2.4 Calculating carcass composition

As an analysis of full carcass composition is an expensive exercise, many studies have correlated the composition of specific cuts to carcass composition. According to Naude (1972), and confirmed by Schönfeldt (1998), the prime rib cut was found to predict the fat and muscle content of the carcass the best. Data obtained from the prime rib cut was used as a prediction of total carcass composition.

#### 4.2.3 Statistical analysis

The data was analysed with Genstat Software 2013 with Linear mixed models, using the Residual Maximum Likelihood (REML) procedure of GenStat(R). The analysis was used to test for differences between the effect of age per cut. The fixed effect was specified as age and the random effect as the composite sample by age interaction. The residuals were normally distributed and heterogeneity of age variances was accounted for. Fisher's protected least significant differences (FPLSD) test at the 1% level was used to separate means (Payne, Murray, Harding, Baird, & Soutar, 2013).

### 4.3 RESULTS AND DISCUSSION

#### 4.3.1 Physical composition

In **Table 4.1** the mean weights of the physically dissected components (starting mass, bone, muscle, visible subcutaneous and intermuscular fat) from the three cuts over the four age groups are presented. As expected, starting mass and physically determined muscle content of the beef cuts increased with age from age A to AB and B, with a significant decrease in muscle from AB to C for prime rib ( $p = 0.23$ ) and from age B to C in the shoulder ( $p = 0.014$ ). Similarly, as expected, physically dissected bone content increased with age in the prime rib ( $p = 0.003$ ) and the shoulder ( $p < 0.001$ ). It should be noted that the rump cut does not contain any bone.



**Table 4.1** Mean physical composition (kg) determined by dissection of Bonsmara beef cuts (prime rib, rump and shoulder) over four age groups

Cut	Age class <sup>#</sup>	n	Starting mass	Bone	Meat	Subcutaneous fat	Intermuscular fat
			kg ± SD	kg ± SD	kg ± SD	kg ± SD	kg ± SD
Prime rib	A	9	4.33 <sup>a</sup> ± 0.07	0.75 <sup>a</sup> ± 0.07	2.97 <sup>a</sup> ± 0.02	0.23 ± 0.003	0.39 <sup>a</sup> ± 0.12
	AB	9	4.25 <sup>a</sup> ± 0.31	0.78 <sup>a</sup> ± 0.08	2.65 <sup>ab</sup> ± 0.28	0.26 ± 0.08	0.55 <sup>ab</sup> ± 0.04
	B	9	4.88 <sup>b</sup> ± 0.18	0.89 <sup>b</sup> ± 0.10	3.00 <sup>a</sup> ± 0.12	0.28 ± 0.05	0.70 <sup>b</sup> ± 0.07
	C	9	4.29 <sup>ab</sup> ± 0.25	0.90 <sup>b</sup> ± 0.11	2.55 <sup>b</sup> ± 0.13	0.22 ± 0.05	0.68 <sup>b</sup> ± 0.09
	P-value		0.023	0.003	0.23	>0.05	0.002
Rump	A	9	6.22 ± 0.44	-	5.32 ± 0.38	0.41 <sup>a</sup> ± 0.04	0.52 ± 0.03
	AB	9	6.33 ± 0.43	-	5.11 ± 0.22	0.55 <sup>ab</sup> ± 0.09	0.65 ± 0.14
	B	9	7.04 ± 0.78	-	5.67 ± 0.62	0.67 <sup>b</sup> ± 0.08	0.66 ± 0.24
	C	9	6.83 ± 0.43	-	5.57 ± 0.21	0.50 <sup>ab</sup> ± 0.11	0.75 ± 0.12
	p-value		>0.05	-	0.244	0.035	0.112
Shoulder	A	9	11.5 <sup>a</sup> ± 0.60	0.80 <sup>a</sup> ± 0.06	9.64 <sup>ab</sup> ± 0.45	0.43 <sup>a</sup> ± 0.07	0.66 <sup>a</sup> ± 0.12
	AB	9	13.5 <sup>b</sup> ± 0.58	1.11 <sup>b</sup> ± 0.08	10.42 <sup>a</sup> ± 0.62	0.73 <sup>b</sup> ± 0.18	1.18 <sup>b</sup> ± 0.10
	B	9	13.5 <sup>b</sup> ± 1.53	1.24 <sup>b</sup> ± 0.24	10.58 <sup>a</sup> ± 0.88	0.58 <sup>ab</sup> ± 0.05	1.14 <sup>b</sup> ± 0.40
	C	9	11.7 <sup>a</sup> ± 1.08	1.23 <sup>b</sup> ± 0.29	9.06 <sup>b</sup> ± 0.76	0.43 <sup>a</sup> ± 0.10	0.89 <sup>ab</sup> ± 0.09
	p-value		0.003	<0.01	0.014	0.016	0.003

<sup>#</sup>Age class was determined according to the South African Carcass Classification System (Department of Agriculture, 1990)

\*SD refers to standard deviation

<sup>a,b,c</sup> Means in the same column per cut, with different superscripts differ significantly (p≤0.05).

In 1981 the South African Department of Agriculture and Fisheries published a technical communication on the cuts of a beef carcass as determined by Naude (1972). According to this technical guideline, the average starting mass of a prime rib cut is 5kg, comprising 3.5% of the whole carcass, with 780g bone. The average starting mass of the prime rib in this study conducted 30 years later indicate comparable, but slightly decreased, prime rib starting weights (**Table 4.1**). Fatness codes are determined by physical evaluation of the subcutaneous fat layer on the beef carcass after slaughter prior to further division into retail cuts (Department of Agriculture, 1990)(Government Notice No. R. 342 of 19 March, 1999). As expected, no significant difference was found for the dissected subcutaneous fat from the prime rib across the four age groups, confirming that the fatness code determined by visual assessment in this study was correct.

Similar to previous studies (Jacobson & Fenton, 1956), subcutaneous and intermuscular fat generally increased with age from young (age A) to older (age AB and B) animals. No significant difference was found between the subcutaneous fat content of the different age groups in the prime rib cut ( $p>0.05$ ), but the intermuscular fat content was found to be significantly higher in the age B and age C than in the age A samples ( $p = 0.002$ ). Similarly no significant difference was observed for intermuscular fat content between the age groups ( $p>0.05$ ) in the rump cut, but the subcutaneous fat content was significantly higher in age B than in the age A. In the shoulder cut age AB had significantly more subcutaneous fat than both cuts from age A and age C ( $p = 0.016$ ), while age AB and B had significantly more intermuscular fat than age A ( $p = 0.003$ ) (**Table 4.1**). As fat content increases, it accumulates in several locations simultaneously, initially subcutaneous and intermuscular, followed by accumulation in the muscle as intramuscular fat (marbling) (Wood, *et al.*, 1999). Marbling is often positively associated with tenderness and juiciness. These positive associations with fat content formed the basis of the development of the United States of America (USA) classification system of beef based on degree of marbling and animal maturity (United States Department of Agriculture, 1997). In South Africa, this is not taken into consideration.

#### 4.3.2 Effect of age on the composition of South African beef

Although increase in marbling is associated with increase in consumer preference due to increase in juiciness (Ngapo, Riendeau, Laberge, & Fortin, 2013), consensus on the increase in tenderness in older animals due to marbling has not been reached. At high levels, e.g. in Kobe beef, where intramuscular fat can exceed 200mg/g muscle, it is possible that the lower resistance to shear due to the dilution of fibrous protein by the soft fat (Wood, *et al.*, 1999), and fat cell expansion within the perimysium possibly forces muscle fibres apart, contributes to increased tenderness (Wood, 1990). In the USA, research has found that marbling should probably exceed 30mg lipid per gram muscle to optimize tenderness (Wood, *et al.*, 1999), whereas in the UK and Europe marbling values are reported at lower values to enhance tenderness. The current research study found that when the prime rib, rump and shoulder cuts are trimmed of all subcutaneous and intermuscular fat, the samples still contained between 18mg and 60mg intramuscular lipid per gram muscle, depending on the age and the cut. Age C had the most intramuscular lipid per gram of muscle for each cut (**Table 4.2**). The rump cut had consistently less intramuscular lipid per age group, followed by shoulder and then prime rib sampled from the same carcasses (**Table 4.2**), indicating the expected variation between cuts from the same carcass.

When cuts are analysed 'as slaughtered' (containing meat, fat and bone components) all the cuts (prime rib  $p = 0.003$ ), rump ( $p = 0.003$ ) and shoulder ( $p = 0.009$ ) had significantly more muscle in age A than ages AB, B and C with no significant difference between ages AB, B, and C. In contrast, lipid content increased with age, with significant increases observed from age A to age B in the rump ( $p = 0.002$ ) and shoulder cuts ( $p = 0.044$ ). When the carcass cuts were analysed as an untrimmed edible portion (bone removed but with all visible fat intact), similar observations were made. Muscle content decreased significantly with age, while lipid content increased significantly with age in all cuts.

In 1981, the average composition of untrimmed prime rib was 61.5% muscle, 23.9% lipid and 14.1% bone (Department of Agriculture and Fisheries, 1981). In the current study, the percentage muscle was higher for marketable age A carcasses (72%), decreasing with age to

62.1% muscle in age C prime rib. Lipid content was notable less (ranging from 11% in age A to 17.1% in age B) in the current study compared to 23.9% lipid recorded for marketable South African beef in 1981.

For untrimmed shoulder with bone, the contribution of muscle to the cut was between 79.3% (age C) and 86.8% (age A). This is a notable increase when compared to the average muscle content in 1981 of 77.8%. Lipid content was notably lower than the previously reported 14.2% in 1981 (Department of Agriculture and Fisheries, 1981), currently ranging from 7.06% (age A) to 11.6% (age AB). The previous contribution of shoulder bone to the cut was recorded as 7.2% (Department of Agriculture and Fisheries, 1981), in the current study the bone content was found to range between 7% (age A) and 21% (age C).

In 1981, the composition of untrimmed rump was 66.5% muscle, 18.8% lipid and 14.6% bone, although the results are not comparable to those of the current study as the bone was not included in the current sampling protocol for the rump cut. When muscle and fat contribution of the cuts are adjusted to not include bone, the contribution of muscle was 78% and lipid 22%.

When edible portions were trimmed of subcutaneous fat, a significant increase in lipid content was observed from age A and age B in the prime rib ( $p = 0.013$ ), and between age A and AB in the rump ( $p = 0.017$ ) and shoulder ( $p = 0.041$ ) cuts. In all cuts there as significantly more muscle in age A cuts, with no statistically significant differences observed in the muscle content between age AB, B or C in all cuts. When all visible fat is removed (subcutaneous and intermuscular fat) (**Table 4.2**), muscle content decreased and lipid content increased with age, however no significant difference was observed in the muscle and lipid content between age A and AB for prime rib and rump, with no significant difference observed in the muscle ( $p = 0.001$ ) and fat ( $p = 0.009$ ) content between ages A, AB or B for the shoulder cut. In all cuts, age C had significantly less muscle and more lipids than age A, even when all visible fat is removed. Trimming of visible fat thus had the least effect on total lipid content in the age C cuts, confirming the increase in lipid deposition within muscle cells (intramuscular adipose tissue / marbling) as animals age (Pflanzer & Eduardo de Felicio, 2011).

**Table 4.2** Physical composition of 100g portions (trimmed and untrimmed) of South African beef (determined by physical dissection and chemical analyses) over four age groups

Cut	Age class <sup>#</sup>	As slaughtered (with bone)			Untrimmed		Trimmed of subcutaneous fat		Trimmed of all visible fat		
		Bone	Muscle	Lipid	Muscle	Lipid	Muscle	Lipid	Muscle	Lipid	Ratio <sup>&gt;</sup>
		g	g	g ± SD	g ± SD	g ± SD	g ± SD	g ± SD	g ± SD	g ± SD	mg/g
Prime rib	A	17.3 ± 1.31	72.0 <sup>a</sup> ± 1.18	11.0 ± 2.15	87.1 <sup>a</sup> ± 2.24	13.3 <sup>a</sup> ± 2.35	90.4 <sup>a</sup> ± 2.38	10.0 <sup>a</sup> ± 2.49	97.1 <sup>a</sup> ± 0.34	3.37 <sup>a</sup> ± 0.33	34.7
	AB	18.4 ± 1.38	65.7 <sup>b</sup> ± 3.61	16.0 ± 3.56	80.7 <sup>ab</sup> ± 4.33	19.6 <sup>ab</sup> ± 4.30	84.9 <sup>b</sup> ± 2.70	15.4 <sup>ab</sup> ± 2.66	96.5 <sup>a</sup> ± 0.81	3.82 <sup>ab</sup> ± 0.77	39.6
	B	18.3 ± 1.08	64.6 <sup>b</sup> ± 1.11	17.1 ± 0.68	79.2 <sup>b</sup> ± 0.59	21.0 <sup>b</sup> ± 0.97	83.0 <sup>b</sup> ± 0.40	17.2 <sup>b</sup> ± 0.05	95.3 <sup>ab</sup> ± 0.40	4.87 <sup>bc</sup> ± 0.52	51.1
	C	21.0 ± 1.96	62.1 <sup>b</sup> ± 1.79	16.2 ± 2.95	79.4 <sup>b</sup> ± 3.41	20.6 <sup>b</sup> ± 3.36	82.2 <sup>b</sup> ± 2.91	17.8 <sup>b</sup> ± 2.86	94.4 <sup>b</sup> ± 1.51	5.62 <sup>c</sup> ± 1.44	59.5
	p-value	-	0.003	0.072	0.035	0.04	0.01	0.013	0.024	0.049	-
Rump	A	-	89.8 <sup>a</sup> ± 0.56	10.8 <sup>a</sup> ± 1.03	89.4 <sup>a</sup> ± 0.87	10.7 <sup>a</sup> ± 0.96	93.0 <sup>a</sup> ± 0.49	7.15 <sup>a</sup> ± 0.66	98.3 <sup>a</sup> ± 0.13	1.84 <sup>a</sup> ± 0.25	18.7
	AB	-	83.7 <sup>b</sup> ± 1.76	16.1 <sup>b</sup> ± 1.65	84.0 <sup>b</sup> ± 1.79	16.1 <sup>b</sup> ± 1.65	89.7 <sup>b</sup> ± 1.22	10.4 <sup>b</sup> ± 1.05	98.2 <sup>ab</sup> ± 0.42	1.93 <sup>a</sup> ± 0.44	19.7
	B	-	82.3 <sup>b</sup> ± 0.29	17.3 <sup>b</sup> ± 0.29	82.7 <sup>b</sup> ± 0.27	17.4 <sup>b</sup> ± 0.30	89.5 <sup>b</sup> ± 1.63	10.5 <sup>b</sup> ± 1.45	97.5 <sup>bc</sup> ± 0.27	2.54 <sup>b</sup> ± 0.18	26.1
	C	-	85.1 <sup>b</sup> ± 2.72	14.9 <sup>b</sup> ± 2.03	84.9 <sup>b</sup> ± 2.03	14.9 <sup>b</sup> ± 2.12	89.0 <sup>b</sup> ± 1.33	10.9 <sup>b</sup> ± 1.45	96.8 <sup>c</sup> ± 0.36	3.01 <sup>c</sup> ± 0.45	31.1
	p-value	-	0.003	0.002	0.002	0.002	0.016	0.017	0.001	0.011	-
Shoulder	A	6.98 ± 0.15	86.8 <sup>a</sup> ± 0.34	7.06 <sup>a</sup> ± 0.21	93.0 <sup>a</sup> ± 0.17	7.56 <sup>a</sup> ± 0.21	94.8 <sup>a</sup> ± 0.15	5.72 <sup>a</sup> ± 0.07	98.0 <sup>a</sup> ± 0.04	2.55 <sup>a</sup> ± 0.08	26.0
	AB	8.25 ± 0.09	80.1 <sup>b</sup> ± 2.16	11.6 <sup>b</sup> ± 1.92	87.5 <sup>b</sup> ± 2.17	12.7 <sup>b</sup> ± 2.12	90.9 <sup>b</sup> ± 0.88	9.28 <sup>b</sup> ± 0.78	97.2 <sup>a</sup> ± 0.25	2.98 <sup>a</sup> ± 0.29	30.7
	B	9.13 ± 0.43	80.4 <sup>b</sup> ± 2.67	10.6 <sup>ab</sup> ± 2.02	88.6 <sup>ab</sup> ± 2.46	11.6 <sup>ab</sup> ± 2.29	91.2 <sup>b</sup> ± 2.40	9.07 <sup>b</sup> ± 2.25	97.1 <sup>a</sup> ± 0.67	3.16 <sup>a</sup> ± 0.52	32.5
	C	10.4 ± 0.56	79.3 <sup>b</sup> ± 2.57	9.52 <sup>ab</sup> ± 1.65	89.2 <sup>ab</sup> ± 1.85	10.7 <sup>ab</sup> ± 1.97	91.0 <sup>b</sup> ± 1.31	8.92 <sup>ab</sup> ± 1.44	95.5 <sup>b</sup> ± 0.61	4.46 <sup>b</sup> ± 0.81	46.7
	p-value	-	0.009	0.044	0.034	0.04	0.026	0.041	0.001	0.009	-

<sup>#</sup>Age class was determined according the South African Carcass Classification System (Department of Agriculture, 1990)

<sup>></sup>Ratio intramuscular lipid to muscle

<sup>a,b,c</sup> Means in the same column per cut, with different superscripts differ significantly (p≤0.05).

### 4.3.3 The effect of trimming on the composition of beef

In **Table 4.3** the reduction of lipid content due to trimming is presented. Trimming of the subcutaneous fat layer reduced total lipid content by between 14% and 40%. Removing all visible fat from the raw edible portions decreased total lipid contribution by between 58% and 88%. In both the rump and shoulder cuts, the average chemical lipid content is reduced to less than 10% of edible portion when subcutaneous fat content is removed. When all visible fat is removed, all three cuts contained on average less than 6% chemical lipid per edible portion. The implications of the findings are that the contribution which South African beef makes to fat (lipid) intake can be significantly reduced if visible fat is removed.

**Table 4.3** The effect of trimming on the lipid content of South African beef

Cut	Age	Edible portion	Trimmed of subcutaneous fat		Trimmed of all visible fat	
		Lipid (g)	Lipid (g)	Reduction (%)	Lipid (g)	Reduction (%)
Prime rib	A	13.3	10.0	24.8	3.37	74.7
	AB	19.6	15.4	21.4	3.82	80.5
	B	21.0	17.2	18.1	4.87	76.8
	C	20.6	17.8	13.6	5.62	72.7
	Average	18.6	15.1	18.9	4.42	76.3
Rump	A	10.7	7.15	33.2	1.84	82.8
	AB	16.1	10.4	35.4	1.93	88.0
	B	17.4	10.5	39.7	2.54	85.4
	C	14.9	10.9	26.9	3.01	79.8
	Average	14.8	9.74	34.1	2.33	84.2
Shoulder	A	7.56	5.72	24.3	2.55	66.3
	AB	12.7	9.28	26.9	2.98	76.5
	B	11.6	9.07	21.8	3.16	72.8
	C	10.7	8.92	16.6	4.46	58.3
	Average	10.6	8.25	22.5	3.29	69.1

Lean beef can form part of a low fat or energy controlled diet. The fat content of South African beef cuts as found in this study compares favourably with that of other animal source foods (**Table 4.4**). Untrimmed, South African beef cuts from all ages compare well with untrimmed

lamb, mutton, pork and chicken with skin, with the exception of age C prime rib which contained notably more fat.

When trimmed of subcutaneous fat, South African rump and shoulder cuts from age A animals (7.15g and 5.72g per 100g) had a lower lipid content than the dark meat of chicken without the skin (7.62g fat / 100g dark chicken meat). When all visible fat is removed, i.e. if only marbling and muscle remains, all cuts from all the age groups have a lower lipid content than South African dark chicken meat without the skin, as well as pork shoulder trimmed of all visible fat. The lipid content of trimmed beef compares well with trimmed lamb and leg and loin pork cuts.

**Table 4.4** A comparison of the fat content of trimmed and untrimmed South African animal products (100g raw edible portion)

Food (100g, raw)	Fat (g)		
	Untrimmed	Trimmed of subcutaneous fat	Trimmed of all visible fat
Beef (age A), prime rib	13.3	10.0	3.37
Beef (age A), rump	10.7	7.15	1.84
Beef (age A), shoulder	7.56	5.72	2.55
Beef (age C) prime rib	20.6	17.8	5.62
Beef (age C), rump	14.9	10.9	3.01
Beef (age C), shoulder	10.7	8.92	4.46
Lamb (age A), leg <sup>^</sup>	10.2	6.15	3.84
Lamb (age A), loin <sup>^</sup>	16.7	11.3	4.96
Lamb (age A), shoulder <sup>^</sup>	13.0	9.63	5.80
Mutton (age C), leg <sup>^</sup>	11.0	6.77	-
Mutton (age C), loin <sup>^</sup>	18.8	11.4	-
Mutton (age C), shoulder <sup>^</sup>	13.4	9.46	-
Chicken, dark meat <sup>#</sup>	17.8	-	7.62
Chicken, white meat <sup>#</sup>	9.63	-	2.70
Pork, shoulder <sup>*&amp;</sup>	13.1	-	7.5
Pork, loin <sup>*&amp;</sup>	11.6	-	3.9
Pork, leg <sup>*&amp;</sup>	11.7	-	4.3

<sup>^</sup> (Schönfeldt, Hall, & Van Heerden, 2012)

<sup>#</sup> (Schonfeldt, Van Heerden, Van Niekerk, Visser, & Heinze, 1998)

<sup>\*</sup> (Van Heerden & Smith, 2013)

<sup>&</sup> (Van Heerden, Smith, Sainsbury, & Meissner, 2008)

#### 4.3.4 Changes in composition of South African beef over time

The physical (and consequently nutritional) composition of agricultural commodities such as red meat continuously changes over time. In **Table 4.5** the physical composition of South African beef over time is presented based on the composition of the prime rib cut. In the 1990s the lipid content of marketable South African beef carcasses from fat code 2 was determined as 19.8g/100g for A age carcasses, 19.9g/100g for AB age carcasses and 20.1g/100g for C age carcasses (Schönfeldt, Naudé, & Boshoff, 2010). These values show a decrease in the lipid content of marketable beef of 23% in the 1970s (Naudé, 1974).

**Table 4.5** Physical composition (bone, muscle, lipid) of marketable South African beef\* recorded over time

Year		1972 <sup>1</sup>	1984 <sup>2</sup>			1990 <sup>3</sup>			Current study			
Age		Not available	A	AB	C	A	AB	C	A	AB	B	C
Bone	%	13.7	-	-	-	17.7	17.9	20.4	17.3	18.4	18.3	21.0
Muscle	%	63.5	-	-	-	67.8	64.9	64.1	72.0	65.7	64.6	62.13
Fat	%	22.8	14.0	16.5	16.1	15.1	17.0	16.2	11.0	16.0	17.1	16.2

\*Physical composition of the whole carcass was predicted from the chemical composition of the prime rib cut (Naudé, 1972)

<sup>1</sup>Naudé, 1972

<sup>2</sup>Klingbiel, 1984

<sup>3</sup>Schonfeldt, Naudé & Boshoff, 2010 (publication of data generated in 1990s)

#Age class and fat codes were determined according to classification within the South African Carcass Classification System at the time of each study (Government Notice No. 992 of 20 May, 1949; Department of Agriculture, 1990)

The lipid percentage of South African age A beef has decreased from 15% to 11% since the 1990s, while the lipid percentage of age C carcasses has remained relatively constant at 16%. As age A carcasses are the most marketable carcasses in the consumer market, it is concluded that consumer demands for lean and tender meat are contributing reasons for the reduction in total lipid percentage through breeding and feeding practices.

The effect of uncontrollable variables that should be considered when data is compared with previous research studies includes the lack of knowledge related to the samples used in the referenced publications (Greenfield & Southgate, 2003). Characteristics such as breed, age and fatness were not reported in the previous studies referenced in **Table 4.5**. It is assumed that the



most marketable beef carcasses were included in the previous studies, as is the case with the current study. South African Bonsmara cattle were used in the current study as they represent 27% of the national stud herd, and more than 50% of feedlot cattle are Bonsmara-cross breeds. The carcasses included in the current study were also controlled for the most marketable fat class (fat code 2). Based on the assumption that the current data is representative of that which is available on the market, it seems reasonable to conclude that beef has decreased notably in lipid content and increased in muscle content since the 1980s (Department of Agriculture and Fisheries, 1981).

#### **4.4 CONCLUSIONS**

Due to breeding and feeding practices, the lipid content of South African beef has decreased substantially over time, and when further trimmed of visible fat, beef in fact compares well in terms of lipid content with other lean animal source foods such as chicken without skin, and trimmed mutton and pork. The average lipid content of lean South African beef cuts, containing muscle and intramuscular fat (marbling) of marketable age (age A) is less than 3.5g/100g. As animals age, fat content increases and muscle content decreases in all cuts. Yet, even when older animals are selected for consumption, trimming of visible fat (subcutaneous and intermuscular adipose tissue), age C beef cuts still contain less than 10% lipid, clearly indicating the possibility of including lean South African beef, as part of a healthy, balanced and energy controlled diet.

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## CHAPTER 5: FATTY ACIDS IN GRAIN FED AND GRASS FED BEEF: THE UNIQUE SOUTH AFRICAN SCENARIO

*The paper was also presented as an oral presentation at the 25<sup>th</sup> International Congress of the Nutrition Society of South Africa and the 13<sup>th</sup> Congress of the Association of Dietetics in South Africa. The paper presents results from the composition study supported by Red Meat Research and Development South African (RMRDSA) and the National Research Foundation (NRF). The results provide valuable insight on the beneficial fatty acid composition of South African beef and the differences observed in beef from the different production systems to be used in arguments towards sustainable developments of livestock production. This paper was submitted to Meat Science. The article is currently under review.*

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### ABSTRACT

Different fatty acids elicit different responses in the human body once ingested. Although red meat is often considered a source of fatty acids negatively impacting on human health (such as saturated fatty acids), many studies have reflected the variability in the quantity and quality of fatty acids found in red meat produced on different production systems in different countries. This study evaluated the fatty acid profile of South Africa beef as produced by the different production systems practiced in the country. Data is reported as percentage lipid per 100g total fat, and to ensure accurate estimation of the contribution which the products can make to human diets, the fatty acid composition was translated into edible portions, taking fat trimming (as a health trend often associated with red meat intake) into consideration.

Notable differences were found in the quantity and quality of different fatty acids between the production systems. As the South African classification system is unique and drives the characteristics of meat available to consumers, the results of the study also indicate distinctive differences between local red meat and data on international produce.

## 5.1 INTRODUCTION

The role of fat (and more recently the quality of fatty acids) in human diets has been given a great deal of attention throughout the past centuries and today the journal with the highest Impact Factor (12.963) on the ISI Web of Knowledge in the subcategory of Nutrition and Dietetics is the journal, *Progress on Lipid Research*. In 1850, The Lancet published The Gustomian Lectures, presented by Thomas King Chambers, entitled: *Corpulence; or, excess of fat in the human body: it's relations to chemistry and physiology, its bearings on other diseases and the value of human life, and its indications for treatment* (Chambers, 1850). Since the early 1900s, the roles of individual fatty acids in human health have been investigated and published (Annotations, 1925; Annotations, 1956). The first expert consultation on Fats and Oils in Human Nutrition was held in 1977 by the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) followed by the second expert consultation held in 1993. In 2008 the third and most recent consultation on the topic was held in Geneva from 10 to 14 November 2008. The timeframe of these Expert Consultations is also linked to the recognition of the increasing global burden of nutrition-related chronic disease (FAO, 2008). Other recent closely related publications of the FAO and WHO relating to the field of fats in human nutrition includes, among others, the 2002 Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases (WHO, 2003) and the FAO scientific update on *trans* fatty acids (Nishida & Uauy, 2009). These integrated efforts by the associated United Nations organizations along with relevant peer-reviewed research publications provide the scientific basis that guides strategies, programmes and national dietary guidelines (FAO, 2008).

It is the current position statement of the American Dietetic Association (ADA) and the Dietitians of Canada that *dietary fat for the adult population should provide 20% to 35% of energy and emphasize a reduction in saturated fatty acids and trans fatty acids, and an increase in the omega 3 polyunsaturated fatty acids*.

They furthermore recommend a food-based approach for achieving these guidelines, and include lean protein sources in their recommendations (American Dietetic Association, 2007). In South Africa, the national food-based dietary guidelines were reviewed in 2013, and arguments

presented in the scientific background paper of the fat guideline are in line with those made by the ADA. It is specifically noted that dietary fats should no longer be seen as merely a good source of energy, but as an essential component of the human diet.

The South African guidelines state that *total fat should provide 20% to 30% of daily energy intake and that polyunsaturated fatty acids should contribute 6% to 10% of energy. Omega 6 fatty acids should provide 5% to 8% of energy and omega 3 should provide 1% to 2% of energy. The remainder of the energy from total fat should be from monounsaturated fatty acids, with trans fatty acid intake being less than 1%* (Smuts & Wolmarans, 2013).

When considering dietary intake and food sources of fatty acids in human diets, animal sources of food (including red meat) have been previously noted to be responsible for providing a significant proportion of total and saturated fatty acids in westernised diets (O'Sullivan *et al.*, 2011). However, red meat can also provide essential fatty acids (McNeill *et al.*, 2012). Furthermore, changes in cattle breeding and management, as well as trimming of visible fat at retail or home, have resulted in leaner meat cuts with a lower total fat content, and often with a favourable fatty acid profile (McNeill *et al.*, 2012). Different production systems, and especially type of feed, have significantly altered the fatty acid profile of beef, and research has been published on the fatty acid profiles of grass fed and grain fed beef (Daley *et al.*, 2010). However, little data is available on the fatty acid profile of South African beef from different production (feeding) systems.

Similar to international trends, grain finishing of beef has increased in South Africa as it enables producers to respond more efficiently to consumer demand (Williams & Droulez, 2010; Capper, 2013). More than 70% of beef available to South African consumers is currently produced in this manner (Webb & Erasmus, 2013). Typically, weaned calves are sold to feedlots where they are given grain-based (or concentrated) diets for approximately 110 days to obtain the optimum fatness level according to the South African carcass classification system (Department of Agriculture, 1990) within a relatively short period of time (Webb & Erasmus, 2013). This method of production has also been shown to produce less greenhouse gas emissions (GHG) due to reduced resource use with an improved growth rate (Capper, 2013; Du Toit *et al.*, 2013).



However, some South African producers prefer to still produce beef on extensive (grass or forage based) feeding systems as they deliver a product with alternative attributes in line with many other social aspects of sustainable agriculture, i.e. producing naturally-produced or grass fed beef (Webb & Erasmus, 2013).

As with most other grading or classification systems, the South African carcass classification system dictates most of the attributes and characteristics of locally produced fresh beef produced for the consumer market. What make this system unique compared to other global classification or grading systems is that it classifies meat according to the amount of visible, subcutaneous (outside) fat on the carcass, as well as the age of the animal (Strydom, 2011).

Since the 1930s, studies on the nutritional and physical composition of South African red meat, together with consumer research, have assisted in guiding the development of the national carcass classification system over time (Naude *et al.*, 1990). In 1970, more than 70% of South Africans preferred between 3mm and 6mm fat covering on beef roasts (approximately 6% subcutaneous fat, and 18% dissectible carcass fat). A follow-up survey conducted in 1987 found that 77% of the population preferred a lower fat cover. Based on these results, the current classification system for South African beef, sheep, lamb and goats was introduced in 1992 (Naude *et al.*, 1990). As a baseline consideration, a lean fat cover on the carcass (between 1mm to 3mm thickness) achieves the optimum price in South Africa, and producers, irrespective of production system, aims to reach this fat cover prior to slaughter. Breeds and feeding techniques have been adapted over time to produce carcasses which reach this optimal fat cover using the lowest possible quantity of resources.

Grain based production systems have been formulated to produce beef with optimum characteristics from young animals in a short period of time. To reach the optimum fatness level attaining the best price incentive per slaughtered mass on extensive (grass or forage based) production systems does take a longer period of time than grain finishing, thus delivering meat from slightly older animals to the South African market. In addition to beef produced specifically for the meat market and slaughtered relatively young, old (culled or retired) animals – often produced from communal or marginal farming systems in South Africa - are also slaughtered for

human consumption. The beef products derived from these older carcasses are available on the market as a lower price for marginalized and emerging consumers who dominate the current South African population (Bureau of Food and Agricultural Policy, 2014). These animals typically spend their life on grass, but once they reach an age when they no longer produce offspring efficiently, they are sold to feedlots to be finished on grain for a short period of time to reach optimal fatness prior to slaughter.

This study evaluated the fatty acid profile of South Africa beef as produced by the different production systems practiced in the country. Although global country-specific research shows important differences, no data has previously been available to extrapolate the effect of feeding regime within the framework of the unique South African carcass classification system on the fatty acid profile of South African beef. Furthermore, meat science studies often only report on the differences in fatty acids as percentage of total fatty acids, or as grams per 100g total fat. To ensure accurate estimation of the contribution which the products can make to human diets, dietary advice and analyses should reflect red meat as consumed (Williams & Droulez, 2010). The current study aimed, in addition to fatty acids expressed as proportional to total fatty acids, to *trans* late the fatty acid composition into edible portions, taking fat trimming (as a health trend often associated with red meat intake) into consideration. This additional mode of expression of the results “as consumed” enables translation of the scientific findings to human dietary recommendations.

## 5.2 METHODOLOGY

Breed was identified as a controllable factor to minimize variation between the datasets (Van Elswyk & McNeill, 2014). Cattle from the Bonsmara breed were included in the study. The Bonsmara breed is a locally developed, predominant breed in South African with approximately 70% of the commercial beef herd being Bonsmara type medium framed cattle (Du Toit *et al.*, 2013).

Four different production groups were identified based on typical market share. Group 1 included young animals with 0 incisors (permanent teeth) which were grain-finished prior to

slaughter, group 2 included young animals with 1-2 incisors which were exclusively grass fed, group 3 included older animals with 2 to 6 permanent incisor from exclusive grass fed systems, and group 4 which consisted of old animals with more than 6 incisors. Animals from group 4 were originally from grass-based feeding systems, but were rounded off on grain based diets to the desired level of fatness.

Nine carcasses from each group were included in the study, and screened according to their fatness to fall within the optimum leanness of 1-3mm subcutaneous fat layer on the prime rib according to the South African carcass classification system (Department of Agriculture, 1990). All animals were slaughtered and dressed according to standard commercial procedures at the Agricultural Research Council registered abattoir in Irene, Pretoria, South Africa. Carcasses were electrically stimulated for 15 seconds (400 V peak, 5 ms pulses at 15 pulses/s) after exsanguination and entered the cold rooms (1–4 °C) 45 minutes after exsanguination. Carcasses were chilled at 0–3 °C before being processed the day after slaughter.

All carcasses were sectioned down the vertebral column. Cuts from the left side of each carcass were kept raw for nutritional analysis, while the cuts from the right sides were cooked prior to nutritional analysis. The sides were subdivided into the primal carcass cuts according to the London and Home Counties cutting techniques as described by Naudé (1974). The prime-rib cut was selected for analyses as it represents the composition of the carcass the best (Naude, 1972). An experienced deboning team was responsible for the physical dissection of the cuts. Dissection took place in an environmentally controlled de-boning room (10°C). The cuts were weighed and dissected into visible meat, subcutaneous fat (adipose tissue under the skin), intermuscular fat (adipose tissue between muscles) and bone. Each fraction was weighed and recorded, in order to calculate cut composition. After nutrient analysis, cut composition was used to calculate nutrient content.

For nutritional analysis, the muscle and fat fractions from three of the same cuts were grouped together as composite samples of muscle and composite samples of fat. These fractions were mixed, cubed, minced twice (5mm, then 3mm mesh plates), vacuum sealed and frozen. The samples were freeze dried and sent for nutritional analysis to be performed on a double blind

basis at the NutriLab, University of Pretoria, South Africa and the Department of Microbial, Biochemical and Food Biotechnology, University of the Free State. The proximate analyses of the cuts were carried out to determine total moisture (Official method of analysis 934.01, AOAC 2000), fat (ethanol extracted) (Official method of analysis 954.02, AOAC, 2000), nitrogen (Official method of analysis 968.06, AOAC, 2000.) and ash (Official method of analysis 942.05, AOAC, 2000) (AOAC 2005). The conversion factor of 6.25 was used in the calculation of the protein content (Jones, Munsey & Walker 1942). The method of Carroll and Conniffe (1967) was used to calculate physical composition from chemically analysed moisture, protein, ash and lipids together with the physical dissection data.

Total lipid from the meat samples was quantitatively extracted, according to the method of Folch *et al.* (1957). Total extractable lipid was determined gravimetrically from the extracted fat and expressed as % fat (w/w) per 100 g tissue. A lipid aliquot (20 mg) was converted to methyl esters by base-catalysed *trans* esterification, in order to avoid CLA isomerisation, as proposed by Park *et al.*, (2001), Kramer *et al.*, (2002) and Alfaia *et al.*, (2007). Fatty acid methyl esters (FAMES) from fat were quantified with flame ionization gas chromatography using a fused silica capillary column. Hydrogen functioned as the carrier gas, while nitrogen was employed as the makeup gas. Fatty acid methyl ester samples were identified by comparing the retention times of FAME peaks from samples with those of standards.

The data was statistically analysed with Genstat Software 2013 with Linear mixed models, using the Residual Maximum Likelihood (REML) procedure of GenStat(R). The analysis was used to test for differences between the effects of each group per cut. Fisher's protected least significant differences (FPLSD) test at the 1% level was used to separate means (Payne *et al.*, 2013).

## **5.3 RESULTS & DISCUSSION**

### **5.3.1 Fatty acid content as percentage of total fatty acids**

#### *5.3.1.1 Saturated fatty acids*

To enable comparison of results with the plethora of international and local research on fatty acid composition, the data is expressed as percentage fatty acids per total fatty acids (w/w)

(**Table 5.1**). No statistically significant difference was found between the total or individual saturated fatty acids (SFA) from South African beef produced on different production systems, except for arachidonic acid (C20:0). Arachidonic acid was not detected in group 1 (grain fed), while the two groups finished on pasture had a significantly higher percentage of arachidonic acid than group 4 (cullled animals finished on grain). A review by Daley *et al.*, (2010) also found little difference in the concentration of SFAs between production groups, with grass fed beef generally having a slightly higher total SFA content, similar to the results found in South Africa. When compared to international studies however, it can be seen that South African beef fat, irrespective of production system; contains on average a higher percentage of total SFA than in the USA, UK or Argentina (**Table 5.1**).

According to the ADA, animal fats contribute 60% of the total saturated fat intake of human diets, most of which are palmitic (C16:0) and stearic acid (C18:0) (American Dietetic Association, 2007). Stearic acid has been noted to have no biological effect association with raising total, LDL or HDL cholesterol, and has thus been termed a cholesterol neutral fatty acid (American Dietetic Association, 2007). Although the majority of fatty acids (>30% in all groups) found in South African beef are palmitic acid (C16:0) which could increase total and LDL cholesterol, a notable proportion (>20% in all groups) consists of the cholesterol neutral SFA, stearic acid (C18:0). Many studies have reported that grass finished beef contains a higher proportion of this cholesterol neutral fatty acid (Daley *et al.*, 2010), yet this is not seen in South African produced beef (**Table 5.1**). Variations between countries are also evident, with studies in the US, UK and Argentina reporting stearic acid values between 10% to 14% for grain fed beef, and 13% to 17% in grass fed beef, compared with 20% and 23% found for South African grain and grass fed beef respectively (**Table 5.1**).

#### 5.3.1.2 Monounsaturated fatty acids

The monounsaturated fatty acids (MUFAs) palmitoleic acid (C16:1) and oleic acid (C18:1) in human health have been shown to decrease total and LDL cholesterol (American Dietetic Association, 2007). More than 25% of fatty acids in South African beef is oleic acid (C18:1) (**Table 5.2**). Although no significant difference is found between the different groups, group 1

(young, grain finished beef) contained a slightly higher percentage of oleic acid than the other groups from grass based feeding systems (**Table 5.2**). Internationally, in the USA and Argentina, beef from grain based feeding systems contained a slightly higher proportion of MUFAs, compared to grass based feeding systems, similar to the results obtained in the current study. In the UK this tendency is reversed. It is also noted that, although they are prevalent in smaller quantities compared to palmitoleic and oleic acid, that heptadecenoic (C17:1) and eicosenoic acid (C20:1) differ significantly between the production groups.

#### 5.3.1.3 Polyunsaturated fatty acids

Polyunsaturated fatty acids (PUFAs) are commonly known as beneficial fatty acids that lower total and LDL cholesterol, with certain PUFAs exhibiting anti-cancer properties as well as anti-inflammatory responses and other cardiovascular benefits. The omega 3 and omega 6 PUFAs are required in the diets of humans as they cannot be synthesized within the human body, and function as the carriers of fat soluble vitamins and play an integral role in the immune system (Webb & O'Neill, 2008).

In the current research study, it was found that beef finished on grain finished diets (groups 1 and 4) contained a statistically significant higher proportion of PUFAs than grass fed beef ( $p = 0.005$ ) (**Table 5.3**). The majority of the PUFA were linoleic acid (C18:2), an omega 6 fatty acid. This finding is similar to studies in the UK (Enser *et al.*, 1996) and Argentina (Garcia *et al.*, 2008) which notably reported more (between 2 and 3 times) omega 6 fatty acids in grain fed beef than in grass fed beef (**Table 5.3**). The concentration of omega 3 fatty acids (specifically alpha-linolenic acid (C18:3)), were found to be significantly higher in the two groups from grass-based feeding systems, than the groups finished on grain ( $p < 0.001$ ). This higher ratio of omega 3's in grass fed beef has been recorded internationally (Enser *et al.*, 1996; Duckett *et al.*, 2009; Garcia *et al.*, 2008).

Research has shown significantly more omega fatty acids in phospholipids (an essential component of the cell-membranes of muscles), and a declining proportion of phospholipids to total fat, as total fat of the carcass increases (32). What this means is that the higher the

intermuscular and subcutaneous fat content of beef, the lower the proportion of PUFA to total fat would be. Although the amount of subcutaneous fat is not reported in the current study, the assumption can be made that as grain finished beef contained significantly higher proportions of PUFAs (**Table 5.3**), this grain finished beef possibly contained less subcutaneous fat than intramuscular fat.

**Table 5.1** Saturated fatty acid composition of South African beef produced on different production systems\*, expressed as percentage (%) total fatty acids and compared to international data

Fatty acid	Current study (RSA)						USA (Duckett <i>et al.</i> , 2009)		UK (Enser <i>et al.</i> , 1996)		Argentina (Garcia <i>et al.</i> , 2008)	
	Group 1	Group 2	Group 3	Group 4	P-Value	Std Error	Grass	Grain	Grass	Grain	Grass	Grain
<b>Myristic (C14:0)</b>	5.13	4.82	5.48	5.02	0.51	0.3	2.46	2.79	2.31	2.49	2.19	2.44
<b>Palmitic (C16:0)</b>	31.4	31.6	33.1	31.7	0.58	0.92	0.59	0.45	24.3	23.2	23.1	22.1
<b>Margaric (C17:0)</b>	-	2.03	1.80	1.69	0.09	0.09	1.14	1.34	-	-	1.39	1.69
<b>Stearic (C18:0)</b>	20.0	23.0	21.0	24.3	0.31	1.64	17.4	14.0	15.8	13.7	13.1	10.8
<b>Arachidonic (C20:0)</b>	-	0.50 <sup>a</sup>	0.47 <sup>a</sup>	0.28 <sup>b</sup>	0.04	0.05	-	-	-	-	-	-
<b>Total SFA</b>	56.5	61.9	61.9	62.9	0.08	1.59	44.2	43.4	42.4	39.4	40.4	37.5

\*Group 1: young, grain finished beef; Group 2: Young, grass finished beef; Group 3: Older, grass finished beef; Group 4: Old, culled cows, traditionally from grass, finished off on grain based feeding systems

#Mean of all production groups included in the study

- Not detected during analyses

<sup>a,b,c</sup> Mean values in a row with different superscript differ significantly in fatty acid content between the different production groups (p<0.05)



**Table 5.2** Monounsaturated fatty acid content of South African beef produced on different production systems\*, expressed as percentage (%) total fatty acids and compared to international data

Fatty acid	Current study (RSA)						USA (Duckett <i>et al.</i> , 2009)		UK (Enser <i>et al.</i> , 1996)		Argentina (Garcia <i>et al.</i> , 2008)	
	Group 1	Group 2	Group 3	Group 4	P-Value	Std Error	Grass	Grain	Grass	Grain	Grass	Grain
<b>Myristoleic (C14:1)</b>	-	-	-	-	-	-	0.38	0.60	-	-	0.48	0.67
<b>Palmitoleic (C16:1)</b>	3.38	3.83	4.38	3.23	0.06	0.27	2.72	3.46	3.65	3.58	3.35	3.82
<b>Heptadecenoic (C17:1)</b>	-	0.68 <sup>a</sup>	0.68 <sup>a</sup>	0.46 <sup>b</sup>	0.003	0.03	-	-	-	-	0.96	1.63
<b>Elaidic (C18:1t9)</b>	5.97 <sup>a</sup>	5.10 <sup>ab</sup>	4.17 <sup>b</sup>	4.68 <sup>ab</sup>	0.03	0.33	3.38	1.83	2.50	2.69	3.22	4.35
<b>Oleic (C18:1c9)</b>	31.5	26.3	26.9	26.1	0.1	1.49	32.0	39.4	35.9	31.9	31.2	32.8
<b>Eicosenoic (C20:1)</b>	0.14 <sup>a</sup>	0.49 <sup>c</sup>	0.40 <sup>bc</sup>	0.31 <sup>ab</sup>	0.01	0.06	-	-	-	-	-	-
<b>TOTAL MUFA</b>	40.9	36.4	36.5	34.7	0.08	1.47	38.5	45.3	42.1	38.2	39.2	43.3

\*Group 1: young, grain finished beef; Group 2: Young, grass finished beef; Group 3: Older, grass finished beef; Group 4: Old, culled cows, traditionally from grass, finished off on grain based feeding systems

#Mean of all production groups included in the study

- Not detected during analyses

<sup>a,b,c</sup> Mean values in a row with different superscript differ significantly in fatty acid content between the different production groups (p≤0.05)

**Table 5.3** Polyunsaturated fatty acid composition of South African beef produced on different production systems\*, expressed as percentage (%) total fatty acids and compared to international data

Fatty acid	Current study (RSA)						USA (Duckett <i>et al.</i> , 2009)		UK (Enser <i>et al.</i> , 1996)		Argentina (Garcia <i>et al.</i> , 2008)	
	Group 1	Group 2	Group 3	Group 4	P-Value	Std Error	Grass	Grain	Grass	Grain	Grass	Grain
<b>Linoleic (C18:2 n6)</b>	2.32 <sup>a</sup>	0.91 <sup>b</sup>	0.83 <sup>b</sup>	1.21 <sup>b</sup>	<0.001	0.13	2.75	2.97	2.50	8.28	3.41	6.19
<b>Gamma-linolenic (C18:3 n6)</b>	-	0.17	0.2	0.09	0.31	0.03	-	-	0.02	0.05	-	-
<b>Alpha-linolenic (C18:3 n3)</b>	0.30 <sup>a</sup>	0.73 <sup>c</sup>	0.64 <sup>bc</sup>	0.50 <sup>b</sup>	<0.001	0.04	1.08	0.37	1.23	0.52	1.30	0.28
<b>CLA (C18:2c9,t11)</b>	0.36 <sup>a</sup>	0.75 <sup>c</sup>	0.73 <sup>bc</sup>	0.54 <sup>ab</sup>	0.002	0.05	0.78	0.36	-	-	0.72	0.31
<b>TOTAL PUFA</b>	2.62 <sup>a</sup>	1.69 <sup>b</sup>	1.60 <sup>b</sup>	2.42 <sup>a</sup>	0.003	0.15	6.09	4.50	6.65	12.9	8.67	9.62

\*Group 1: young, grain finished beef; Group 2: Young, grass finished beef; Group 3: Older, grass finished beef; Group 4: Old, culled cows, traditionally from grass, finished off on grain based feeding systems

#Mean of all production groups included in the study

- Not detected during analyses

<sup>a,b,c</sup> Mean values in a row with different superscript differ significantly in fatty acid content between the different production groups (p≤0.05)

### 5.3.2 Fatty acid composition per edible portion and the effect of trimming

To extrapolate the fatty acid composition of food to human diets, compositional values need to be expressed as per edible portion. Calculating the fatty acid composition per edible portion requires knowledge on the amount of fat and meat tissue present. In **Table 5.4** the fat content of beef from the four groups, and the effect of trimming on this composition, is presented.

#### 5.3.2.1 Total fat content

In 1984 an Australian study already reported that nearly 50% of women and 30% of men thought that trimming fat from meat was very important for health (Worsley & Crawford, 1985). A review of national studies in Australia showed that this preference towards trimming increased from 48% (percentage of meat and poultry reported to be trimmed) in 1983 to 55% in 1996. The percentages were higher for red meats than for poultry in 1995 (67% trimmed red meat, while 47% trimmed poultry) (Cobiac *et al.*, 2000). In South Africa as a result of lean produce also being increasingly popular, the average fat content of South African target market beef has decreased over time, from 22% fat on raw carcasses in the 1970s to less than 12% in 2014 (Hall *et al.*, 2014).

Most of the beef produced in South Africa falls within group 1 of the current study, and interestingly, this grain fed group also has the least amount of fat per edible portion (**Table 5.4**), as well as the lowest intermuscular fat percentage of all the production groups (Hall *et al.*, 2014). This is in direct contrast to the findings from a review of four studies on the composition of beef in the United States which found that grass or forage feeding significantly lowers total fat content (Daley *et al.*, 2010; Van Elswyk & McNeill, 2014), probably due to the notable differences in our production and classification (grading) systems.

Although group 1 had a lower fat content (**Table 5.4**), when cooked and untrimmed, there was no statistically significant difference in total fat content (g/100g) between beef produced on the different production systems, and fat content ranged between 17g and 22g per 100g. When trimmed of the subcutaneous (outside) fat cover after cooking, fat content increased significantly with animal age ( $p = 0.019$ ) (culler, grain finished, animals in group 4 had significantly more fat

than young grain finished animals in group 1). When trimmed of all visible fat, i.e. trimmed of subcutaneous and intermuscular fat with only marbling (intramuscular fat) remaining, young animals from feedlots contained significantly less fat ( $p = 0.007$ ) than the other production groups. Translated to human consumption, a 100g portion of trimmed beef from young feedlot animals would contain between 3g and 4g less fat per 100g than beef from grass or forage based feeding systems (**Table 5.4**).

It should be noted that as the cuts were cooked with all fat intact, and only trimmed after cooking, the values for total fat content of all the groups is relatively high due to fat basting the meat during cooking. When South African beef cuts from the four groups were trimmed prior to cooking, raw edible portions had a notably lower total fat content (Hall *et al.*, 2014). This should be kept in mind when dietary recommendations are made regarding preparation techniques, i.e. promote trimming of visible fat prior to cooking.

#### 5.3.2.2 Saturated fatty acids

When evaluating fatty acid composition of edible portions, no statistically significant differences are seen for either total SFA, MUFA or PUFA content between untrimmed edible portions of South African beef from different production systems. However, when fully trimmed significant differences are observed. Not only is total fat content lower, but the total SFA content is significantly lower in fully trimmed young, grain fed animals from group 1 ( $p = 0.003$ ), compared to animals from the other groups.

Untrimmed, the SFA's lauric acid (C12:0), pentadecydic acid (C15:0) and arachidic acid (C20:0) were significantly less in group 1 and 4 (groups finished off on grain based diets). When fully trimmed of all visible fat, these young, grain fed animals from group 1 contained significantly less stearic acid (C18:0) and palmitic acid (C16:0) than all the other groups, and less lauric (C12:0), myristic (C14:0), pentadecydic (C15:0) and arachidic acid (C20:0) than the two exclusively grass fed groups (group 2 and 3) (**Table 5.2**). When fully trimmed, a 100g serving of South African beef from grain based feeding will deliver at least 1g less SFA than the same

serving of grass fed beef. For beef produced in the United States, the SFA content is also observed to be lower in grain fed beef than in grass fed beef (Van Elswyk & McNeill, 2014).

### 5.3.2.3 *Monounsaturated fatty acids*

Beef is known to be a primary source of MUFAs in Western diets, with the most common source being oleic acid (C18:1). In the United States, it has been found that oleic acid increases in beef as marbling differentiates, and grass fed beef in the states contain between 30 and 70% less MUFA than grain fed beef with a higher degree of marbling (Van Elswyk & McNeill, 2014). In South Africa no statistically significant difference is seen in the MUFA content between the different production systems (**Table 5.4**), most probably due to the fact that the South African classification or grading system does not promote marbling, and young, target grade beef is produced as lean as possible, and in fact contains somewhat less (although not statistically significant) MUFAs than the slightly fattier grass fed beef produce that contain slightly more total fat (**Table 5.4**). In the context of dietary recommendations, in the US, research has predicted that increasing the consumption of grass fed beef in favour of grain-finished beef could negatively impact the MUFA:SFA ratio (Van Elswyk & McNeill, 2014). This in turn could lower plasma HDL cholesterol, increase triglycerides and increase LDL cholesterol. As no statistically significant difference is seen between the MUFA content of South African grass fed versus grain fed beef, this same hypothesis cannot be made for South African produce.

### 5.3.2.4 *Omega 6 and omega 3 polyunsaturated fatty acids*

The polyunsaturated fatty acid (PUFA) content of beef is relatively low, averaging up to 5% of total fatty acids (Van Elswyk & McNeill, 2014). Daley *et al.*, (2010) has found that PUFA in US beef increases by as much as 25% in response to grass-feeding, however, with the lower total fat content of grass fed beef in the US, the total amount of PUFA consumed from grass fed beef may in fact be lower than that consumed from grain fed beef. In South Africa, little difference is seen in the total fat and total PUFA content of untrimmed beef produced on the different production systems (**Table 5.4**). However, noteworthy statistically significant differences are seen between the individual PUFAs, particularly as related to omega 6 and omega 3 fatty acids.

The omega 6 fatty acids linoleic acid (C18:2) is the primary PUFA found in beef. In South African untrimmed beef linoleic acid (C18:2c9) (omega 6) was significantly more prevalent in grain finished produce, whereas alpha-linolenic acid (C18:3c9) (omega 3) was found to be significantly higher in the grass finished red meat (groups 2 and 3), similar to results found by Warren *et al* (2008) which reported that omega 3 fatty acids (C18:3n-3) in beef muscles from grass silage based diets were higher than those from grain-based diets and omega 6 fatty acids (C18:2n-6) from grain-based concentrate diets was higher in muscles than in beef fed grass silage diets. This finding is not influenced by trimming (**Table 5.4**).

It has been recommended that a healthy diet should consist of up to four times more omega 6 fatty acids than omega 3 fatty acids, yet the majority of Western diets contain between 10 and 30 times more omega 6 than omega 3 fatty acids (Daley *et al.*, 2010). This scenario has been associated with the rise in inflammatory disorders in many Westernised populations (Daley *et al.*, 2010). In South African beef, the young, grain fed beef contains about 20 times more omega 6 than omega 3 fatty acids, whereas grass fed beef contains only twice as much omega 6 as omega 3 fatty acids, attributed to the generally high concentration of omega 3 fatty acids (specifically alpha-linolenic acid) in grass fed beef. This favourable relationship needs to be further investigated, but it seems as if grass fed beef can positively contribute to the intake of omega 3 fatty acids in South African diets.

It should however be considered that, although not firmly established, evidence from prospective secondary prevention studies suggests that intakes of omega 3 fatty acids ranging from 0.5 to 1.8 grams per day significantly reduce the number of deaths from heart disease (Kris-Etherton *et al.*, 2003). Even in the untrimmed groups, South African beef contained only between 0.01 (grain fed) and 0.05 (grass fed) grams of omega 3 fatty acids per 100g product. Caution should be made before recommendations are made to increase consumption of beef for omega 3 intakes. An unreasonable amounts of all groups of beef, irrespective of the statistically significant difference between the feeding groups, needs to be consumed per day to meet the 0.5 grams per day minimum requirement.

#### 5.3.2.5 Conjugated linoleic acid (CLA)

While non-conjugated *trans* fatty acids derived from partially hydrogenated vegetable oils may adversely influence human health, research has found that conjugated *trans* fatty acids produced by ruminant animals, mainly conjugated linoleic acid (CLA), have various beneficial health implications (Dilzer & Yeonhwa, 2012). CLA consists of a grouping of isomers of linoleic acid (C18:2). There is currently ample research focus on the long-term health implications of CLA intake, however, many findings are still inconclusive (Onakpoya *et al.*, 2012; Dilzer & Yeonhwa, 2012).

CLA is predominantly found in the milk and meat of ruminant animals, produced by a microbial process in the rumen of these animals. Fish and some vegetable products have also been documented to contain smaller concentrations of CLA (Chin *et al.*, 1992). A review on the CLA content of meat and meat products found the reported values for CLA concentrations in raw beef to be between 1.2 and 10.0 mg/g fat, varying significantly between countries, production systems and cuts of the carcass (Schmid *et al.*, 2006; Pestena *et al.*, 2012; Van Elswyk & McNeill, 2014). Conjugated linoleic acid (CLA) in South African beef was significantly higher ( $p < 0.05$ ) in beef spending most of their lives on grass (groups 2,3 and 4) than in the beef finished on grains (group 1), irrespective of the degree of trimming (**Table 5.4**). Research has shown that animal diet significantly influences CLA content, with meat from pasture fed animals consistently showing higher concentrations than those from grain or concentrate based diets (Schmid *et al.*, 2006). Higher CLA content has also been associated with higher intramuscular fat content, explaining why CLA content only decreases somewhat with trimming of visible fat (Raes *et al.*, 2004).

Optimal dietary intake levels for CLA still need to be established. In the 1980s results from rat studies reported that an intake of 3.5g CLA per day was needed to elicit human health benefits (Ha *et al.*, 1989), while in the 1990s studies recommended that as little as 95mg CLA per day would be sufficient to show positive effects in the reduction of breast cancer (Enser *et al.*, 1999). In 2001, researchers reported values of 620mg/day for men and 441mg/day for women which could have an anticarcinogenic effect (Ritzenthaler *et al.*, 2001). The average intakes of CLA

from natural sources are estimated at 151-212mg per day in the United States, and 97.5mg/day in Britain (Ritzenthaler *et al.*, 2001; Dilzer & Yeonhwa, 2012). According to Schmid *et al.*, (2006), meat and meat products contribute approximately 25-30% of total dietary CLA intake in Western populations. South African beef contain between 10mg and 60mg per 100g portion, depending on production system and degree of trimming (**Table 5.4**), with untrimmed grass fed beef providing the highest quantity of beneficial CLA per edible portion at 60mg per 100g cooked portion.



**Table 5.4** The fat and fatty acid composition of trimmed and untrimmed portions of South African beef produced on different production systems per 100g\*

Fat / fatty acid	Unit	Untrimmed cooked portion						Trimmed of subcutaneous fat						Trimmed of subcutaneous and intermuscular fat					
		Group 1	Group 2	Group 3	Group 4	p-value	Std error	Group 1	Group 2	Group 3	Group 4	p-value	Std error	Group 1	Group 2	Group 3	Group 4	p-value	Std error
<b>Total fat</b>	g	17.5	20.4	20.6	21.6	0.06	0.91	14.5 <sup>a</sup>	16.3 <sup>ab</sup>	19.6 <sup>ab</sup>	19.7 <sup>b</sup>	0.02	0.90	6.96 <sup>a</sup>	9.77 <sup>b</sup>	10.3 <sup>b</sup>	10.4 <sup>b</sup>	0.01	0.55
<b>Lauric C12:0</b>	g	0.005 <sup>a</sup>	0.01 <sup>ab</sup>	0.01 <sup>b</sup>	0.005 <sup>a</sup>	0.03	0.001	0.004 <sup>a</sup>	0.007 <sup>ab</sup>	0.009 <sup>b</sup>	0.004 <sup>a</sup>	0.02	0.001	0.002 <sup>a</sup>	0.004 <sup>b</sup>	0.005 <sup>b</sup>	0.002 <sup>a</sup>	0.001	0.0004
<b>Myristic C14:0</b>	g	0.34	0.42	0.51	0.4	0.23	0.05	0.28	0.34	0.43	0.37	0.13	0.04	0.14 <sup>a</sup>	0.20 <sup>b</sup>	0.21 <sup>b</sup>	0.19 <sup>ab</sup>	0.005	0.01
<b>Myristoleic C14:1c9</b>	g	0.04 <sup>a</sup>	0.05 <sup>ab</sup>	0.07 <sup>b</sup>	0.04 <sup>a</sup>	0.04	0.01	0.03 <sup>a</sup>	0.04 <sup>ab</sup>	0.06 <sup>b</sup>	0.04 <sup>a</sup>	0.04	0.01	0.02 <sup>a</sup>	0.02 <sup>a</sup>	0.04 <sup>b</sup>	0.02 <sup>a</sup>	0.004	0.003
<b>Pentadecylic C15:0</b>	g	0.06 <sup>a</sup>	0.11 <sup>b</sup>	0.11 <sup>b</sup>	0.05 <sup>a</sup>	0.01	0.01	0.05 <sup>a</sup>	0.09 <sup>b</sup>	0.09 <sup>b</sup>	0.04 <sup>a</sup>	0.01	0.01	0.02 <sup>a</sup>	0.05 <sup>b</sup>	0.05 <sup>b</sup>	0.02 <sup>a</sup>	<0.001	0.003
<b>Palmitic C16:0</b>	g	2.6	3.43	3.75	3.33	0.16	0.32	2.15	2.74	3.19	3.03	0.08	0.25	1.04 <sup>a</sup>	1.64 <sup>b</sup>	1.83 <sup>b</sup>	1.61 <sup>b</sup>	0.002	0.09
<b>Palmitoleic C16:1c9</b>	g	0.21	0.27	0.39	0.27	0.06	0.04	0.17 <sup>a</sup>	0.21 <sup>ab</sup>	0.33 <sup>b</sup>	0.24 <sup>ab</sup>	0.03	0.03	0.08 <sup>a</sup>	0.13 <sup>a</sup>	0.19 <sup>b</sup>	0.13 <sup>a</sup>	0.003	0.01
<b>Margaric C17:0</b>	g	0.15	0.18	0.18	0.12	0.08	0.02	0.12	0.14	0.15	0.11	0.17	0.01	0.06 <sup>a</sup>	0.09 <sup>b</sup>	0.09 <sup>b</sup>	0.06 <sup>a</sup>	0.01	0.01
<b>Stearic acid C18:0</b>	g	2.13	2.67	2.62	2.74	0.27	0.22	1.76	2.14	2.23	2.49	0.11	0.18	0.86 <sup>a</sup>	1.28 <sup>b</sup>	1.27 <sup>b</sup>	1.32 <sup>b</sup>	0.01	0.08
<b>Elaidic C18:1t9</b>	g	0.04 <sup>a</sup>	0.03 <sup>b</sup>	0.02 <sup>b</sup>	0.03 <sup>ab</sup>	0.02	0.003	0.03 <sup>a</sup>	0.02 <sup>ab</sup>	0.02 <sup>b</sup>	0.03 <sup>ab</sup>	0.04	0.00	0.02	0.01	0.01	0.01	0.21	0.002
<b>Oleic C18:1c9</b>	g	3.12	3.6	3.81	3.51	0.65	0.39	2.58	2.89	3.25	3.20	0.49	0.33	1.24	1.72	1.88	1.70	0.10	0.16
<b>Vaccenic C18:1c7</b>	g	0.24	0.17	0.11	0.14	0.08	0.03	0.20	0.14	0.10	0.13	0.14	0.03	0.10	0.08	0.06	0.07	0.43	0.02
<b>Linoleic C18:2c9</b>	g	0.21 <sup>a</sup>	0.04 <sup>b</sup>	0.05 <sup>b</sup>	0.13 <sup>ab</sup>	0.01	0.03	0.17 <sup>a</sup>	0.03 <sup>b</sup>	0.04 <sup>b</sup>	0.12 <sup>ab</sup>	0.01	0.02	0.08 <sup>a</sup>	0.02 <sup>b</sup>	0.02 <sup>b</sup>	0.06 <sup>ab</sup>	0.02	0.01
<b>Arachidic C20:0</b>	g	0.01 <sup>a</sup>	0.07 <sup>b</sup>	0.07 <sup>b</sup>	0.03 <sup>a</sup>	0.002	0.01	0.01 <sup>a</sup>	0.05 <sup>b</sup>	0.06 <sup>b</sup>	0.03 <sup>a</sup>	0.003	0.01	0.01 <sup>a</sup>	0.03 <sup>b</sup>	0.03 <sup>b</sup>	0.01 <sup>a</sup>	<0.001	0.002
<b>Eicosenoic C20:1c11</b>	g	0.01	0.01	0.01	0.01	0.93	0.002	0.01	0.01	0.01	0.01	0.95	0.002	0.004	0.004	0.004	0.004	1.00	0.001
<b>CLA C18:2c9,t11</b>	g	0.02 <sup>a</sup>	0.06 <sup>b</sup>	0.06 <sup>b</sup>	0.04 <sup>ab</sup>	0.01	0.01	0.02 <sup>a</sup>	0.05 <sup>b</sup>	0.05 <sup>b</sup>	0.04 <sup>b</sup>	0.005	0.01	0.01 <sup>a</sup>	0.04 <sup>c</sup>	0.03 <sup>c</sup>	0.02 <sup>b</sup>	<0.001	0.002
<b>α-Linolenic C18:3c9</b>	g	0.01 <sup>a</sup>	0.05 <sup>b</sup>	0.05 <sup>b</sup>	0.02 <sup>a</sup>	0.001	0.01	0.01 <sup>a</sup>	0.04 <sup>b</sup>	0.04 <sup>b</sup>	0.02 <sup>a</sup>	0.002	0.00	0.004 <sup>a</sup>	0.02 <sup>b</sup>	0.02 <sup>b</sup>	0.01 <sup>a</sup>	<0.001	0.002
<b>Total SFA</b>	g	5.31	6.88	7.24	6.66	0.20	0.61	4.39	5.51	6.16	6.07	0.10	0.48	2.16 <sup>a</sup>	3.30 <sup>b</sup>	3.52 <sup>b</sup>	3.22 <sup>b</sup>	0.003	0.18
<b>Total MUFA</b>	g	3.66	4.12	4.42	3.99	0.67	0.43	3.02	3.31	3.77	3.65	0.52	0.37	1.45	1.97	2.18	1.94	0.11	0.18
<b>Total PUFA</b>	g	0.23	0.15	0.16	0.19	0.20	0.03	0.19	0.12	0.14	0.18	0.17	0.02	0.09	0.07	0.08	0.09	0.47	0.01
<b>Total Omega- 6</b>	g	0.23	0.10	0.11	0.17	0.05	0.03	0.19	0.08	0.10	0.16	0.06	0.03	0.09	0.05	0.05	0.08	0.13	0.01
<b>Total Omega- 3</b>	g	0.01 <sup>a</sup>	0.05 <sup>b</sup>	0.05 <sup>b</sup>	0.02 <sup>a</sup>	0.005	0.01	0.01 <sup>a</sup>	0.04 <sup>b</sup>	0.04 <sup>b</sup>	0.02 <sup>a</sup>	0.002	0.004	0.004 <sup>a</sup>	0.02 <sup>b</sup>	0.02 <sup>b</sup>	0.01 <sup>a</sup>	<0.001	0.002

\*Group 1: young, grain finished beef; Group 2: Young, grass finished beef; Group 3: Older, grass finished beef; Group 4: Old, culled cows, traditionally from grass, finished off on grain based feeding systems

<sup>a,b,c</sup> Mean values in a column with different superscript differ significantly in fatty acid content between the different production groups (p≤0.05)

## 5.4 CONCLUSIONS

The study found that South African beef from young animals fed on grain based diets, contain less total fat per edible portion than grass finished beef. Grain finished animals produce beef that, if trimmed of all visible fat, contains less saturated fat than grass fed beef, which is contradictory to most research done in other westernised countries such as the US where grain fed beef is observed to be significantly higher in total fat, and subsequently, higher in SFA per edible portion. This finding for South African meat can most probably be linked to the current classification system (grading system) which drives price, and is based on consumer research promoting the production of leaner beef carcasses for optimal market price. Beef from grass based feeding systems contained significantly more total fat (when trimmed) as a result of more intramuscular fat (marbling), as well as more omega 3 fatty acids and more CLA per edible portion (when trimmed or untrimmed). Dietary recommendations on the consumption of South African beef as related to fatty acid intake should thus be considered within a unique context, as these results are clearly specific to the country and its exclusive production and classification system.

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## CHAPTER 6: THE IMPACT OF ANIMAL SOURCE FOOD PRODUCTS ON HUMAN NUTRITION AND HEALTH IN SOUTH AFRICA

*This paper was submitted as an invited paper to the South African Journal of Animal Science Special Issue: A balanced perspective on animal production, from environment to human health. This review article provides an overview of the nutritional quality of animal source foods to provide evidence supporting arguments related to environmental issues associated with livestock production. (SAJAS, 2013, 41(3), p394-412)*

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### ABSTRACT

Throughout the ages the quest for food and drink has influenced humanity's economic, social and political development, and played a role in the organization of society and history. Nutrition (or what we choose to consume) influences the health of human beings and therefore their quality of life. Animal source foods are often the dietary component that evokes the widest array of complex scientific, economic, environmental and political issues. It is viewed as the most expensive component of any diet, yet can make significant contributions to human health by providing high quantities of essential nutrients. In addition to quantity, the high quality of the nutrients in animal source foods is important as high-quality nutrients are more readily absorbed into the human body than lower-quality nutrients from other food and non-food sources. As South Africans increasingly suffer the consequences of inappropriate diets (over- and undernutrition), the role of animal source foods as part of a healthy diet requires continuous investment in research and extrapolation of information to formulate appropriate guidelines and recommendations. Although it is often suggested that the intake of animal source foods should be limited because of possible linkages between animal product consumption and health, scientific evidence increasingly indicates the beneficial role that animal source foods can play in preventing and combating obesity and certain non-communicable diseases related to overnutrition. This article aims to describe the nutritional role of animal source foods as part of a healthy South African diet and presents a review of recent findings related to their nutrient contribution, as well as evidence relating to common health concerns.



## 6.1 INTRODUCTION

The contributions made to the diet by products from livestock such as cattle, sheep, goats, pigs, chickens, fish and a dozen or so lesser known species can either be beneficial or harmful to overall human health. In appropriate amounts animal source foods are valuable sources of complete, high quality, easily digestible protein and many essential micronutrients such as iron, zinc, calcium, vitamin A and vitamin B<sub>12</sub>. On the other side of the malnutrition scale, the overconsumption of food, and specifically foods high in saturated fat and cholesterol, salt (sodium) and total energy have been linked to overweight, obesity and resulting diseases of lifestyle (WHO, 2007).

To maintain a healthy balance, it is recommended to consume a balanced diet containing a diversity of foods from all the different food groups, including starchy foods and cereals, vegetables and fruit, dairy products, meat and meat alternatives, as well as fats and sugars in minimal quantities.

The rapid increase in overweight and obesity, in the midst of persistent nutritional deficiencies, has increased the focus on dietary choices. Animal source foods are often a subject of this debate, because of the potential of animal source foods to be nutrient dense (defined as a high ratio of nutrients (in grams) compared to the total energy content (in kilojoules) of a specific food product) and the possibility that certain animal source food options could be considered high in fat, saturated fat and total energy.

To highlight the severity of nutritional imbalances (due to both over- and undernutrition) in South Africa, it should be kept in mind that the five of the top 10 risk factors for death are directly related to dietary choice, overweight and obesity, namely high blood pressure, excess body weight, high cholesterol, diabetes and physical inactivity. In comparison to the significant burden which overweight and obesity has on South Africans, childhood and maternal underweight are ranked as the 12<sup>th</sup> greatest risk factor for death, with vitamin A deficiency 14<sup>th</sup> and iron deficiency anaemia 16<sup>th</sup> (Norman *et al.*, 2007). In this article the role of animal source foods in relation to health concerns related to both undernutrition and overnutrition are discussed.

### **6.1.1 Undernutrition, related health risks and the role of animal source foods**

The global fight against hunger is well recognised, and ample policies are in place to increase food availability and access. Yet, the provision of energy, without the adequate intake of critical nutrients such as protein and micronutrients, may increase weight but not height. This may promote adipose tissue (fat) gain and obesity, while not contributing to other dietary needs such as protein and micronutrient requirements. This, furthermore, may contribute to the prevalence of both stunting and obesity within a single individual (Uauy & Kain, 2002), which is increasingly observed in South Africa (NFCS-FB-I, 2008; SANHANES-1, 2013b). An insufficient supply of nutrients to the human body restricts and retards not only physical development, but also cognitive (mental) development, and both manifest as prominent financial and social burdens on a society. The United Nations Standing Committee on Nutrition has concluded that nutrition is an essential foundation for poverty alleviation, and good nutrition is essential to meet the Millennium Development Goals (MDGs) which are related to improved education, gender equality, child mortality, maternal health and disease (FAO, 2004).

### **6.1.2 Undernutrition in South Africa**

In South Africa, stunting in children (indicating severe micronutrient deficiencies during the growing years) is a significant concern. Stunting is a risk factor for increased mortality, poor cognitive and motor development and other impairments in function. It usually persists into adulthood, resulting in smaller body size and work performance (Iversen *et al.*, 2011). In 1994 stunting in children (6 to 71 months) was recorded as 22.9% (SAVACG, 1996). In 1999 stunting was recorded as 21.6% (NFCS, 1999) and by 2005, after the implementation of the mandatory fortification of staple foods, 18% of children were still recorded as being stunted (NFCS-FB-I, 2008). Compared to the previous national survey in 2005, the South African National Health and Nutrition Examination Survey (SANHANES-1) done in 2012 indicated an increase in stunting (26.5%), but a clear decrease in wasting (extreme low weight for age) (2.2%) and underweight (6.1%) among children under three years. In the global context, the prevalence level may be classified as of medium severity for stunting and low for wasting and underweight (SANHANES-1, 2013a).

Micronutrients of concern, contributing to the incidence of stunting, include vitamin A, iron and zinc among others. Despite the mandatory fortification of staple foods with a fortification mix (vitamin A, B-vitamins, zinc and iron) in October 2003, a national survey in 2005 found persistent nutritional deficiencies in children and women. More than 60% of children and nearly 30% of women had vitamin A deficiency, nearly 30% of children and women had iron-deficiency anaemia and more than 45% of children had zinc deficiency (NFCS-FB-I, 2008). When the SANHANES-1 findings were compared with those of the 2005 NFCS, it was shown that the prevalence of anaemia and iron deficiency anaemia decreased by 63% and 83.2%, respectively. At the national level, the prevalence of vitamin A deficiency was 43.6%, which is a decrease from the 2005 reported prevalence (63.6%) (SANHANES-1, 2013a). Although a decrease is observed, the data still indicates that there is a need to promote multiple approaches to improve nutrition in South Africa. A food-based approach, as well as fortification of staple foods and supplementation are advised, as supplementation alone has not been successful in eliminating specific nutrition deficiencies.

Although studies indicate that food insecurity threatens a significant proportion of South African households and nutritional deficiencies continue to exist, increased incidence of overweight and obesity is reported in the same communities. This co-occurrence of nutritional problems suggests that they are the consequence of a monotonous diet high in energy, but low in variety and essential nutrients such as protein, vitamins and minerals. This seems to be a feasible hypothesis when we keep in mind that the NFCS (1999) found that the five most commonly consumed foods in South Africa are maize meal, brown bread, sugar, tea and small amounts of whole milk. It has been shown that although animal source foods are not absolutely essential to humans, including even small amounts in diets of malnourished individuals can play a key role in improving nutritional status (Millward, 1999).

## **6.2 IMPORTANT NUTRIENTS FROM ANIMAL SOURCE FOODS AND HUMAN HEALTH**

Many diets in developing countries are deficient in the quantity of energy, protein and other nutrients compared to recommendations, but the *quality* of the sources of nutrients is also important (Layman, 2010). Dietary quality, or the ability of a given diet to provide all the required

water, energy, protein, fatty acids, minerals, vitamins and fibre, is as significant as dietary quantity. In addition to how much food is consumed, the nutritional profile of the food consumed should also be considered when trying to improve the nutritional status of a population, or when any dietary recommendation is made. Animal-based proteins contain greater amounts of protein per portion, and contain all the essential amino acids. Animal source foods do not inhibit the absorption of other essential nutrients as is the case with most plant based foods. Furthermore, animal source foods contain bioavailable haem iron which is more readily available for absorption in the human body than iron from plant sources, similar to many other essential micronutrients. (Bioavailability of a nutrient refers to the proportion of the nutrient ingested which gets absorbed and is available for bodily functions).

### 6.2.1 Protein

According to the World Health Organization (WHO) dietary protein intake in developing countries falls significantly short of the recommended 0.66 g/kg body weight per day (FAO, 2011). In these countries protein is obtained from staple foods which are mainly cereal based (Layman, 2010). These staple foods contain a lower quantity of protein when compared to animal sources of protein (**Table 6.1**), and are often low in the essential amino acids lysine, tryptophan (Millward, 1999) and the sulphur containing amino acids, thus compromising the quality of the protein source (Bender, 1992). The quality of a protein source has a direct influence on protein digestibility, as a greater proportion of higher quality proteins are absorbed and become available for bodily functions. Protein obtained from animal sources has both a high quantity and quality as it contains a full complement of the essential amino acids in the right proportions (Millward, 1999).

Research has shown that adding even small amounts of animal proteins to a plant-based diet can yield large improvements in maternal health and child development (Dagnelie *et al.*, 1994) (Neumann *et al.*, 2003). Significant associations have been found between animal protein intake and lean mass, but no such association with vegetable protein intake has been reported. High quality protein, in combination with micronutrients provided by animal sources, facilitates protein synthesis during growth, tissue repair after extreme physical activity, and also assists in

repairing and preserving muscle mass in elderly individuals to postpone and combat sarcopenia (Lord *et al.*, 2007; Paddon-Jones & Rasmussen, 2009).

**Table 6.1** Protein content of a serving of selected foods commonly consumed by South Africans (Wolmarans *et al.*, 2010)

Food group	One Serving	Protein amount (g)
Meat, chicken & fish	85 g beef, lean cooked	28
	85 g chicken, cooked	26
	85 g sardines (pilchards) with bone	21
Legumes	172 g (1 cup) cooked soybeans	29
	196 g (1 cup) boiled split peas	16
	256 g (1 cup) red kidney beans	13
Egg	50 g (1 large) boiled egg	6
	245 g (1 cup) milk	8
Dairy	28 g Cheddar cheese	7
	30 g low fat cottage cheese	3
Starch & cereals	158 g (1 cup) white rice, cooked	4
	219 g (1 cup) oat bran	7
	28 g (1 slice) whole wheat bread	4
Vegetables & Fruit	180 g (1 cup) spinach	5
	1 (118 g) banana	1

### 6.2.2 Beneficial fatty acids

Fat is generally a valued element in the diet to provide energy, act as a carrier for the fat-soluble vitamins A, D, E and K as well as  $\beta$ -carotene, increases palatability of dry foods and/or serves as a cooking medium. Fat content differs significantly among animal source foods. In **Table 6.2** the fat and fatty acid compositions of various products are compared. Fillet is the leanest portion in beef (Schönfeldt *et al.*, 2010), loin is the leanest portion in pork (Van Heerden *et al.*, 2008), while leg is generally the leanest cut for both lamb and mutton (Schönfeldt & Hall, 2012). Breast is generally the leanest part in poultry meat. Skin is probably the main source of fat in poultry meat retail cuts (Wolmarans *et al.*, 2010).

In general, dietary fat was originally considered as a source of energy. Later research has introduced the concept of essential fats which need to be provided by the diet to prevent deficiencies. Two dietary fatty acids are classified as essential, namely, linoleic acid (C18:2) and linolenic acid (C18:3). Research has also shown that certain fatty acids play a major role in preventing chronic conditions such as cardiovascular diseases. This has resulted in an increased interest in the quality of the dietary lipid supply as a major determinant of long-term health and well-being (Uauy & Kain, 2002).

The contribution of animal source foods to the supply of total fat and saturated fatty acids is well known but their supply of dietary unsaturated fatty acids is less widely recognized. Overall, red meat contains similar proportions of monounsaturated fatty acids (MUFAs) and saturated fatty acids (SFAs), although the exact proportions of the fatty acids vary depending on fat content. Lean meat is relatively higher in polyunsaturated fatty acids (PUFAs), and lower in SFAs and total fat than untrimmed meat. Meat and meat products contribute consistently not only in terms of the essential fatty acids such as linoleic (C18:2n-6) and  $\alpha$ -linolenic (C18:3n-3) acid to the diet, but also C20 and C22 polyunsaturated fatty acids present in meat phospholipids. Ruminant meats and oily fish are the only significant sources of preformed C20 and C22 PUFA in the diet (Enser *et al.*, 1998; Wyness *et al.*, 2011). Although human beings have the metabolic capacity to synthesize the latter from the n-6 or n-3 precursors of linoleic and  $\alpha$ -linolenic acid respectively, an increase in the consumption of C20 and C22 n-3 polyunsaturated fatty acids has the potential to overcome the perceived imbalance in the ratio of n-6:n-3 polyunsaturated fatty acids in modern diets. Omega 3 fatty acids have been shown in epidemiological and clinical trials to reduce the incidence of cardiovascular disease (Kris-Etherton *et al.*, 2003). Large-scale epidemiological studies suggest that individuals at risk of coronary heart disease benefit from the consumption of plant-, animal- and marine derived omega 3 fatty acids, although the ideal intakes are still unclear (Kris-Etherton *et al.*, 2003).

Animal source foods contain naturally occurring *trans* fats. Recent concern about the nutritional effects of *trans* fatty acids in the diet on the risk of coronary heart disease (CHD) has led many countries to implement strategies to reduce consumption of dietary *trans* fatty acids. However,

the available evidence across multiple geographical locations at normal levels of consumption indicates an inverse or no association between ruminant *trans* fatty acid (rTFA) intake and CHD (Uauy *et al.*, 2009; Gebauer *et al.*, 2011). Therefore most recommendations currently require reductions in consumption of *trans* fatty acids from industrial hydrogenated fats (Enser *et al.*, 1998; Craig-Schmidt & Rong, 2009; Gordon, 2013). Reducing intake of *trans* fatty acids from animal source foods, however, might have the consequence of reducing intake of other beneficial dietary components including protein, vitamin B<sub>12</sub>, iron, calcium and zinc.

There has been considerable interest in conjugated linoleic acid (CLA) in recent years because of the interesting effects of CLA isomers in human nutrition. CLA is probably the best known *trans* fatty acid found in meat and dairy products of ruminants. Biological synthesis of CLA occurs through the microbial isomerization of dietary linoleic acid in the digestive tracts of ruminants. The products from ruminant species are therefore rich dietary sources of CLA (Enser *et al.*, 1998; Schmid *et al.*, 2006; Gebauer *et al.*, 2011). Rumenic acid (C18:2 c-9, t-11) is the main CLA component in milk, with vaccenic acid (C18:1t-11) the main monounsaturated *trans* fatty acid, being present at 46.5% of total *trans* fatty acids. Vaccenic acid can be desaturated to rumenic acid in the human body thereby increasing the CLA available to tissues considerably above dietary intake (Gordon, 2013). Although animal studies suggested that CLA may lower plasma cholesterol and triacylglycerol concentrations, most human studies have found no significant effect on plasma total, low-density lipoprotein (LDL) and high-density lipoprotein (HDL) cholesterol concentrations (Baer, 2012; Gordon, 2013). CLA was also found to have no significant effect in humans on body weight or body weight regain after a weight loss programme. In addition, the evidence on the anti-carcinogenic effects is still not sufficiently convincing to allow a conclusion as to the positive anti-carcinogenic effect of CLA (Gordon, 2013). More clinical studies are warranted due to the limited number of studies and inconsistencies in the available data to substantiate positive or negative claims regarding the health claims of rTFA and CLA.

### 6.2.3 Micronutrients

Many of the current policy programmes aimed at improving food security and nutrition promote a sustainable, food-based approach to combat malnutrition (FAO, 2012). The nutrient levels in selected foods are presented in **Table 6.3**. Animal based foods tend to be richer sources of some of the nutrients of concern such as iron and zinc, than plant based foods. Although the nutrient density of animal products provides ample reason to promote inclusion of these in optimal diets, the quality and bioavailability of the specific nutrients of concern should also be considered (Gibson, 1994; Welch & Graham, 2005). According to the 1999 National Food Consumption Survey, the five most often consumed foods in South Africa are maize porridge, brown bread, black tea, sugar and a small amount of full cream milk (NFCS, 1999). The naturally present fibres, phytates, oxalates and tannins in the three most often consumed foods may interfere with absorption of nutrients. Although essential minerals such as calcium, iron and zinc are also present in cereals and vegetables, they have a lower bioavailability in plant based foods due to their chemical form and the presence of inhibitors within the food source such as phytic acid, oxalic acid and dietary fibre. Foods and diets are clearly far more than the sum of their single nutrients. Single nutrients are not consumed in isolation – many factors within a food influence the effects of a single nutrient and it is inaccurate to generalize about the effects of a single nutrient without considering the food it is present in.

As an example, animal source foods and plant source foods contain different types of iron. Plant source foods such as the popularly referenced spinach, contain only non-haem iron, while animal source foods contain both haem and non-haem iron. The bioavailability of iron ingested differs significantly between the types of iron (haem or non-haem). In general, the rate of non-haem iron absorption is related to its solubility in the upper part of the small intestine. Thus the presence of soluble enhancers and inhibitors consumed during the same meal will have a significant effect on the amount of non-haem iron absorbed. Haem iron is much less affected by other dietary factors and contributes significantly to absorbable iron. Animal source foods are considered to be good sources of the more bio-available haem iron (Pettit *et al.*, 2011).



Another animal source food, dairy, is known for its unique nutritional contribution to human diets, specifically its contribution of calcium. Calcium must be in a soluble form, generally ionized ( $\text{Ca}^{2+}$ ), at least in the upper small intestine or bound to a soluble organic molecule before it can cross the wall of the intestine (Guéguen & Pointillart, 2000). Several molecules in the diet make calcium soluble or keep it in solution within the ileum, in particular milk proteins such as the phospho-peptides derived from casein (Scholz-Arens & Schrezenmeir, 2000) and amino acids like L-lysine and L-arginine, which form soluble chelates with calcium. Lactose, lactic acid (Rasic, 1987) and other carbohydrates, which are more gradually absorbed, also have an effect, but the mechanism involved is still a matter of controversy. It is now generally agreed that lactose, at least in high doses (15% - 30%), increases the passive absorption of calcium (Guéguen & Pointillart, 2000; Kwak *et al.*, 2012). Other dietary factors make calcium irreversibly insoluble at near-neutral pH values, by converting it into forms such as oxalates (Heaney *et al.*, 1988), phytates (Kärkkäinen *et al.*, 1997) phosphates and soaps, which prevent passive absorption in the ileum (Guéguen & Pointillart, 2000). The high level of calcium in dairy products plays a particularly important role in the development, strength and density of bones for children and in the prevention of osteoporosis in older people. In addition, calcium has also been shown to be beneficial in reducing cholesterol absorption, and in controlling body weight and blood pressure (Gaucheron, 2013).

The high nutrient density of animal source food types has an advantage in food-based interventions targeting vulnerable groups such as infants, children and people living with HIV/AIDS, who may have difficulty consuming the large volumes of plant based foods needed to meet their nutritional requirements (FAO, 2009b).

A 100 g of cooked beef provides almost an entire day's recommended intake of vitamin B<sub>12</sub>, half of the recommended intake of protein and zinc and contributes substantially to meeting the vitamin B<sub>1</sub>, vitamin B<sub>2</sub>, vitamin B<sub>6</sub> and iron recommendations. Similarly, two large eggs would supply more than 20% of the daily protein requirements, nearly 30% of daily vitamin B<sub>2</sub> requirements and two thirds of daily vitamin B<sub>12</sub> requirements (**Table 6.4**). A serving size (30 g)

of cheddar cheese provides almost 20% of the daily calcium requirements, more than 10% of daily zinc requirements and 8% of daily vitamin B<sub>2</sub> and B<sub>12</sub> requirements.

Furthermore, animal source foods provide multiple micronutrients simultaneously, which may be important in diets that are marginally lacking in more than one nutrient. For example, vitamin A and riboflavin are needed for iron mobilization and haemoglobin synthesis, and iron supplements may not reduce the prevalence of anaemia if intakes of these other nutrients are low (Murphy & Allen , 2003). Thus, foods such as liver that contain substantial levels of both iron and preformed vitamin A may be more effective than single nutrient supplements in alleviating poor micronutrient status, emphasising the delivery of nutrients within a specific food matrix. In addition, the bioavailability of carotenoids such as vitamin A precursors is now believed to be lower than indicated in traditional food composition tables (Scott & Rodriguez-Amaya, 2000; Van Het Hof *et al.*, 2000; Tang, 2010). Thus, for diets that depend on plant sources for provitamin A carotenoids, more fruits and vegetables are needed to meet vitamin A requirements than was previously thought. In the case of vitamin B<sub>12</sub>, all requirements must be met from animal source foods or supplementation, as there is virtually no vitamin B<sub>12</sub> in plant source foods (Murphy & Allen , 2003).

**Table 6.2** Comparison of the fat content and lipid profile of the edible portion of different animal source foods (per 100 g raw edible portion)

Food	Individual fatty acids								Total Omegas	Cholesterol	P:S ratio <sup>#</sup>
	Fat	SFA	MUFA	PUFA	Omega 3	Omega 6	Omega-9				
	g	g	g	g	g	g	g	g			
Beef <sup>a</sup>	14.2	5.95	5.29	0.64	-	-	-	-	76	0.1	
Lamb, lean <sup>b</sup>	6.79	3.62	2.92	0.25	0.04	0.25	3.08	3.37	63	0.07	
Mutton, lean <sup>b</sup>	7.85	4.18	3.36	0.31	0.09	0.24	3.45	3.78	49	0.07	
Pork <sup>c</sup>	5.23	2.08	2.15	1.00	0.05	0.92	-	0.97	40	0.48	
Chicken, fresh, white meat <sup>d</sup>	2.7	0.75	1.05	0.68	-	-	-	-	41	0.89	
Chicken, fresh, dark meat <sup>d</sup>	7.6	2.06	3.14	1.98	-	-	-	-	62	0.96	
Egg, chicken, whole, raw <sup>d</sup>	10.3	3.01	4.00	1.36	-	-	-	-	419	0.45	
Milk, full fat/whole, fresh <sup>d</sup>	3.4	1.9	0.84	0.10	-	-	-	-	10	0.05	
Cheddar cheese <sup>d</sup>	32.3	18.4	8.11	0.75	-	-	-	-	115	0.04	
Low fat cottage cheese <sup>d</sup>	4.0	2.67	0.98	0.13	-	-	-	-	5	0.05	

<sup>a</sup>(Schönfeldt & Hall, 2008); <sup>b</sup>(Schönfeldt *et al.*, 2012); <sup>c</sup>(Van Heerden *et al.*, 2008); <sup>d</sup>(Wolmarans *et al.*, 2010).

<sup>#</sup>P:S ratio– polyunsaturated:saturated fatty acid ratio.

**Table 6.3** Composition of selected foods (per 100 g) compared with the nutrient reference intake (NRV) for individuals four years and older

Nutrient	Unit	Fortified maize porridge, stiff <sup>a</sup>	Fortified brown bread <sup>a</sup>	Spinach, boiled <sup>a</sup>	Chicken with skin (frozen) boiled <sup>a</sup>	Egg, chicken, boiled <sup>a</sup>	Beef, fillet, cooked, untrimmed <sup>a</sup>	Cheese, cottage, low fat <sup>a</sup>	Lamb, loin, cooked, trimmed <sup>b</sup>	Nutrient reference Intake <sup>c</sup>
Energy	kJ	455	1029	134	923	616	803	369	761	-
Protein	g	2.7	9	2.7	26.8	12.6	30.9	10.5	27.8	56
Fat	g	0.6	1.4	0.3	12.6	10.3	7.5	4.0	7.8	-
Vitamin B <sub>1</sub>	mg	0.13	0.46	0.02	0.08	0.11	0.24	0.04	0.12	1.2
Vitamin B <sub>2</sub>	mg	0.05	0.11	0.07	0.15	0.38	0.19	0.21	0.22 <sup>d</sup>	1.3
Vitamin B <sub>6</sub>	mg	0.12	2.13	0.04	0.17	0.04	0.44	0.07	0.06 <sup>d</sup>	1.7
Vitamin B <sub>12</sub>	µg	0	0	0	0.3	1.6	2.3	0.7	1.60 <sup>d</sup>	2.4
Calcium	mg	2	14	104	11	39	7.1	120	7.6 <sup>d</sup>	1300
Iron	mg	1.3	4.1	2.2	0.8	1.8	2.5	0.6	2.87	18
Zinc	mg	0.63	4.49	0.49	1.78	1.15	7.45	0.63	3.11	11

<sup>a</sup> (Wolmarans *et al.*, 2010); <sup>b</sup> (Schönfeldt *et al.*, 2012); <sup>c</sup> (Department of Health, 2010); <sup>d</sup> (Purchas & Wilkinson, 2011).

### **6.3 ANIMAL SOURCE FOODS, OVERNUTRITION AND RELATED HEALTH RISKS**

When populations modernize as a result of socio-economic development, urbanisation and acculturation, it is often characterized by changes in dietary patterns and nutrient intakes that increase the risk of diet-related non-communicable diseases (Vorster *et al.*, 2011). While some of the associated dietary changes improve calcium and iron intake as a result of higher dairy and meat intake, they are also associated with an increased consumption of saturated and total fat, sodium and added sugars. Intake of legumes and vegetables commonly decreases while intake of micronutrient-poor snack foods, convenience foods (often high in sodium and fat) and sweetened carbonated beverages as well as added sugar increases (Chopra *et al.*, 2002; Vorster, 2010).

#### **6.3.1 Overnutrition in South Africa**

In addition to persistent nutritional deficiencies, the incidence of overweight and obesity is increasing. In 1999 nearly 10% of South African children under 9 years were recorded as overweight or obese, with 4% being obese (NFCS, 1999). 29% of adult men and 55% of women were overweight, and 9% of men and 29% of women were obese in 1998 (SADHS, 1998). By 2003, 56.2% of the total adult population was recorded as either overweight or obese (SADHS, 2003). When findings from SANHANES-1 are compared to the 2003 South African Demographic and Health Survey (SADHS), the former study showed that the percentage of people who were underweight or had normal weight had decreased, while those who were overweight or obese had increased. Some 19.6% of men and 25% of women were overweight, and 11.6% of men and 40.1% of women were obese (SANHANES-1, 2013b).

#### **6.3.2 Animal source foods and weight management**

Health problems associated with being overweight have escalated during the last 10 years, even within developing countries. Currently, overweight and obesity are linked to more deaths worldwide than underweight. Obesity, with its co-morbidities such as metabolic syndrome and cardiovascular

diseases, is a growing public health concern around the world, with significant statistics reported for South Africans (SADHS, 2003; SANHANES-1, 2013b). To address this problem, it is imperative to identify treatment interventions that target a variety of short- and long-term mechanisms. An energy appropriate, nutrient dense total diet that includes minimally processed and fibre-rich foods helps to support a healthy body weight throughout the life cycle (McNeill & Van Elswyk, 2012). Obesity is a complex disorder with a diverse range of causal factors, including metabolic (e.g. control of food selection) and behavioural (e.g. binge eating or limited physical activity) traits (Butland *et al.*, 2007). One undeniable fact, however, is that for an individual to become obese, energy intake must be higher than energy expenditure for an extended period of time. This means that either more energy than needed is consumed and/or that too little energy is used by the body because of a lack of physical activity. In general, weight gain seems to be a result of a combination of both increased energy intake and decreased energy expenditure (**Table 6.4**).

**Table 6.4** Energy intake and expenditure in relation to weight management (Schönfeldt & Hall, 2012)

<b>Maintaining weight</b>	In balance – Energy consumed through food and drink is equal to energy spent
<b>Gaining weight</b>	Energy excess – Energy consumed is exceeding energy spent, and the body deposits excess energy in fat storage cells
<b>Losing weight</b>	Energy deficit – Energy consumed is less than energy spent, thus the body is forced to burn fat in storage cells as energy

### 6.3.3 Animal source foods, fat and weight management

To lose weight, an energy deficit is required, either through an increased energy expenditure (increased physical activity), or a decrease in energy intake (controlled dietary consumption). Conventionally, fat intake is often limited in energy controlled diets, as fat contributes more than double the kilojoules per gram when compared to protein or carbohydrates. As dietary fat is derived

from a variety of sources, the fat content of the diet as a whole needs to be reduced. The target recommendation is that no more than 35% of total food energy (total kilojoules ingested) should be from fat (FAO, 2010).

Animal source foods contain high biological value protein and important micronutrients required for optimal body functioning, but are considered sources of fat contributing to the intake of total fat and saturated fatty acids in the diet. As a result of consumer demand, the fat content of South African red meat has decreased to less than 10 g per 90 g portion through breeding, farming and butchering techniques (Schönfeldt *et al.*, 2012).

Contrary to popular belief, lean red meat compares favourably in terms of fat content to other animal source foods including chicken with, or without the skin (**Table 6.5**). It is important to maintain or reduce the fat content of the protein source. This can be done through choosing lean cuts, trimming visible fat (including skin) prior to consumption and limiting the addition of fats or oils during cooking or basting. It is also important to keep within recommended portion size and spread protein intake throughout the day to increase the benefit of satiety derived from the protein and moderate fat content (Schönfeldt & Hall, 2008). Satiety is defined as the sensation of fullness that persists after eating until hunger returns (Benelam, 2009).

**Table 6.5** Fat content of trimmed (lean) and untrimmed animal products (Wolmerans *et al.*, 2010; Schönfeldt *et al.*, 2012)

<b>Food (100 g, cooked)</b>	<b>Fat (g)</b>
<b>Trimmed</b>	
Lamb, leg, roasted, lean	7.7
Lamb, loin, roasted, lean	7.8
Lamb, shoulder, braised, lean	9.9
Mutton, leg, roasted, lean	7.2
Mutton, loin, roasted, lean	9.8
Mutton, shoulder, braised, lean	8.7
Chicken, dark meat, roasted, without skin	9.8
Chicken, dark meat, boiled, without skin	9.7
Chicken, white meat, roasted, without skin	3.6
Chicken, white meat, boiled, without skin	4.1
Pork, loin, braised, lean	8.3
<b>Untrimmed</b>	
Pork, thick rib/breast, braised, untrimmed	25.4
Lamb, leg, roasted, untrimmed	11.7
Lamb, loin, roasted, untrimmed	20.9
Lamb, shoulder, braised, untrimmed	15.8
Mutton, leg, roasted, untrimmed	10.1
Mutton, loin, roasted, untrimmed	25.4
Mutton, shoulder, braised, untrimmed	11.3
Beef, rump, roasted, untrimmed	14.4
Beef, prime rib, roasted, untrimmed	18.0
Beef, shoulder, braised, untrimmed	8.2
Chicken, meat and skin, boiled	12.6
Chicken, meat and skin, roasted	13.0
Pork, loin, grilled, untrimmed	13.9



#### 6.3.4 Animal source foods, protein and weight management

In addition to controlling fat intake, there is ample evidence suggesting that diets restricted in carbohydrates and with a stronger emphasis on protein intake can aid weight loss (Paddon-Jones *et al.*, 2008). Some of the reasons why red meat may help decrease weight include the increased satiating properties of protein which may explain decreased food intake (Benelam, 2009), as well as the effect that increased protein intake has on thermogenesis, body composition and decreased energy efficiency (Wyness *et al.*, 2011).

There has been increased interest in the manipulation of satiety in order to control energy intake and body weight. Many studies have found that meals with a higher protein content significantly increase satiety compared to low protein meals (1 to 24 hours) (Wyness *et al.*, 2011). In general, it has been found that in diets where energy intake is unrestricted, increased consumption of high protein foods has also been associated with lower body weight (Halton & Hu, 2004; Layman, 2010).

A high intake of the amino acid leucine, and providing more than 1.2 g protein/kg body weight per day or a minimum of 30 g protein at each of three daily meals, have been shown to promote muscle health and long-term weight management (Layman, 2010). Evidence has shown that adding even small amounts of animal protein to a plant based diet can yield large improvements in maternal health and child development, as plant based diets are often low in normally limited amino acids, including lysine and the sulphur containing amino acids methionine and cysteine. Recommended intakes for protein are presented in **Table 6.6**. Refer to **Table 6.1** for the protein content per serving of different foods.

**Table 6.6** Recommended daily protein intake (g/kg body weight) per population group

<b>Group</b>	<b>g protein per kg body weight per day</b>
Population average	0.66
Sedentary people	0.8 - 1.0
Recreational exercisers	0.8 - 1.0
Athletes in early phase of training	1.5 - 1.7
Athletes in established programme	1.0 - 1.2
Serious endurance athletes	1.2 - 1.6
Adolescent athletes	1.5 - 2.0
Female athletes	15% less than men

### **6.3.5 Animal source foods and cancer**

More than 13% of all deaths globally are related to cancer, with approximately 70% (and rising) of all cancer deaths occurring in industrialised countries (WHO, 2012). The burden of cancer is increasing in developing countries as childhood mortality declines and more people live to older ages while adopting western lifestyles, such as smoking, higher consumption of saturated fat and energy dense foods, and reduced physical activity (American Cancer Society, 2007). In South Africa 1 in 6 men have a lifetime risk of getting cancer, 1 in 23 prostate cancer, 1 in 69 lung cancer, 1 in 82 oesophageal cancer, and 1 in 97 colorectal cancer (NHLS, 2012). One in 8 women have a lifetime risk of cancer, with 1 in 29 breast cancer, 1 in 35 cervix cancer and 1 in 162 colorectal cancers (NHLS, 2012).

A plethora of studies have investigated the association between environmental and lifestyle factors, including dietary factors, and the risk of cancer. It has been suggested that cancer is a largely preventable disease, with the World Cancer Research Fund and the American Institute for Cancer Research (WCRF/AICR, 2007) describing changes in the rates of different cancers in genetically identical populations that migrate from native countries to other countries around the world.

Patterns of production and consumption of food and drink, physical activity and body composition have changed significantly over time (WCRF/AICR, 2007).

Studies consistently show changes in patterns of cancer development as populations shift, and projections indicate that rates of cancer are liable to increase as countries progress towards westernised diets. Most changes are in line with urbanisation and industrialisation and in South Africa these changes often go hand in hand with acculturation from traditional cultures and habits to westernised cultures and habits. In South Africa, the population is increasingly moving towards higher living standards in more urbanised settings (BFAP, 2011).

Cancer, however, remains a disease of genes which are vulnerable to mutation, particularly over the increasing human lifespan (WCRF/AICR, 2007). Yet, environmental factors have been proven to be the most important contributors to cancer development and can be modified. External factors include tobacco, chemicals, radiation, infectious organisms, etc., while internal factors include genetic mutations, hormones, immune conditions, metabolism, mutations, etc. Normally various factors act together or in sequence to initiate or promote carcinogenesis, and it should be remembered that no single study can prove that any single factor is a cause of, or is protective against any specific type of cancer. Therefore, as listed in **Table 6.7**, risks should be considered against prevalence to provide insights.

A critical review of thousands of epidemiological studies found that the available scientific evidence does not support an independent association between red meat or processed meat and cancer (Alexander *et al.*, 2010). Any observed links between selected cancers and animal source foods are likely to be in relation with other westernised lifestyle factors, including obesity and low physical activity, increased consumption of refined foods, alcohol and smoking and a decreased consumption of vegetables and fruits.

**Table 6.7** The most common risk factors for the development of cancer

<b>Ranking</b>	<b>Risk Factor</b>
1	Growing older
2	Tobacco
3	Sunlight
4	Ionizing radiation
5	Certain chemicals and other substances
6	Some viruses and bacteria
7	Certain hormones
8	Family history of cancer
9	Alcohol
10	Poor diet, lack of physical activity, or being overweight

### **6.3.6 Animal source foods and hypertension (high blood pressure)**

Hypertension refers to the constant pumping of blood through the blood vessels with excessive force. As blood pressure (BP) rises to above 120 mm Hg systolic and above 80 mm Hg diastolic, the risk for cardiovascular disease (CVD) and stroke increases. BP levels are measured as systolic (the pressure in the vessels when the heart beats), and diastolic (the pressure in the vessels when the heart rests between beats).

Hypertension is considered one of the leading causes of death globally, resulting in 51% of deaths from stroke and 45% of deaths from coronary heart disease. Nearly 1 billion people have hypertension and the incidence is increasing, specifically in developing countries. It is predicted that by 2025, an estimated 1.56 billion people globally will be living with hypertension (WHO, 2011).

The most comprehensive estimates of the prevalence of hypertension in South Africa (SA) were reported by the Demographic and Health Survey (SADHS, 1998). According to this survey 6 million adults suffered from hypertension with BP greater than 140/90 mm Hg. In 2005, the prevalence of hypertension was reported as 55% in adults, with 59% in black African adults, 55% in coloured and

Indian adults, and 50% in white adults (Connor *et al.*, 2005). With CVD ranked as one of the greatest contributors to death in the country (Bradshaw *et al.*, 2000), it is no surprise that hypertension has been shown to constitute more than 7.5% of the total health care spend in SA (Seedat & Rayner, 2007).

Transition of households from rural to urban settings, often resulting in the adoption of westernised lifestyle and eating habits, has been reported to be accompanied by an increased incidence of hypertension (Steyn & Temple, 2008). These urbanised individuals have been recorded to have higher body weight, and urinary sodium/potassium ratio than their rural counterparts. Other factors often associated with these urbanised subjects include high intakes of saturated fat and sodium, suggesting the significant impact which lifestyle and eating habits have on the risk of hypertension. However, an increasing risk of hypertension is not only associated with urbanisation, as an increasing incidence has also been reported in rural areas (Steyn *et al.*, 2006).

Dietary sodium is associated with elevated BP levels, in some but not all populations, with intakes recommended below 6 g per day. Although many reports suggest low addition of salt during food preparation and at the table, hidden salt in food products contributes to a significant proportion of dietary sodium intake in South Africa (Carlton *et al.*, 2005). Consumers should be advised to be aware of this fact, and read food labels. From sodium values reported on food labels, salt quantity can be calculated by multiplying sodium content with a factor of 2.5.

Daily salt intakes for South Africans have been recorded at 7.8 g/day in the black population, 8.5 g/day in the coloured population and 9.5 g/day in the white population, all being significantly higher than the recommended 6 g/day. Ethnic differences in sodium intake have also been recorded with the black population consuming significantly lower levels than the other population groups. The greatest contributors to sodium intake in South Africa are cereals, and even more specifically breads (Carlton *et al.*, 2005).

Adequate consumption of dietary potassium lowers the risk of hypertension and stroke (D'Elia *et al.*, 2011). It has been hypothesised that it is due to this functionality of potassium that populations consuming primitive and vegetarian diets often have a low incidence of hypertension and heart disease. **Table 6.8** presents the sodium (Na) and potassium (K) content of certain foods consumed by South Africans.

Animal source foods inherently contain very little sodium. Sodium is often added to meat for a variety of reasons, including enhancement of sensory properties (taste), reducing water activity and increasing microbial safety. Many consumers also add salt habitually. Consumer benefit associated with the reduction of salt, and particularly added salt, should be emphasised.

Processed meat products can be a significant contributor to dietary salt intake. It has been suggested that the higher sodium levels in processed meats (not fresh or frozen red meat) could be a potential contributor to increased hypertension risk (McNeill & Van Elswyk, 2012). It is also suggested that this may explain the disparity in findings related to dietary patterns and risk of CVD. It is recommended that processed meat and unprocessed red meat should be grouped and investigated separately in future research studies.

Evidence furthermore supports the inclusion of lean red meat and dairy as part of a healthy and balanced diet designed to manage CVD and hypertension (McNeill & Van Elswyk, 2012). The DASH (Dietary Approaches to Stop Hypertension) study proved that non-pharmacological methods can decrease blood pressure equal to the effect of certain medications (Appel *et al.*, 1997). The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of Hypertension (NIH, 2003) recommended weight reduction, the adoption of a DASH eating plan, reducing dietary sodium, increasing physical activity and moderating alcohol consumption. The World Health Organization (WHO) in addition recommended increased consumption of dietary potassium as a possible dietary intervention to decrease risk for hypertension (WHO, 2011).

**Table 6.8** Sodium (Na) and potassium (K) content of selected South African foods (100 g edible portion)

<b>Food products</b>	<b>Na (mg)</b>	<b>K (mg)</b>
<b>Meat &amp; meat products</b>		
Lamb, trimmed (lean) <sup>#</sup>	71*	288
Lamb, untrimmed <sup>#</sup>	61*	248
Mutton, trimmed (lean) <sup>#</sup>	73*	272
Mutton, untrimmed <sup>#</sup>	65*	243
Beef, untrimmed <sup>#</sup>	80*	282
Chicken, white meat, roasted <sup>#</sup>	48*	269
Chicken, dark meat, roasted <sup>#</sup>	73*	262
Fish, hake, steamed <sup>#</sup>	126*	361
Egg, whole, boiled <sup>#</sup>	126*	98
Vienna <sup>^</sup>	953	101
Sausage, smoked, beef and pork <sup>^</sup>	945	189
Sausage roll, commercial, baked <sup>^</sup>	1044	114
<b>Dairy</b>		
Cheese, cheddar <sup>^</sup>	487	82
Milk, whole, fresh <sup>^</sup>	48	157
<b>Vegetables &amp; fruit</b>		
Broccoli, boiled <sup>^</sup>	4*	121
Carrots, boiled <sup>^</sup>	29*	156
Potato, baked <sup>^</sup>	8*	418
Apple <sup>^</sup>	4	99
Banana <sup>^</sup>	41	206
Peach <sup>^</sup>	4	201
<b>Cereals</b>		
Bread, brown, fortified <sup>^</sup>	648	227
Bread, white, fortified <sup>^</sup>	653	214
Maize, soft, fortified <sup>^</sup>	5*	24
Rice, white <sup>^</sup>	2*	39
Rice, brown <sup>^</sup>	5*	43
<b>Condiments</b>		
Chutney, fruit <sup>^</sup>	811	25
Gravy, brown, powder, prepared with water <sup>^</sup>	417	22
Tomato sauce <sup>^</sup>	582	465
Soup, powder, onion <sup>^</sup>	8957	667
Soup, powder, average, prepared with water <sup>^</sup>	431	64

Values are reported as per 100 g edible portion; portion sizes usually consumed should also be considered when giving dietary advice

\*No salt was added during cooking

<sup>^</sup>Wolmarans *et al.*, 2010

<sup>#</sup>Schönfeldt & Hall, 2012

The South African Hypertension Guidelines 2011 published by the South African Hypertension Society (SAHS) also emphasise that a healthy lifestyle remains the cornerstone of managing hypertension, regardless of the BP level of the individual (Seedat & Rayner, 2007). In addition to decreasing blood pressure, lifestyle changes enhance antihypertensive drug efficiency and decrease total CVD risk. These recommendations include the maintenance of a healthy body weight (BMI 18.5 to 24.9), reducing sodium intake to <6 g salt per day, limiting alcohol consumption, limiting fat intake to between 15% and 30% of total dietary energy intake and reducing SFA and TFA intakes, increasing fruit and vegetable consumption, limiting free sugars and increasing physical activity (Seedat & Rayner, 2007).

### **6.3.7 Nutrient density**

A healthy, balanced diet builds upon the foundation of the right amounts of nutrient dense foods from a variety of food groups, including lean meat, whole grains, vegetables, fruit and dairy products. The more nutrients present and the fewer the kilojoules, the higher the nutrient density. The term 'nutrient-rich foods' is commonly used as a synonym for nutrient dense.

Animal source foods play a key role in a balanced diet by providing nourishing nutrients. A serving of lean red meat provides more than seven nutrients in significant amounts which are important to human health and development. A 90 g edible portion of lean South African lamb or mutton, i.e. the meat from about two lamb chops, contribute to nearly half of an adult's Recommended Dietary Allowance (RDA) for protein, more than 30% of the RDA for zinc and it contributes significantly to the intake of other essential vitamins and minerals including iron and magnesium, as well as the B-vitamins.

### **6.3.8 Portion size**

Apart from deciding what and when to eat, another important decision is how much to eat. Many health conscious consumers are perfectly capable of making healthy food choices for three



wholesome meals per day, yet many people struggle with portion sizes. Most of the time we unknowingly eat portions that are too large and this contributes to an increased risk of overweight and obesity.

Over-sized portions of food have become the norm in many households. The portion sizes of take-aways, soft drinks and meals served at restaurants, have increased over the last 20 years, often as a result of the increased demand for value-for-money. Unfortunately, portion sizes which were once considered far too big to consume in one sitting, are now considered normal. Larger portions contain more kilojoules, and growing waistlines are often the result. Consuming three regular meals per day has also changed to constant grazing, with individuals often losing track of what they are consuming throughout the day and over consuming food.

The South African Food-Based Dietary Guidelines recommend up to 560 g lean red meat per week, or between 80 g and 90 g per day. This is in line with the average consumption statistics available for South Africans. However, it is well known that this range differs significantly from person to person. Cooking losses in meat are on average between 20% to 30% (Schönfeldt *et al.*, 2012), depending on cut composition (meat, bone and fat ratio), temperature of the heat source, internal temperature of cooked meat, adding of condiments, etc. This means that an 80 g cooked lean meat portion is roughly equivalent to 100 g raw lean meat.

## **6.4 CONCLUSIONS AND RECOMMENDATIONS**

There is consensus in international dietary recommendations that animal source foods can form part of a healthy and balanced diet. Important nutrients provided by animal source foods include high quality and bioavailable protein, beneficial fatty acids as well as essential, bioavailable micronutrients such as haem iron (e.g. red meat) and calcium (e.g. dairy products). These nutrients are important in terms of their individual health benefits, but animal source foods can also be useful as a food-based approach to combat persistent undernutrition observed in South Africa.

Unfortunately, animal source foods are often considered the most expensive components in the diet and the components which evoke the widest array of comments and international debate. As such, it is often recommended that animal source food be limited in the human diet. Yet, ample evidence indicates that health concerns often related to animal source food consumption (such as increased risk of weight gain, cancers and hypertension) are questionable, and evidence increasingly suggest a beneficial effect which animal source foods may have in preventing and controlling obesity and certain NCDs.

Furthermore, there is a lack of recent food consumption data in South Africa accurately describing the contribution which animal source foods makes to the South African diet. Until such data is available, caution should be used when sanctions are made to reduce intake, as actual intake may in fact be below the recommended amounts of the Food-Based Dietary Guidelines. It should also be remembered that animal source foods are very seldom consumed on their own, but form part of a whole meal. The composition of the rest of the meal should not be neglected when healthy food choices are made. Certain nutritional considerations, such as nutrient density and portion size, should be applied to all foods included in the diet.

Investment in research (e.g. describing animal source food consumption, health properties, and nutrient composition), is essential to address consumer concerns and accurately position animal source foods as part of a healthy, sustainable diet.

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## CHAPTER 7: ANIMAL SOURCE FOODS AS PART OF THE FOOD-BASED DIETARY GUIDELINES FOR SOUTH AFRICA

*In South Africa, the national food-based dietary guidelines are brief, positive dietary recommendation messages that are used to inform consumers on how to choose food and beverage combinations that will lead to a diet that is adequate, that meets nutrient need and that is, at the same time, prudent, for example, which lowers the risk of non-communicable diseases (NCDs). These guidelines were revised in 2013, based on the best available scientific evidence on the relationship between what we eat and our health, as influenced by prevailing eating patterns and public health problems within South Africa. This paper was used as the scientific background document for the revision of the guidelines on animal source foods and was published in the South African Journal of Clinical Nutrition special issue (S Afr J Clin Nutr 2013; 26(3)(Supplement): S66-S76)*

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### ABSTRACT

Food products from animals provide a variety of macro- and micronutrients. Fish, chicken and meat contain both high quantity and quality protein as it contains all the essential amino acids in the right proportions. In South Africa eight micronutrients, namely vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin B12, niacin, iron and zinc were identified as lacking in the population diet. Fish, chicken and meat are particularly rich sources of all eight of these nutrients and relatively small amounts of these foods, added to a vegetarian diet, can substantially increase nutrient adequacy.

Generally, animal source foods are also associated with nutrients that are less desirable in the diet, such as saturated fat and cholesterol. However, by choosing lean prudent portions of these foods, intake of these macronutrients can be controlled.

Animal source foods add variety and nutrients to any meal. Some people choose not to eat meat, for a variety of reasons, but as there is no evidence that a moderate intake of fish, chicken, lean

meat and eggs has any negative effects on health, there is no scientific justification for excluding these foods from the diet. As recommended in dietary guidelines globally, lean meat, fish and eggs consumed in moderation, can be promoted as part of a healthy, balanced South African diet.

## 7.1 INTRODUCTION

Fish, chicken, lean meat and eggs in appropriate amounts are valuable sources of complete, high quality, easily digestible protein and many essential micronutrients such as iron, zinc, vitamin A, vitamin B12 and calcium. Animal source foods are not absolutely essential to human diets, yet meat remains desirable and popular.<sup>1</sup> Including small amounts of animal source foods in diets of malnourished individuals has proven to play a key role in improving nutritional status.<sup>2</sup>

Although the production of livestock has increased in developing countries, undernutrition, including insufficient consumption of protein, remains a persistent problem in the developing world. Many diets within these developing countries are deficient in the quantity of energy, protein and other nutrients compared to recommendations, therefore the quality of the sources of protein are especially important<sup>1</sup>. On the other side of the malnutrition scale, the overconsumption of foods, and specifically those high in saturated fat and cholesterol, has been linked to overweight, obesity and subsequent diseases of lifestyle.<sup>3</sup>

Meat is the flesh and organs of animals and fowls. There are numerous legal definitions of meat in different countries designed to control the composition of products made with meat. The flesh of cattle, pigs and sheep is distinguished from that of poultry, with the exception of ostrich, by the term red meat, while the flesh of poultry (chicken, turkey, duck, pigeon and guinea fowl) is termed white meat. Red meat mostly refers to beef, veal, pork, mutton and lamb (fresh, minced and frozen), but also includes goat, ostrich and venison.<sup>4,5</sup> Other animal products include offal, fish, eggs and dairy products such as milk, cheese, and yoghurt. Offal refers to the organs namely: tongue, heart, liver, kidneys, lungs, stomach and intestines.

There is no international definition for “lean” meat, but standards seem to be similar in different countries. For example:

- Australia and New Zealand - meat containing less than 10% fat meets the Heart Foundation's approval,<sup>6</sup>
- Denmark - meat containing between 5 and 10% fat is classified as “lean”,<sup>6</sup>
- USA - less than 10g total fat, 4.5g or less saturated fat, and less than 95mg of cholesterol,<sup>7</sup>
- South Africa - minced meat and processed meat products with less than or equal to 10% of total fat can be classified as “lean”. Meat with less than or equal to 5% of total fat can be classified as “extra lean”.<sup>8</sup>

The aim of this article is to discuss the role of lean meat (red meat and white meat), fish and eggs in a healthy, balanced diet within a South African context.

#### **7.1.1 Production figures of fish, chicken, meat and eggs**

Capture fisheries and aquaculture supplied the world with about 142 million tons of fish in 2008. Of this, 115 million tons was used as human food, providing an estimated apparent per capita supply of about 17 kg per annum.<sup>9</sup> Red meat production is expected to keep increasing during the next decade. Population growth estimates indicate that the demand for meat will double by 2050. This increase in the demand for meat will mainly be driven by increasing demand in developing countries on par with population growth.<sup>10</sup>

Trawl fisheries targeting hake provide over half of the value of all fisheries in South Africa. The main export markets are Europe, Australia and the US. The hake stock is above sustainable levels and catches below maximum sustainable levels.<sup>11</sup> Only 10% of anchovy caught is used for human consumption, which is an opportunity for growth in this sector.<sup>12</sup> A redirection of this resource could provide nutrition for the rural poor and create employment in the coastal regions and fisheries industry.

According to data extrapolated from the Abstract of Agricultural Statistics (**Table 7.1**) there was an increase in the last decade in the production of red meat, white meat and eggs in South Africa.<sup>13</sup> However, South Africa remains a net importer of chicken, beef and sheep (mainly mutton) as the annual average growth in production (3.8%) is outpaced by the growth in consumption (4.1%).<sup>14,15</sup> Chicken production will increase to 1.9 million tons over the next decade. Approximately 350 000 tons of chicken meat will still be imported in 2020. In 2011 local egg producers were able to match more than the increase in local consumption of eggs.<sup>14</sup>

**Table 7.1** Production and consumption data of fish and seafood, white meat (poultry), red meat (beef, sheep, pork) and eggs

Year	Total RSA production & imports (1000 t)				Per capita consumption (g per day)			
	Fish, Seafood	White Meat	Red Meat	Eggs	Fish, Seafood	White Meat	Red Meat	Eggs
2000/01	667	869	833.4	329	16.76	58.85	51.95	19.42
2001/02	785	896	881.9	330	19.08	59.32	53.56	18.96
2002/03	798	925	940.6	340	19.10	62.22	56.36	18.85
2003/04	847	928	999.9	328	19.36	63.84	59.15	18.00
2004/05	917	1 019	1044.4	348	27.03	70.82	61.97	19.34
2005/06	830	1143	1161.7	375	23.33	80.79	67.92	20.85
2006/07	634	1 200	1252.4	412	21.64	85.01	71.70	22.63
2007/08	697	1 276	1128.3	438	20.87	86.36	63.75	23.84
2008/09	662	1 358	1151.3	473	-	87.70	63.67	25.26
2009/10	529	1 430	1238.4	450	-	91.40	68.38	23.56
2010/11	642	1 488	1225.2	453	-	95.64	67.04	23.23

Red meat, white meat and eggs<sup>13</sup>  
 Fish and seafood<sup>16</sup>

### 7.1.2 Consumption patterns

Urbanisation and westernisation are growing phenomena in South Africa, with people continually moving from rural areas into urban settlements in the search of better work opportunities and

income generation potential. These changes in lifestyle are often accompanied by acculturation and an increase in the utilization of animal source foods.<sup>17</sup>

**Table 7.2** shows the consumption of red meat, white meat and eggs over the last decade. According to data extrapolated from the Abstract of Agricultural Statistics there was an increase in the last decade in chicken and pork meat, beef and veal consumption, as well as egg consumption. Sheep meat consumption during the same period has decreased, but the total consumption of egg, red meat and white meat has increased.<sup>13</sup>

Publications such as the “Abstract of Agricultural Statistics”,<sup>13</sup> “The South African Agricultural Baseline”<sup>14</sup> and “FAO Fishery Statistical Collections”<sup>16</sup> from which the production and consumption data are extrapolated, provide broad statistical data on population, food production and consumption figures. Such statistics can be used to obtain estimates of food consumption, but these estimates are not fully representative of actual food intake. Food balance sheets are based on statistical data on the production, import and export of carcasses, and eventual shifts in stock. Due to the large quantity of material discarded prior to meat reaching the table for consumption (e.g. bones and cartilage) and at the table (e.g. trimmed fat, bone wastage), the apparent supply from this source will always be an overestimation of the true meat intake in a population. From time of slaughter to actual consumption, up to 70% of the slaughtered products goes to waste (i.e. bone, fat, cooking loss, plate waste, etc.).<sup>18,19</sup> **Table 7.3** calculates estimated actual consumption of animal products (including meat and offal) from the consumption data reported in the Agricultural Abstracts using yield factors<sup>20</sup> when food waste is considered.<sup>13</sup>



**Table 7.2** Per capita consumption (g/day) of red meat, white meat, and eggs over the last decade<sup>13</sup>

	2000/1	2010/11
Beef and Veal	35	47
Pork	7	13
Lamb and Mutton	10	5.5
White meat	59	96
Eggs	19	23

**Table 7.3** Estimated edible portion available for consumption (g/capita/day), calculated from agricultural statistics using yield factors

Species	Raw (kg) / product / year <sup>13</sup>	Raw (g) / capita / day	Yield factor (edible portion) (Cooking loss, bone, waste) <sup>20</sup>	Edible portion cooked product (g) / capita / day*
Beef + veal	17.07	46.77	±0.60	28.06
Pork	4.60	12.60	±0.60	7.56
Sheep + goat	2.90	7.95	±0.50	3.98
White meat	34.91	95.64	±0.40	38.26
Eggs	8.48	23.20	±0.90	20.9
Fish	7.60	20.82	±0.60	12.5
Total	75.56	206.98		111.26

\*Value does not include food waste from production to consumption from possible spoilage, plate, reported to be up to 40% in the UK.

Agricultural data, such as those reported in the Abstract of Agricultural Statistics, do not differentiate between population groups and/or affluent and less affluent communities but present an average available to each individual in the total population per day. **Table 7.4** compares the estimated values from the Abstract of Agricultural Statistics (raw slaughtered product and estimated cooked product available for consumption using yield factors<sup>20</sup> with values from Food Consumption Surveys.

**Table 7.4** Estimated food consumption data (g/day) from Agricultural statistics (2000/01) over the last decade compared to data from food consumption surveys (g/day)

Group (g/day)	2000/2001				2010/2011			
	Agricultural Statistics <sup>13,16</sup>	Summary of food consumption surveys <sup>21</sup>			Agricultural Statistics <sup>13,16</sup>	Adopted from Food Consumption Surveys (2000 to 2010) <sup>22</sup>		
	Raw slaughtered product	<sup>b</sup> Edible portion	Children 1 to 5 yrs	Adults & Children 10+ yrs	Raw slaughtered product	<sup>b</sup> Edible portion	Children <9 yrs	Adults
<b>Meat<sup>a</sup></b>	119	63.6	45	86	163	77.9	58	44 - 60
<b>Fish, seafood</b>	17	10.2	10	12	21	12.5	7	15
<b>Eggs</b>	19	17.1	7	15	23	20.9	-	16.5

<sup>a</sup>Value includes consumption of red and white meat, meat products and offal.

<sup>b</sup>Edible portion calculated using yield factors.<sup>20</sup>

<sup>c</sup>The data are adopted from combined databases using secondary data analyses to show the dietary intake of adults and children.<sup>21,22</sup>

## 7.2 NUTRIENTS IN ANIMAL AND PLANT SOURCE FOODS

Although there has been a longstanding global fight against hunger, it has been well documented that the provision of energy, without the adequate intake of critical protein and micronutrients, may increase weight but not length, promoting adipose tissue gain and obesity. This may contribute to the association of both stunting and obesity within a single individual.<sup>23</sup>

### 7.2.1 Protein

A diversity of foods is recommended in most national dietary guidelines in order to achieve the recommended dietary intake for protein, as well as, other essential nutrients. According to the World Health Organisation (WHO) dietary protein intake in developing countries fall significantly short of the recommended 0.66g/kg body weight per day.<sup>3</sup> In these countries protein is obtained from staple foods which are mainly cereal based.<sup>23</sup> These staple foods contain a lower quantity of protein when compared to animal sources of protein (**Table 7.5**), and are often low in the essential amino acids lysine, tryptophan<sup>2</sup> and the sulphur containing amino acids compromising the quality of the protein source.<sup>24</sup> The quality of a protein source has a direct influence on protein digestibility. Protein obtained from animal sources contains both a high quantity and quality as it contains all the essential amino acids in the right proportions.<sup>2</sup> It can be clearly seen in **Table 7.5** that a portion of the meat food products, followed by legumes, contribute the most to protein intake per serving, while vegetables and fruit contribute the least.

Research has shown that adding even small amounts of animal proteins to a plant based diet can yield large improvements in maternal health and child development.<sup>26,27</sup> Significant associations have been found between animal protein intake and lean mass, but no such association with vegetable protein intake has been reported. High quality protein in combination with micronutrients provided by lean meat intake facilitates protein synthesis during active growth, repair such as after extreme physical activity, for normal growth and repair and even in elderly individuals to postpone and prevent sarcopenia.<sup>28</sup>

**Table 7.5** Protein content of one serving of different food products<sup>25</sup>

<b>Food product</b>	<b>One Serving</b>	<b>Protein amount (g)</b>
Meat	85g sardines (pilchards) with bone	21
	85g beef, lean cooked	28
	84g chicken, cooked light meat	28
	85 g lamb, cooked lean meat	26
	85g pork, cooked lean meat	25
Egg	50g (1 large) boiled egg	6
Legumes	172g (1 cup) cooked soybeans	29
	198g (1 cup) cooked lentils	18
	196g (1 cup) boiled split peas	16
	177g (1cup) boiled red kidney beans	15
Dairy	245 g (1 cup) milk	8
	28 g Cheddar cheese	7
	30g low fat cottage cheese	4
Starch & cereals	158g (1 cup) cooked white rice	4
	219g (1 cup) cooked oat bran	7
	25g (1 slice) whole wheat bread	3
	156g (1 cup) boiled potato	3
Veg & Fruit	180g (1 cup) cooked spinach	5
	156g (1 cup) cooked Brussels sprouts	4
	28g avocado	1
	118g (1) banana	1

### 7.2.2 Fat

Fat is generally a valued element of the diet to provide energy, palatability to dry foods or to serve as a cooking medium. Originally, dietary fat was mainly considered as a source of energy. Later research has introduced the concept of essential fats which need to be provided by the diet to prevent deficiencies. Two dietary fatty acids are classified as essential, namely, linoleic acid (C18:2) and linolenic acid (C18:3). Research has also shown that fatty acids play a major role in preventing chronic conditions such as cardiovascular diseases. This has resulted in an increased interest in the quality of the dietary lipid supply as a major determinant of long-term health and well-being.<sup>29</sup>

The contribution of meat and meat products to the supply of total fat and saturated fatty acids is well known but their supply of dietary polyunsaturated fatty acids is less widely recognized. Overall, red meat contains similar proportions of monounsaturated fatty acids (MUFAs) and saturated fatty acids (SFAs), although the exact proportions of the fatty acids vary depending on its fat content. Lean meat is relatively higher in polyunsaturated fatty acids (PUFAs), and lower in SFAs and total fat than untrimmed meat. Meat and meat products contribute consistently not only in terms of the essential fatty acids, linoleic (C18:2n-6) and  $\alpha$ -linolenic (C18:3n-3) acids, but also C20 and C22 polyunsaturated fatty acids present in meat phospholipids. Ruminant meats and oily fish are the only significant sources of preformed C20 and C22 PUFA in the diet.<sup>30,31</sup> Although human beings have the metabolic capacity to synthesize the latter from the n-6 or n-3 precursors from linoleic and  $\alpha$ -linolenic acid respectively, an increase in the consumption of C20 and C22 n-3 polyunsaturated fatty acids has the potential to overcome the perceived imbalance in the ratio of n-6:n-3 polyunsaturated fatty acids in modern diets.

Animal source foods have naturally occurring *trans* fats. Results from epidemiological studies generally have shown an inverse or no association between ruminant *trans* fatty acid (rTFA) intake and coronary heart disease (CHD) across multiple geographical locations.<sup>32</sup> Conjugated linoleic acid (CLA), a natural occurring *trans* fatty acid, is associated with beneficial health properties such as reducing the risk for cancer, atherosclerosis and diabetes. CLA has also been shown to have positive effects on immune function and body composition. Biological synthesis of CLA occurs through the microbial isomerization of dietary linoleic acid in the digestive tracts of ruminant animals. The products from ruminant species are therefore rich dietary sources of CLA.<sup>30,33</sup> According to recent reviews the *trans* fatty acids in the food supply should be limited to the “natural” ruminant fats in meat and dairy products.<sup>30,32,34</sup> However, more clinical studies are warranted due to the limited number of studies and inconsistencies in the available data.

Cutting out meat from the diet will not necessarily guarantee a low fat diet as many alternatives such as cheese can also be high in fat.

**Table 7.6** Comparison of the fat content and lipid profile of the edible portion of different protein source foods

Food (per 100g, raw, edible portion)	Fat	SFA	MUFA	PUFA	Omega 3	Omega 6	Omega-9	Omega-fatty acids	Cholesterol	<sup>c</sup> P:S ratio
	g	g	g	g				g	mg	
<sup>a</sup> Beef <sup>35</sup>	14.2	5.95	5.29	0.64					76	0.1
<sup>b</sup> Lamb, lean <sup>36</sup>	6.79	3.62	2.92	0.25	0.04	0.25	3.08	3.37	63	0.07
Mutton, lean <sup>36</sup>	7.85	4.18	3.36	0.31	0.09	0.24	3.45	3.78	49	0.07
Pork <sup>37</sup>	5.23	2.08	2.15	1.00	0.05	0.92		0.97	40	0.48
Chicken, white meat <sup>35</sup>	2.7	0.75	1.05	0.68					41	0.89
Chicken, dark meat <sup>35</sup>	7.6	2.06	3.14	1.98					62	0.96
Cheddar Cheese <sup>35</sup>	32.3	18.4	8.11	0.75					115	0.04
Low fat cottage cheese <sup>35</sup>	4.0	2.67	0.98	0.13					5	0.05
Pilchards in tomato sauce <sup>35</sup>	5.4	1.60	1.09	2.13					70	1.33

<sup>a</sup>A study to determine the nutritional composition of lean South African beef (trimmed of subcutaneous fat) is currently underway. No lean values for South African beef have been determined before.

<sup>b</sup>Average age of a lamb carcass in South Africa is five to nine months and with a carcass weight of 17,18 kg.<sup>38</sup> The younger the animal, the higher the cholesterol content as most of the cholesterol in muscle has a definite metabolic or structural function in the cell membranes. Cholesterol content is normally in an inverse relationship with fatness (e.g. the leaner the meat the higher the percentage cholesterol to fat content).<sup>39,40</sup>

<sup>c</sup>P:S ratio– polyunsaturated:saturated fatty acid ratio.

### 7.2.3 Micronutrients

Within many developing countries, including South Africa, apart from low energy intakes in many communities, there is a deficit in the iron and vitamin A status. In South Africa, mandatory fortification of cereal-based staple foods with a combination of micronutrients, has yet to be successful in improving the vitamin A or iron status of an individual.<sup>41</sup> Many of the current policy programmes aimed at improving food security promote a sustainable, food-based approach to combat malnutrition.<sup>42</sup>

The nutrient levels in selected foods are presented in **Table 7.7**. Animal based foods tend to be richer sources of the nutrients of concern such as iron and zinc. Although the nutrient density of animal products provides ample reason to promote inclusion of these in optimal diets, the quality and bioavailability of the specific nutrients of concern should also be considered.<sup>43,44</sup> According to the 1999 National Food Consumption Survey, the five most often consumed foods are maize porridge, brown bread, black tea, sugar and a small amount of full cream milk.<sup>45</sup> The naturally present fibres, phytates, oxalates and tannins in the three most often consumed foods may interfere with absorption. Although essential minerals such as iron and zinc are also present in cereal staples, they have a lower bioavailability in plant-based foods due to their chemical form and the presence of inhibitors within the food source such as phytic acid and dietary fibre.

As an example, animal based foods and plant based foods contain different types of iron. Plant based foods such as the popularly referenced spinach, contain only non-haem iron, while animal based foods contain both haem and non-haem iron. The bioavailability of iron ingested (the amount which gets absorbed and is available for bodily function) differs significantly between the types of iron (haem or non-haem). In general, the rate of non-haem iron absorption is related to its solubility in the upper part of the small intestine. Thus the presence of soluble enhancers and inhibitors consumed during the same meal will have a significant effect on the amount of non-haem iron absorbed. Haem iron is much less affected by other dietary factors and contributes significantly to absorbable iron. Animal foods are considered to be good sources of the more bio-available haem

iron.<sup>46</sup> Small amounts of meat are recognised to enhance the absorption of non-haem iron from other food sources (called the meat factor), although the mechanism for the enhancing effect of meat on non-haem iron absorption is still not fully understood.

The high nutrient density of animal food types has an advantage in food-based interventions targeting vulnerable groups such as infants, children and people living with HIV/AIDS, who may have difficulty consuming the large volumes of plant based foods needed to meet their nutritional requirements.<sup>47</sup> A 100 g serving of cooked beef provides almost an entire day's recommended intake of vitamin B12, half of the recommended intake of protein and zinc and contributes substantially to meeting the vitamin B1, vitamin B2, vitamin B6 and iron recommendations.

Furthermore, animal source foods provide multiple micronutrients simultaneously, which may be important in diets that are marginally lacking in more than one nutrient. For example, vitamin A and riboflavin are needed for iron mobilization and haemoglobin synthesis, and iron supplements may not reduce the prevalence of anaemia if intakes of these other nutrients are low.<sup>48</sup> Thus, foods such as liver that contain substantial amounts of both iron and preformed vitamin A may be more effective than single-nutrient supplements in alleviating poor micronutrient status, emphasizing the delivery of nutrients within a specific food matrix.

In addition, the bioavailability of carotenoids such as vitamin A precursors is now believed to be lower than indicated in traditional food composition tables.<sup>49,50,51</sup> Thus, for diets that depend on plant sources for provitamin A carotenoids, more fruits and vegetables are needed to meet vitamin A requirements than was previously thought. In the case of vitamin B12, all requirements must be met from animal food products or supplementation, as there is virtually no vitamin B12 in plant source foods.<sup>48</sup>



**Table 7.7** Composition of selected foods (per 100g) compared with the nutrient reference intake (NRV) for individuals four years and older

Nutrient	Unit	Fortified Maize porridge, stiff <sup>36</sup>	Fortified brown bread <sup>36</sup>	Spinach, boiled <sup>36</sup>	Chicken with skin (frozen) boiled <sup>36</sup>	Egg, Chicken, Boiled <sup>36</sup>	Beef, Fillet, cooked, untrimmed <sup>36</sup>	Pilchards in tomato sauce <sup>36</sup>	Lamb, Loin, Cooked, untrimmed <sup>37</sup>	Nutrient Reference Intake <sup>52</sup>
<b>Energy</b>	kJ	455	1029	134	923	616	803	531	1171	-
<b>Protein</b>	g	2.7	9	2.7	26.8	12.6	30.9	18.8	23.5	56
<b>Fat</b>	g	0.6	1.4	0.3	12.6	10.3	7.5	5.4	20.9	-
<b>Vitamin B1</b>	mg	0.13	0.46	0.02	0.08	0.11	0.24	0.02	-	1.2
<b>Vitamin B2</b>	mg	0.05	0.11	0.07	0.15	0.38	0.19	0.29	-	1.3
<b>Vitamin B6</b>	mg	0.12	2.13	0.04	0.17	0.04	0.44	-	-	1.7
<b>Vitamin B12</b>	µg	0	0	0	0.3	1.6	2.3	12.0	-	2.4
<b>Calcium</b>	mg	2	14	104	11	39	7.1	300	-	1300
<b>Iron</b>	mg	1.3	4.1	2.2	0.8	1.8	2.5	2.7	2.87	18
<b>Zinc</b>	mg	0.63	4.49	0.49	1.78	1.15	7.45	1.6	3.11	11

### 7.3 PEDIATRIC REQUIREMENTS

Animal source foods have a positive effect on iron and zinc status as it contain both haem iron and zinc, which is highly bioavailable. Haem iron will also have a positive effect on the absorption of non-haem iron present in other food sources in the same meal.<sup>30,53</sup>

With respect to nutrient composition of the diet, it is important to include fish and meat as complementary feeding in the diet from the age of 6 months. Only small amounts of meat are necessary to improve micronutrient status and should be introduced gradually. Among the micronutrients of key public health importance, this applies especially to iron, zinc and vitamin B12. A 30g portion of beef provides approximately 0.75 mg iron, 2.2 mg of zinc and 0.7 µg of vitamin B12.

The importance of incorporating animal source foods (ASF), including meat, into complementary feeding has been emphasized by nutritionists worldwide. In the United Kingdom, meat consumption was positively associated with psychomotor outcome in children up to 24 months of age<sup>54</sup> and with iron status in late infancy<sup>55</sup>. Beef has been shown to improve growth and cognitive function in Kenyan schoolchildren.<sup>26,27</sup>

If is not economically possible to give meat every day, giving it only a few times or even once a week is beneficial. Offal is generally cheaper than meat and is a rich sources of iron, zinc, B-vitamins and vitamin D.<sup>5,6,53</sup>

### 7.4 VEGETARIAN DIETS

People choose to follow a vegetarian diet for a variety of reasons. Well planned vegetarian diets can be both nutritious and healthy. These have been associated with lower risks of heart disease, type 2 diabetes, obesity, certain types of cancer and lower blood cholesterol levels.<sup>56</sup> However, restrictive or unbalanced vegetarian diets may lead to nutritional deficiencies, particularly in situations of high metabolic demand. The nutrients of concern in a vegetarian diet are the intake of protein, iron, calcium, vitamin B12, and omega 3 fatty acids.

While proteins from animal sources contain the complete mix of essential amino acids, few plants do.<sup>2,24,56</sup> Most plant proteins provide some protein, with each plant providing a different combination. Provided that a mixture of different plant proteins is consumed over the course of a day, all the essential amino acids will be provided in the diet. Vegetarian sources of protein include beans and lentils, soya and soya products, seeds and nuts and whole grains.

Although red meat is the richest and most easily absorbed source of iron,<sup>46</sup> a number of plant foods can make a significant contribution. To increase iron intake levels eat plenty of fortified breakfast cereals, beans and lentils, leafy green vegetables, seeds and nuts. Fortified maize meal porridge and brown bread should be included on a regular basis. To aid absorption of iron from plant foods, include a source of vitamin C with the meal such as a glass of fruit juice.<sup>46,56</sup>

Tinned sardines and dairy products are rich sources of calcium and potassium. If none of these are consumed, a diet rich in tofu (soya), calcium-fortified foods, green leafy vegetables, seeds and nuts, and dried fruit must be consumed. Although spinach contains calcium it is bound to a compound called oxalate. This greatly reduces its absorption making it a poor source of available calcium.<sup>46</sup>

Consuming eggs and dairy foods will ensure enough vitamin B12 and B2 in the diet. Vegans should consider including fortified foods containing vitamin B2 and B12. To increase the content of these vitamins in the diet, eat plenty of yeast extract, soya milk and breakfast cereals.

Omega 3 fats are important for good health.<sup>58</sup> There are two types of Omega 3s: long chain fatty acids found in oily fish - docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), and the short chain fatty acid, alpha linolenic acid (ALA) in vegetable oils such as flaxseed, walnut, rapeseed and soya oils. The long chain omega 3 fatty acids are beneficial to the body and current advice recommends eating two portions of fish a week. The different short chain omega 3 fatty acids may not have the same benefits. Although the body can convert some ALA into EPA and DHA, the conversion is not very efficient. If no fish are consumed, a supplement containing algae derived DHA should be considered.<sup>56</sup>

The guideline “Fish, chicken, lean meat or eggs can be eaten daily’ was formulated to indicate that animal source foods can be eaten daily to help meet nutrient needs during the life cycle. Extra care must be taken during pregnancy, breastfeeding, weaning and childhood to make sure that all nutritional needs are being met.

## **7.5 FISH AS PART OF A HEALTHY, BALANCED DIET**

The importance of fish as an element in diets, especially the diets of infants, young children and pregnant women, is widely recognized. The contribution of fish to the supply of protein and micronutrients can be particularly important (**Table 7.5**) as well as the supply of fatty acids that are necessary for the development of the brain and body.<sup>58</sup>

Aquatic animals contain a high level of protein (17-20%) with an amino acid profile similar to that of meat. The flesh of fish is also readily digestible and immediately utilizable by the human body which makes it suitable for complementing a high carbohydrate traditional diet (maize porridge and brown bread). Compared with land animals (with some exceptions, such as shellfish), aquatic animals have a high percentage of edible flesh, and there is little wastage.<sup>59</sup>

Oil-rich fish are higher in fat and saturated fat than white fish and shellfish. However, a significant proportion of the additional fatty acids are from the long chain omega 3 polyunsaturated fatty acid group (n3PUFA), which has been linked with health benefits. The human body cannot produce these essential fatty acids so it is very important to take these in through the diet. As very few other foods contain EPA and DHA, fish intake is strongly recommended. Oil-rich fish include: herring, trout, mackerel, sardines and salmon, but omega 3 fatty acids are also present in white fish, albeit at lower concentrations. There is scientific evidence that regular intake of EPA and DHA reduces the risk of heart attack. Limited evidence was also found that non-salted fish was protective against colorectal cancer.<sup>60</sup>

The key micronutrients provided by fish are the minerals, phosphorus, selenium, potassium, iodine, zinc and magnesium; and vitamins B2, B12 and vitamin D. Owing to the presence of small soft edible bones, tinned sardines are a source of calcium, particularly for people who choose not to consume dairy products.<sup>60</sup>

## 7.6 MEAT AS PART OF A HEALTHY, BALANCED DIET

Meat, a concentrated nutrient source, was traditionally considered essential for optimal growth and development. This reputation diminished as the fat vs health debate increased. However, in response to consumer demand, the meat industry has reduced the fat content of red meat achieving significant results (refer to **Table 7.6** and **Table 7.7**). Progress continues in both total fat reduction and modifications to the fatty acid profiles of meat. As mentioned previously, meat is a significant source of protein that contains all the essential amino acids. It is furthermore a good source of a variety of vitamins and minerals, like iron, zinc and the B-vitamins. It is important to note that in leaner meat, the nutrient content is higher, as fat dilutes the nutrients in the protein matrix.<sup>61</sup> By keeping servings moderate and by trimming off all visible fat, nutritious muscle fibre is retained without increasing fat consumption. Healthier processing and preparations methods also contribute to the increased nutrient density of meat.

Although meat intake has been associated with an increased risk of colon cancer in some studies, this association appears to be stronger for processed meats than for unprocessed fresh meats. Particularly in developing countries, the contribution of fresh meat to improved nutrient intake more than offsets this uncertain association with cancer.<sup>30,62,63</sup>

### 7.6.1 Chicken

At present, poultry meat is one of the leading meat products on the South African market. Poultry meat is a nutritional food of high nutrient density. White and dark poultry meat have a high protein content and are excellent sources of the water-soluble B-vitamins and minerals such as iron and zinc.<sup>35</sup> The fat in chicken is mostly subcutaneous; therefore, the fat content of chicken meat (as with all poultry meat) can easily be lowered by removing the skin. Chicken (white and dark meat) has a fat content of less than 10%. However, it is of a concern that chicken is often consumed after deep frying of the meat and the skin, which increase the fat content considerably. Consumer education relating to “lean” is strongly advised.

### **7.6.2 Beef**

Significant differences in nutritional composition between beef carcasses of different age groups and even more significant differences within a specific age group, between different fatness classes and cuts have been reported. There is a larger difference in the fat content of different cuts within the same carcass than between beef carcasses of different age groups and fatness classes. For instance, a cooked fillet of an A age animal with a fatness level of 2 contains on average 8% fat, compared to 34% fat in the thin flank of the same carcass.<sup>64</sup> South Africa has not escaped the obesity epidemic, with 30% of adult men and 52% of adult women being overweight or obese, a trend that is still increasing.<sup>65</sup> Health as a driver in consumption of beef and a consumer preference for leaner meat have led to a significant reduction of the fat level of beef carcasses from 32% in 1949 to 18% in 1981 to 13% in 1991 and 11,5% in 2011. Cuts low in both fat and saturated fatty acids can be included in a low fat balanced diet.<sup>66</sup>

### **7.6.3 Lamb and Mutton**

In a series of research studies conducted by the University of Pretoria in collaboration with the Agricultural Research Council it was found that lean South African lamb and mutton, trimmed of external fat, contain less than 10% fat on average, and can be included as part of a healthy well-balanced diet. Due to the fact that more than 80% of South African lamb and mutton is raised on natural pasture, 47% of the fat is in the form of the healthy monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). It is therefore a natural source of conjugated linoleic acid (CLA). CLA has been shown to protect the body from cancer and heart disease and to lower cholesterol levels.<sup>36</sup>

### **7.6.4 Pork**

A research study done by the Agricultural Research Council in 2008 revealed that pork produced in South Africa is scientifically bred to be leaner, providing a lower fat content. Fat in pork is mostly visible as subcutaneous fat and can be trimmed off without much difficulty.<sup>37</sup> Fat in pork is a combination of saturated, polyunsaturated and mono-unsaturated fatty acids in varying amounts. It contains less than 50% saturated fatty acids, with the remainder consisting

of MUFA and PUFA. Pork is an excellent source of thiamine (vitamin B1) and a good source of niacin (vitamin B3).

#### **7.6.5 Offal**

In general offal is richer than lean meat in iron, copper and certain B vitamins, with liver being a particularly rich source of vitamins A, B1, B2, B6, B12, niacin and pantothenic acid, with more than a trace of vitamin D and even some minerals.<sup>5</sup> The amount of vitamin A present in liver can be variable and indeed very high, and will depend on the age of the animal and the composition of the feed consumed. Kidneys are a rich source of vitamin B1, B2 and B12. Pancreas meat is a good source of vitamin B1, B2, C and pantothenic acid. Other organ meats compare well with lean meat as sources of the vitamins. All meat products are good sources of zinc and iron, with liver, lungs and spleen being especially rich in iron.<sup>5</sup>

#### **7.6.6 Cheese as meat alternative**

A number of cheeses (e.g. Cheddar, Colby, Gouda, ricotta, cottage cheese) are good sources of protein. The amino acid composition of cheese protein classifies it as a high quality protein, containing all nine of the essential amino acids that cannot be synthesized to meet the body's needs and must be obtained from the diet.<sup>2</sup> Protein in many cheeses is readily digestible because some of the proteins are broken down during ripening to peptides and amino acids.<sup>67</sup> Cheese can also be a source of fat and sodium in the diet. Therefore care must be taken to rather include low fat and low sodium cheese (such as cottage and ricotta cheese) in the diet.

#### **7.6.7 Eggs as part of a healthy, balanced diet**

In the past, research on eggs focused on the associations of serum cholesterol levels with heart health. However, many of these studies are now considered to be methodologically weak since they did not adequately control for potential confounders such as pre-existing hypercholesterolemia, saturated fat intake or smoking.<sup>68</sup>

Eggs are a rich source of protein and several essential nutrients, such as vitamin A, B-vitamins, including thiamine, riboflavin, folate, B12, and B6 as well as vitamin D, selenium and choline compared with other protein foods (**Table 7.6**).<sup>35</sup> They provide a nutrient dense source of energy (approximately 314 kJ per large egg) from protein and fat. Eggs have traditionally been used as the standard of comparison for measuring protein quality because of their essential amino acid (EAA) profile and high digestibility which is important for children, adolescents and young adults since protein is required to sustain growth and build muscle.<sup>68</sup> For older adults, high-quality protein may prevent the degeneration of skeletal muscle<sup>26</sup> and protect against some of the health risks associated with ageing.<sup>69,70</sup> In addition, antioxidants (lutein and zeaxanthin) found in egg yolk may help prevent age-related macular degeneration.<sup>70,71</sup>

Although eggs are a rich source of cholesterol (419 mg/100 g), eggs have a low saturated fat content.<sup>35</sup> Epidemiological studies have consistently shown a non-significant relationship between egg intake and risk of cardiovascular heart disease. Emerging evidence suggests that eating eggs is associated with satiety, weight management and better diet quality.<sup>69</sup>

#### **7.6.8 Processed Meats**

Processed meat includes meat that has been preserved by methods other than freezing, such as salting, smoking, marinating, air-drying or heating e.g. ham, bacon, sausages, hamburgers, salami, corned beef and tinned meat.<sup>4</sup> According to the South African National Standard (SANS 885:2012) processed meat is meat that has been subjected to any process which alters its original state, excluding sectioning, and freezing, with or without other ingredients, and which as a result of this process or these processes the product is irreversibly changed. It excludes raw processed meat as defined in the current relevant legislation.<sup>72</sup> It includes both meat from animals (red meat) and from fowls (white meat).

The composition of different processed meats varies widely between type and producer. Overall, processed meats are more likely to have a higher content of sodium and nitrites than lean meat. Sodium is added to meat products to enhance and modify the flavour, the physical properties and sensory attributes of the food, and to contribute to the preservation of the



product. Due to the adverse health effects associated with a high intake of sodium, work is underway in South Africa to reduce and control the amount of salt in processed meat products.

Nitrite has been consumed since the beginning of time in a variety of foods including vegetables and cured meat. Nitrite is considered an essential curing ingredient responsible for developing colour, creating a unique flavour profile, controlling oxidation of lipids, and it has effective antimicrobial properties. Despite the controversies about the safety of nitrites often found in processed meats, ongoing research focused on the metabolism of nitrite, nitrate and nitric oxide appears to reaffirm the general benefits of nitrate/nitrite in human health.<sup>73,74</sup>

In a cross-sectional study of Irish adults it was indicated that it is important to distinguish between meat groups as there is a large variation in the dietary quality of consumers of red meat, white meat and processed meat. For example, increasing processed meat intake has been found to be associated with a lower intake of wholemeal bread, fruit and vegetable and fish intake and poorer overall dietary quality.<sup>75</sup> Other factors, such as fruit, vegetable and fibre intake and physical activity are also important and risk of cancer may be more effectively reduced by tackling all diet related and lifestyle risk factors together.

## **7.7 CONSTRAINTS TO CONSUMPTION OF FISH, MEAT AND EGGS**

Although consumer attitudes to animal source foods (ASF) are influenced by a number of factors, such as price and availability, the major differences in the volume and type of product consumed between countries are thought to be primarily due to differences in culture and traditional eating habits.<sup>76</sup> Furthermore, some individuals choose to either avoid meat altogether or certain types of ASFs for a variety of reasons, such as taste, ethical or religious reasons, health concerns such as additives, hormones, fat and cholesterol, or because of socio-economic factors.<sup>30,77</sup> The consequences, such as greenhouse gas emissions, the water footprint and land use, of ASF production and consumption have received considerable publicity.<sup>78</sup>

## 7.8 DIETARY GUIDANCE FOR ANIMAL SOURCE FOODS

Animal source foods can form part of a healthy, balanced diet that includes plenty of fibre from fruit, vegetables, pulses and wholegrain cereals. **Table 7.8** shows dietary guidance relating to the consumption of animal protein for different countries.<sup>7,79,80,81,82</sup> The challenge in the context of this paper is to aim for an optimal and diverse diet for all South Africans from all socio-economic groups.

It is therefore recommended that the diet would include:

- Two to three servings of fish per week; preferably oily fish such as sardines (pilchards) and mackerel (including tinned versions);
- About four eggs per week;
- A serving of lean meat can be eaten daily; preferably not more than 90g/day or 450-500g/week. Trim visible fat from red meat and remove skin from chicken. Prepare the meat with no or little added fat and salt;
- Limit the intake of processed meat;
- Limit the intake of high fat cheeses, rather opt for low fat cheeses.

**Table 7.8** Examples of recommendations related to animal protein consumption in dietary guidance

Country	Recommendations	Reference or Source
<b>United States</b>	<p>Eat a variety of foods from the protein group each week.</p> <p>Eat seafood in place of meat or poultry twice a week.</p> <p>Select lean meats and poultry.</p> <p>Trim or drain fat from meat and remove poultry skin before cooking or eating.</p> <p>Try grilling, broiling, poaching, or roasting as these cooking methods do not add extra fat.</p> <p>Drain fat from ground meats after cooking.</p> <p>Avoid breading on meat and poultry.</p>	<p>Dietary Guidelines for Americans. 2010<sup>79</sup></p> <p><a href="http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf">http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf</a></p>
<b>European Region</b>	<p>Eat a nutritious diet based on a variety of foods originating mainly from plants, rather than animals.</p> <p>Replace fatty meat and meat products with beans, legumes, lentils, fish, poultry or lean meat.</p> <p>Use milk and dairy products (kefir, sour milk, yoghurt and cheese) that are low in both fat and salt.</p> <p>Choose a low-salt diet. Total salt intake should not be more than one teaspoon (6g) per day, including the salt in bread and processed, cured and preserved foods. (Salt iodisation should be universal where iodine deficiency is endemic.)</p>	<p>Twelve steps to healthy eating. Food based dietary guidelines in the WHO European Region<sup>80</sup></p> <p><a href="http://www.euro.who.int/_data/assets/pdf_file/0017/150083/E79832.pdf">http://www.euro.who.int/_data/assets/pdf_file/0017/150083/E79832.pdf</a></p>
<b>Pacific Countries</b>	<p>Choose a variety of foods from the three food groups (energy foods, protective foods and body-building foods). Local are best.</p>	<p>Pacific Guide to Healthy Eating<sup>81</sup></p> <p><a href="ftp://ftp.fao.org/es/esn/nutrition/dietary_guidelines/pac_1.pdf">ftp://ftp.fao.org/es/esn/nutrition/dietary_guidelines/pac_1.pdf</a></p>
<b>Canada</b>	<p>Choose lower-fat dairy products, leaner meats and foods prepared with little or no fat.</p>	<p>Canada 's Guidelines for Healthy Eating<sup>82</sup></p> <p><a href="http://www.ymcahbb.ca/filemanager_files/Health%20Tips/Canada%20Guidelines.pdf">http://www.ymcahbb.ca/filemanager_files/Health%20Tips/Canada%20Guidelines.pdf</a></p>

## 7.9 CONCLUSIONS

Meat, fish and eggs provide many important nutrients, particularly protein, long-chain n-3 fatty acids, iron, zinc, selenium, vitamin D and vitamin B12. Meat is a well recognised source of bioavailable iron and zinc. In the light of current low levels of iron and zinc intake in South Africa, particularly among women and children, meat has the potential to make an important contribution to the intake of these nutrients. Meat, fish and eggs also contain a range of B vitamins, although the levels vary between different food products. Red meat and fish, in particular are good sources of vitamin B12. As this vitamin is only found naturally in foods of animal origin, subgroups of the population who do not consume meat or animal products, may have inadequate intakes.

Although meat and eggs are seen as contributors to SFA intake, lean meat actually contains a higher proportion of unsaturated fatty acids. Fish contains high levels of the long-chain n-3 fatty acids, EPA and DHA. Furthermore, work is currently underway to identify methods to alter the fatty acid profile of meat, to obtain a more positive fatty acid profile in terms of heart health. Various research studies have been conducted to establish if there is a link between red and processed meat intake and risk for chronic diseases. Obtaining definitive evidence to confirm diet-risk relationships is a challenging process due to complex interactions and confounding factors including genetics, lifestyle, and infectious and environmental factors.

Meat is a versatile food that adds variety to eating occasions and is enjoyed by many. Some people choose not to eat meat, for a variety of reasons, but as there is no evidence that a moderate intake of lean meat, fish and eggs has any negative effects on health, there is no scientific justification for excluding it from the diet. As recommended in dietary guidelines globally, lean meat, fish and eggs consumed in moderation, can be promoted as part of a healthy, balanced South African diet.

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## CHAPTER 8: CONSUMER EDUCATION ON THE HEALTH BENEFITS OF RED MEAT – A MULTIDISCIPLINARY APPROACH

*This paper was published in Food Research International as an invited paper on the approach used in South Africa towards educating consumers on the role of red meat (a generic agricultural commodity) as part of healthy diets. (Food Res Int, 2012, 47(2), p152 – 155).*

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### ABSTRACT

This paper first presents food quality trends observed in the international context and the manifestation of these and other trends within the food industry. From a consumer perspective, improved knowledge on the composition and function of foods has contributed to many of the changes in these qualities. This is due to an increased demand, and a subsequent response from the food science industry. Science based education on health could continue these positive changes in nutritional behaviour (demand), and continue the development of healthier food options provided by industry (supply). Changing agents in this process should be seen as believable and trustworthy. In the case of health and well-being, health influencers, such as scientists and medical practitioners, are seen as the key towards change.

### 8.1 INTRODUCTION

In 1992, the International Conference on Nutrition identified strategies and actions to improve nutritional well-being and food consumption globally (Clay, 1997). Through these, governments were called upon “to provide advice to the public by disseminating, through use of mass media and other appropriate means, qualitative and/or quantitative dietary guidelines relevant for different age groups and lifestyles and appropriate for the country’s population” (FAO/WHO, 1992).

Recently, non-governmental bodies all over the world are increasingly contributing to the aim of better health for all, and are devoting time and funds towards consumer education. Consumer health education projects, often called social marketing campaigns, aim to promote awareness of the health and nutritional advantages of foods, based on current composition data, in an

effort to change behaviour. As examples of the global relevance of evidence-based consumer education, both the Nutrition Working Group of the International Dairy Federation (IDF) (representing more than 60 countries), as well as the International Meat Secretariat (IMS) (representing more than 30 countries), disseminates current research findings to both the scientific community and the consumer. Through both of these working groups the research findings are used to inform the scientific community, aiding in the identification of research needs for the food industry and providing perspectives to add value to food products in the context of improving human nutrition. Furthermore the information is shared during events or via specific newsletters and publications to the general public.

## **8.2 CONSUMER EDUCATION PROGRAMMES**

Nutrition education is used in many countries to improve the nutritional wellbeing of target populations. The general objectives of such programmes are to enable the target population to make the best use of existing food resources, and to familiarize them with country specific food based dietary guidelines for good health and nutrition (FAO, 2001). Broad goals of Consumer Education Programmes (CEPs) and actions needed to increase effectiveness include: 1) To bring about appropriate and meaningful changes in knowledge, attitudes and dietary practices which will result in improved nutritional status; 2) To empower consumers to have full knowledge about the nutritional qualities of the foods they consume; and 3) To protect the consumer from incorrect commercial information with respect to the nutritional qualities of foods. To increase effectiveness of such a campaign, they need to be well planned, implemented, monitored and evaluated; consider social and cultural relevance of the messages and the way in which it is delivered; the programme design should reflect understanding of the social, economic and cultural determinants of current food, health and nutritional behaviour. As a new trend, the use of social marketing methods would strongly be recommended (FAO, 2001).

Consumers should have the knowledge, as well as the means, to make informed food choices. Different socioeconomic groups should also be targeted differently. In developed countries, where more individuals suffer from obesity than those suffering from undernutrition (WHO, 2004; CDC, 2006), there is an increased awareness of the consequences of dietary choices

and actions, and the risks associated with bad dietary habits. Global trends observed include greater focus on health, convenience, environmental impact and indulgence. However, it is recognised that consumers are motivated by different drivers when finally consuming food, which is easily explained by the growth in worldwide obesity. Food consumption behaviour goes hand in hand with availability and affordability, often irrespective of the knowledge of healthy food choices. Another complicating factor which should not be ignored is the surge in contradictory messages related to health and nutrition. The credibility of information sources thus strongly comes into focus.

Developing countries are often subjected to the double burden of persisting undernutrition in the midst of the growing epidemic of obesity and non-communicable diseases (UN/SCN, 2004; FAO, 1996; Steyn & Temple, 2008). Africa is the only developing region in the world with increasing numbers of underweight and stunted pre-schoolers (UN/SCN, 2004) and hungry people (FAO, 1996). The burden of non-communicable disease on the African continent (and in SA) continues to demonstrate the potential for improvement in health (Steyn & Temple, 2008). Understanding, skills and motivation to make the best food choices available, are required along with sufficient sources to produce or purchase food (FAO Newsroom, 2005).

In South Africa, 56.2% of the adult population was overweight or obese (SADHS, 2003), while 10% of children (1 – 9 yrs) were underweight and more than 20% were stunted (NFCS, 1999). SA is classified as a middle-income developing country, but is characterized by extremes of wealth and poverty. It is divided into developed metropolises and developing rural and peri-urban areas. Like many developing countries, SA is faced with both nutritional deficiencies and excesses. The IFIC Foundation (2006) reports that taste and price remain the two most important criteria determining food choice in SA, followed by healthfulness and convenience. The SA Bureau of Food and Agricultural Policy (BFAP) reported that health, convenience and indulgence are among the most important local food trends (BFAP, 2010).

## 8.3 A MUTLI-DISCIPLINARY APPROACH TO CONSUMER EDUCATION PROGRAMMES

### 8.3.1 The message and the medium

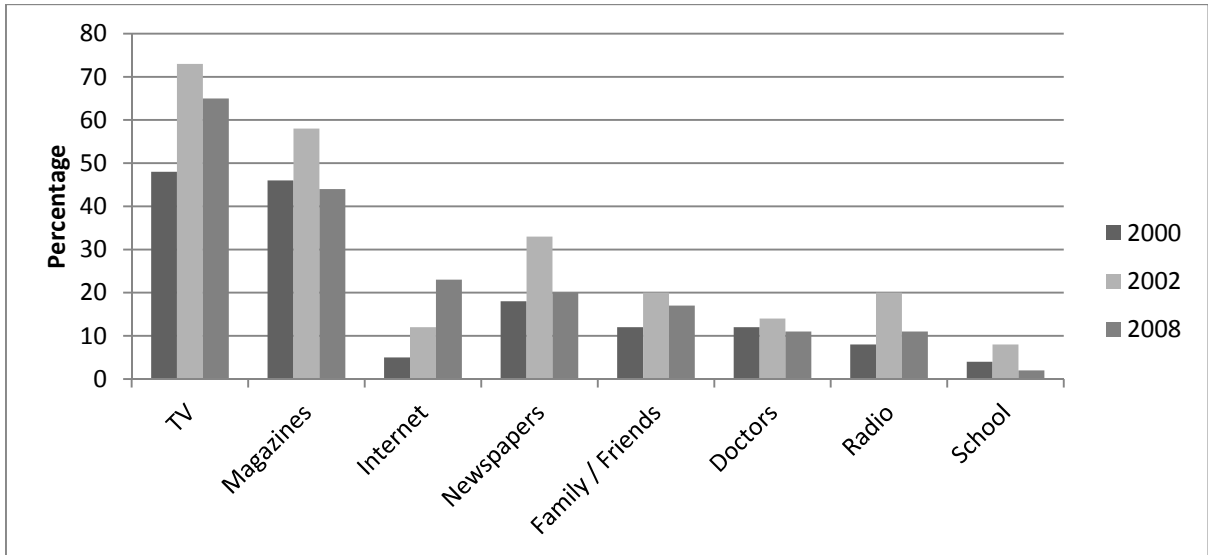
With the surge in contradictory media messages related to health and nutrition, nutrition information should form the basis in any consumer education programme to ensure success.

Messages communicated to the target audience should be:

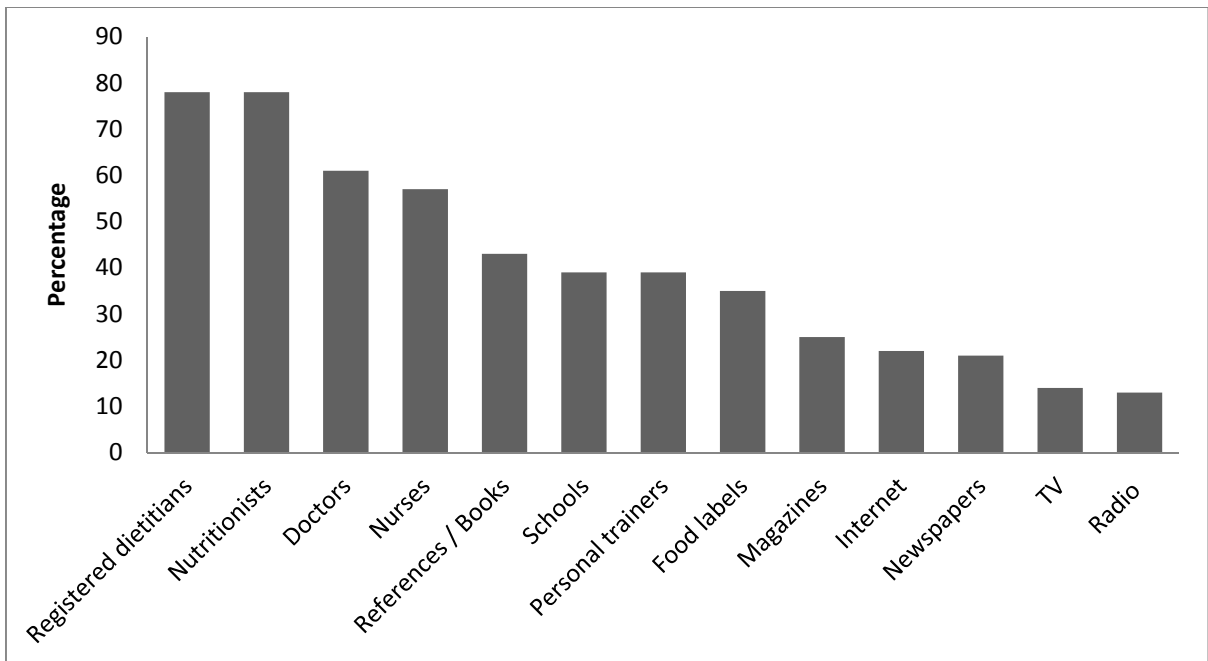
- Current
- Scientifically correct
- Translated into understandable messages
- Communicated
- Simple and consistent

Agents of change in this process must be believable and trustworthy. According to the American Dietetic Association (2008), the most popular sources of information are among the least credible. Television is the most popular source of nutrition information, followed by magazines, the internet and newspapers (**Figure 8.1**). The most credible sources of information are considered to be registered dietitians and nutritionists (78 %), doctors (61 %) and nurses (57 %) (**Figure 8.2**) (American Dietetic Association, 2008). Within the local context, 1 250 South African households were interviewed and the most often used sources of health information were food packaging, magazines and TV adverts, whereas the most credible sources are considered to be doctors, dietitians and nurses, followed by on pack labelling (Kellogg's Nutrition Advisory Science, 2008). The approach of the International Dairy Federation (IDF) and International Meat Secretariat (IMS) to disseminate research findings to both the scientific community and the consumer ensures that the messages which the consumer receives in the public domain are reiterated by the health professional they trust.





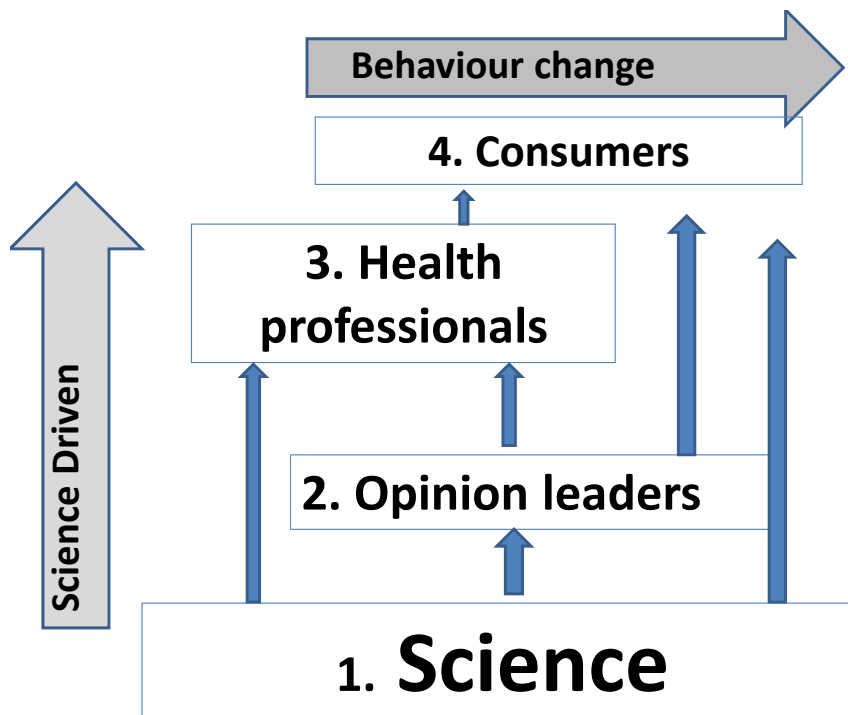
**Figure 8.1** The most popular sources of nutrition information over time (American Dietetic Association, 2008).



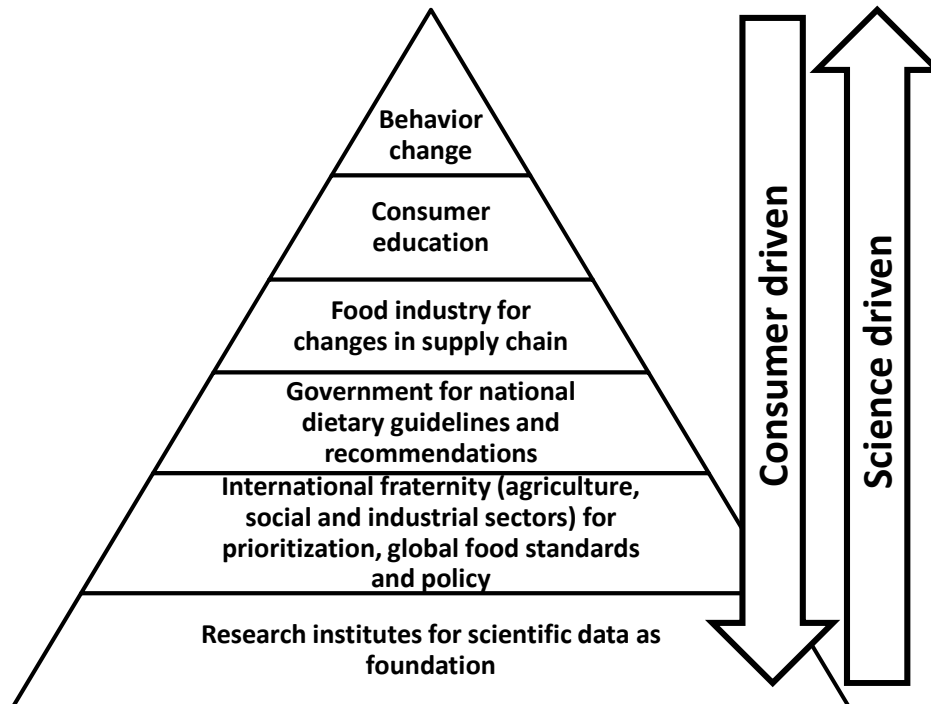
**Figure 8.2** The sources of nutrition information which are considered most credible (American Dietetic Association, 2008).

#### 8.4 A science based foundation

The process towards behaviour change for better nutrition needs to follow a multisectoral approach, with the foundation being science based (**Figure 8.3**). As the consumer-driven trend towards health is affecting changes within the entire food chain, from food research, to food production product formulation, and retail activities, (consumer driven) emphasis is placed on communicating these findings to the consumer (science driven) to further encourage them towards correct food choices (**Figure 8.4**).



**Figure 8.3** Science based education strategy for nutrition communication in the aim of behaviour change



**Figure 8.4** Science driven integration between multiple sectors for behaviour change towards better nutrition (Schönfeldt & Gibson, 2010).

#### 8.4.1 The Consumer Education Campaign of the South African Sheep Meat Marketing Forum

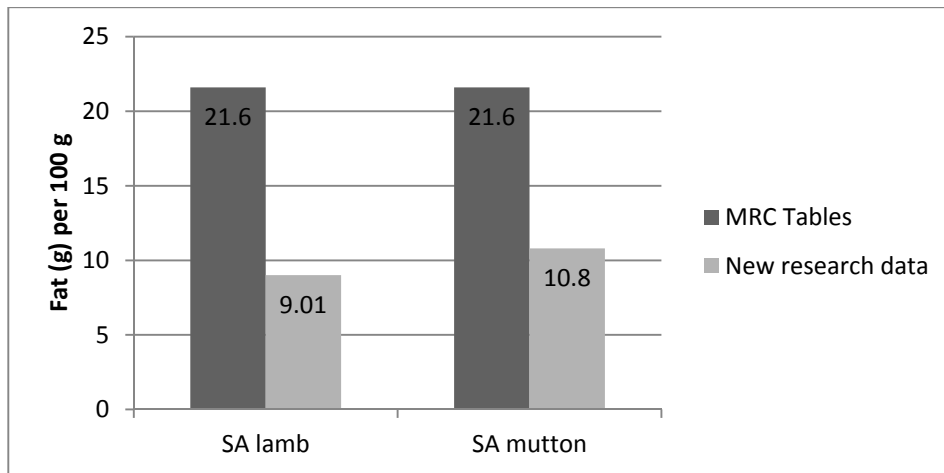
There is ample current scientific research indicating that red meat can be consumed daily. However, based on epidemiological studies, obesity and high saturated fat intake from animal products has a positive association (Biesalski, 2005; Chao, Thun, Connell, McCullough, Jacobs, Flanders, Rodriguez, Sinha & Calle, 2005). This has led to the consumption of smaller portions less frequently, in an aim to restrict fat intake. Meat plays an integral role in global eating (Grunert, 2006) and the nutritional attributes of meat, which provide a major proportion of consumer requirements for protein, vitamins and minerals, are highlighted studies conducted in many countries (Breidenstein, 1987; Johnson, 1987; Robinson, 2001). These studies also reflect the substantial changes over time in the composition of carcass meat, especially reduction in the amount of fat both on the carcass itself and after trimming in the shop or at home, as well as the effect of changes in processing and preparation methods (Chan, Brown, Lee & Buss, 1995; Higgs, 2000). The percentage fat present in New Zealand beef carcasses

has decreased from 23.3% in 1981 to 7.1% in 1997 (EuroFIR, 2008). In South Africa similar results have been found with the average fat content of target grade beef decreasing from 32% in 1949 to 18% in 1981 to 13% in 1991 (Naudé, 1994). These changes in the fat content can be attributed to the increase in consumer demand for leaner red meat products, and the response of the science fraternity by adapting animal diets, breeding techniques and other food science activities, as well as preparation techniques.

Although meat is a favourite and popular food in the diet of South Africans (Scholtz, Vorster, Matsego & Vorster, 2001), the popularity of red meat locally and abroad is consistently declining in favour of white meat as well as other non-meat proteins. An on-going campaign to promote the consumption of South African lamb and mutton among South African consumers was launched in 2007 by the Sheep Meat Marketing Forum on behalf of the Red Meat Industry Forum. The campaign was based on from an initial review published in 2006 of the most recent research surveys on the consumer perceptions of red meat in South Africa. The critical factors important to the consumer, including the perception that South African lamb and mutton is high in fat, were highlighted, and served as a guide in the approach to the educational campaign. The campaign is based on current scientific knowledge of the composition data of South African lamb and mutton.

#### *8.4.1.1 The science based foundation of the campaign*

Nutritional data on the composition of South African lamb and mutton were determined before, by the Agricultural Research Council (ARC) Irene. The main findings of the study showed that South African lamb and mutton are substantially leaner and thus contain less fat compared to the values listed in the South African Food Composition Tables of the Medical Research Council (MRC), which are derived from the United States Department of Agriculture. Based on the new data, South African lamb and mutton contains on average only 9.01 % and 10.8 % fat respectively, compared to 21.6 % fat published in the MRC tables (**Figure 8.5**).



**Figure 8.5** Changes in fat content of lamb and mutton

#### 8.4.1.2 *The focus of the educational campaign*

The campaign is aimed to educate South African consumers on the role of South African lamb and mutton in a balanced diet, based on scientific results. The campaign consists of two parallel streams of education which are deployed to health professionals and directly to consumers (**Table 8.1**).

**Table 8.1** Strategy of the Consumer Education Campaign of the Sheep Meat Marketing Forum

	<b>Health Professionals</b>	<b>Consumers</b>
Why	Considered one of the most important and credible sources of nutrition information	Consumers are currently very interested in the foods they consume
Who	Health professionals, e.g. medical doctors, nutritionists and dietitians	Consumers
How	Support and stimulate continued scientific research Disseminate research results in the form of booklets, leaflets and other publications Distribution of information leaflets through their professional organizations Advertorials, pamphlets and peer reviewed articles in scientific / medical journals Participation at scientific conferences in the form of presentations, scientific posters or exhibitions All information available electronically at <a href="http://www.healthymeat.co.za">www.healthymeat.co.za</a>	Educational posters, information pamphlets and recipe booklets (containing recipes and health related information) are distributed via retail partners, the Department of Education, butchers, etc. Advertorials in popular magazines and newspapers All information available electronically along with recipes at <a href="http://www.healthymeat.co.za">www.healthymeat.co.za</a>
What	SA lamb and mutton contains on average less than 10 % fat Nutrient density Bioavailability of iron and zinc from animal sources A food based approach to alleviate iron deficiency Updates on the health properties of ruminant <i>trans</i> fats Portion sizes	Positive changes in the fat content of SA lamb and mutton Nutrients in red meat The health effects of different fats Red meat as part of a balanced diet A food based approach to alleviate iron deficiency Portion sizes Selecting and preparing red meat prudently

## 8.5 CONCLUSIONS

For any education campaign to be credible and trustworthy, the latest results from recent peer-reviewed scientific studies are required. In 2010, in line with this requirement, more than double the amount of funding was spent on research within the red meat industry, than on direct educational activities.

Sound food composition data is the first requirement for this type of educational campaign. This composition data needs to be continually updated and extended, as:

- Analytical methodologies improve (e.g. *trans* fats and bioavailability)
- Products change (e.g. natural pastures vs. corn fed)
- New cutting practises are implemented (results in difference in description of cut and therefore composition)
- Changes in cooking trends (e.g. trimming prior to cooking and tomato based vs. oil based marinades)
- Shifts in carcass composition (e.g. consumer demand for leaner carcass meat with less visible fat)
- Shift in consumer demand for slaughter age (e.g. consumer demand for lamb has shifted the market almost exclusively to lamb in 2010 translating into >85% of production)

The dynamic nature of red meat and red meat products, changing in nutrient composition all the time according to consumer preferences, requires concurrent communication of the research findings to health professionals and consumers. This needs to be done to empower professionals and members of the public with the knowledge of the true nutrition and health properties of the food product they consume as part of a balanced diet. Furthermore, the challenge to the food scientist is to deliver a value added product that falls within the scope of what the health professional communicates, and what the consumer demands.

If all credible sources of health information are persistently informed of these scientific results and work together to disseminate comparable health messages to the consumer through various means, such educational campaigns can be successful, thereby contributing towards the goal of nutritional well-being of the target population.

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## CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

### 9.1 INTRODUCTION

The study initially started in 2010 as a research project financially supported by Red Meat Research and Development South African (RMRDSA) and the National Research Foundation (NRF) to supply the red meat industry with an updated nutritional profile of South African beef as currently produced and consumed, including extrapolation of the effect which trimming as a health trend, has on its composition. However, in view of the current and emergent global agenda on sustainable development, including the United Nations' process to finalise a set of Sustainable Development Goals (SDGs) (to build on the Millennium Development Goals (MDGs) as part of the post-2015 development agenda), the focus of the study was expanded to include the interpretation of the scientific data it had generated within this sustainability context. The Global Nutrition Report (2014) highlights this essential role which nutrition, and consequently the consumption of nutrient dense foods, can play in attaining sustainable development and delivering on these SDGs.

The final aim of the thesis was to investigate the sustainability of red meat consumption from a human nutrition perspective, and included six objectives, each addressed by means of an article submitted for publication in a peer reviewed journal.

### 9.2 OVERVIEW

In **Chapter 2** a review was conducted on the current South African policy landscape to provide the foundation for needs identification of scientific data to guide future policy development, particularly in view of the fact that the current global post-2015 development agenda focuses on sustainable development. Despite economic growth, undernutrition in South Africa has not improved when compared to other industrialised nations, while simultaneously, diet-related non-communicable diseases and obesity have increased. Although adequate food is a constitutional right of all South Africans, many South Africans suffer from the consequences of inappropriate diets, namely either an excess or a deficiency of nutrients.

The three aspects of sustainability, therefore, include social and economic considerations in addition to environmental impact assessments, which is why the role of livestock production and consumption in the livelihoods of South Africans (in terms of both nutrition and food security) should not be ignored. The South African government supports this argument, manifested through three particular policy programmes. To improve income generation and promote food security, the red meat industry integrated value chain has been identified by the Agricultural Policy Action Plan (APAP) of 2014 to 2019 as a Key Action Programme focused on building South Africa's production capacity and the commercialisation of the livestock system. Furthermore, nutrient dense animal source food options (low in fat and kilojoules, high in protein and micronutrients) are promoted as part of healthy, sustainable diets in the revised national Food-Based Dietary Guidelines (2013) of the Department of Health, and in the recently released Strategic Plan for the Prevention and Control of Non-Communicable Diseases (DOH, 2013).

Science based evidence is required to guide the alignment of policies, and the programmes and guidelines that they generate. Furthermore, relevant nutrient content data (in terms of quantity and quality) can form important scientific baselines for various other arguments related to the role of the specific food product in sustainable diets. As an example, a recent publication by Drenowski *et al.*, (2014) evaluated the energy and nutrient density of foods in relation to their carbon footprint. The paper concluded that although meat and dairy had the highest carbon footprint per 100g, their nutrient density and potential contribution to human health was notably higher than for foods with lower carbon footprints.

The nutritional composition of South African beef was previously determined in the 1990s, but since then various consumer trends as well as breeding and production practices have changed. In South Africa, grain based (intensive) production systems have increased exponentially, providing nearly 80% of the fresh meat market with grain fed beef. The remaining fresh meat reaching consumers is produced on grass based or extensive production systems. Consumers are also increasingly concerned about health and in particular weight management, and the trimming of fat from fresh meat (either prior or after cooking), has become a general trend. The effect that trimming of visible fat has on the nutrient composition of South African beef has not been determined before. Because such scientific data was regarded as important,

the nutritional composition of raw and cooked, trimmed and untrimmed, South African beef from four different age groups and two production systems in South Africa was determined. The results of the study were published in three separate articles. Firstly the data from the study was combined with previous data generated on the composition of South African lamb and mutton to provide an overview of the differences in the composition of South African red meat, as a non-homogenous, generic, agricultural commodity. It was observed that the amount of fat on red meat carcasses has been reduced over time, simultaneously improving nutrient density. Actions which contributed to these changes included breed selection, feed manipulation, and alterations in animal slaughter age and weight. Further removal of fat through retail and food preparation practices, such as trimming, has resulted in even leaner end products, in line with current nutrition and health recommendations and the South African Food-Based Dietary Guidelines (**Chapter 3**).

In **Chapter 4**, the results of the study, i.e. the physical and nutrient composition of beef from four age groups and different production systems (as well as the effect of fat trimming) were presented. Fat content of marketable beef has decreased notably since the 1930s, and South African beef contains less than 10g fat per 100g after trimming of subcutaneous fat, irrespective of age. Removal of all visible fat reduces the fat content to less than 5g per 100g, comparing favourably with other lean animal products in terms of fat content.

As many arguments associated with the social as well as environmental concerns of sustainable development are related specifically to the type of animal production system, the study specifically extrapolated the effect of feeding regime on the fatty acid profile of beef (**Chapter 5**). It was found that South African beef from young animals fed on grain based diets, contain less total fat and saturated fat per edible portion than grass finished beef, which is contradictory to most research done in other westernised countries such as the United States where grain fed beef is observed to be significantly higher in total fat, and subsequently, higher in saturated fatty acids per edible portion. This finding for South African meat can probably be linked to the current carcass classification system which is based on consumer research promoting the production of leaner beef carcasses for optimal market price. On the other hand, it was found that beef from grass based feeding systems contained significantly more total fat

(when trimmed) as a result of more intramuscular fat (marbling), as well as more omega 3 fatty acids and more conjugated linoleic acid per edible portion (when trimmed or untrimmed). These essential fatty acids have been noted to play an important role in heart health, and the higher quantities found in grass fed beef could be promoted as a beneficial nutritional consideration of grass fed beef. Dietary recommendations on the consumption of beef should thus consider these findings, as the results are clearly country specific.

Scientific data on the nutrient composition of commonly consumed food products is integrated into and guides policies and programmes, including consumer education campaigns. Red meat, being a primary provider of essential nutrients (including protein) to human diets, is a popular South African food, but often evokes a wide array of complex and contradictory arguments. In the context of public health, the quantity and quality of the nutrients found in animal source foods should be considered and effectively communicated, especially as South Africans are increasingly suffering from the consequences of inappropriate diets. Although it is often suggested that the intake of animal source foods should be limited, because of the possible link between animal product consumption and health concerns, scientific evidence increasingly indicates that animal source foods could play a beneficial role in preventing and combating obesity and certain non-communicable diseases related to overnutrition. The role of animal source foods as part of a healthy diet requires continuous investment in research and extrapolation of the information obtained in the form of appropriate guidelines and recommendations. **Chapter 6** reviews this role of animal source foods from available scientific evidence and served as the scientific background paper for the revision of the South African Food-Based Dietary Guideline related to the consumption of meat, chicken, fish and eggs. The challenge in the context of this paper was to aim for an optimal and diverse diet for all South Africans. Based on the available evidence, it was recommended that “fish, chicken, lean meat and eggs can be eaten daily”. Diets should include two to three fish servings per week and approximately four eggs per week, and a serving of lean meat (limited to 90g per day) can be consumed daily. Trimming of visible fat is furthermore promoted, and added salt and fats should be limited.

Animal source foods are often subject to scrutiny in the context of their environmental impact. However, to enable a balanced approach to the argument of sustainable development, and specifically to guide social considerations, a scientific paper was written on the nutritional role of animal source foods in the diets of South Africans (**Chapter 7**). The paper was an invited article to a special issue of the South African Journal of Animal Science entitled “A balanced perspective on animal production, from environment to human health”. Food products from animals provide a variety of macro- and micronutrients, including high quality and bioavailable protein, beneficial fatty acids and essential, bioavailable micronutrients such as haem iron and calcium.

For a variety of reasons it is often recommended that animal source foods should be limited in the human diet. Yet, ample evidence indicates that health concerns related to animal source food consumption (such as increased risk of weight gain, cancers and hypertension) are questionable, and evidence increasingly suggests that animal source foods may have a beneficial effect in preventing and controlling obesity and certain non-communicable diseases (Schönfeldt *et al.*, 2013). In addition, relatively small amounts of these foods, added to vegetarian or monotonous staple-based diets often found in developing communities can substantially increase nutrient adequacy (IFPRI, 2014). There is consensus in international dietary recommendations that animal source foods form part of healthy, balanced diets, but animal source foods are often also associated with nutrients that are less desirable in the diet, such as saturated fat and cholesterol (Schönfeldt *et al.*, 2013). By choosing lean prudent portions of these foods, the intake of these macronutrients can be controlled. There is also a lack of recent food consumption data that captures the contribution (amount and frequency) that animal source foods make to the South African diet (Van Heerden & Schönfeldt, 2010). Until such data becomes available, caution should be used when sanctions are made to reduce intake, as intakes reported are already below the recommended amounts. Animal source foods are furthermore seldom consumed on their own, but form part of a whole meal. The composition of the rest of the meal (nutrient density, portion sizes and bioavailability) should not be neglected when healthy, sustainable food choices are made.

The final published article which formed part of this thesis provides a brief insight into the multidisciplinary approach which is followed to communicate scientific findings related to nutrition, to consumers. From a consumer perspective, improved knowledge on the composition and function of foods has contributed to many of the changes in these qualities. This is due to an increased demand, and a subsequent response from the various industries. Science based education about health could continue these positive changes in nutritional behaviour (demand), and continue the development of healthier food options provided by industry (supply). Since the publication of the paper the consumer education campaign of Lamb and Mutton South Africa has aligned its messages to comply with the four most pressing and recent food quality trends related to red meat, namely health, convenience, indulgence, and not surprisingly, sustainability.

In summary, the thesis provides data on the updated nutritional profile of South African beef as produced and consumed, and compares this to other animal source foods. Sustainable food systems need to include societal and economic considerations in addition to being environmentally conscious. Improving people's nutritional status is central to attaining sustainable development, as improving nutritional status will make large contributions to the Sustainable Development Goals of the United Nations related to poverty, food, health, education, gender and employment (Global Nutrition Report, 2014). Within a country with increasing incidence of overweight and obesity observed in the midst of persistent micronutrient deficiencies, nutrient dense foods (high in nutrients and lower in energy) such as South African red meat could make a unique contribution.

### **9.3 LIMITATIONS OF THE STUDY**

When the methodology was developed and finalised, various factors were considered; firstly the principles for data collection in the beef study had to be comparable to those of previous studies on South African lamb and mutton composition, and secondly analytical costs needed to be kept within the bounds of the financial means at our disposal. Two specific limitations that were associated with this methodology were noted:



- a) Due to the high financial implications of nutritional analyses, the nutrient composition study on South African beef was limited to the sampling of only three primary carcass cuts. Although these cuts (prime rib, rump and shoulder) have been found to most effectively predict the composition of the whole carcass (Naude, 1972) (Schönfeldt *et al.*, 2010) and only three cuts were analysed during the previous sheep meat studies, the data which was obtained and available for application is consequently limited to these three cuts.
- b) To comply with both requirements set out above, intermuscular and subcutaneous fat from each sample were combined for nutritional analysis. However, with the increased focus on fatty acids in human health, the variations in degree of trimming performed by butchers and consumers, as well as the unique results found in the current project, it would have been valuable to determine which fraction of fat (intermuscular or subcutaneous) has the most beneficial fatty acid composition.

At the time of the study, no laboratory in South Africa was able to accurately determine the vitamin B content of fresh meat. The use of international laboratories was explored, but the legal, monetary and logistical aspects related to the export of the fresh meat samples resulted in vitamin analyses being excluded from the current study. Vitamin content values are thus still being “borrowed” from appropriate sources when required.

Nutrient composition data on lamb and mutton were obtained from the results of previous studies commissioned by the South African Red Meat Industry in 2006 and 2008 (Van Heerden, 2007; Sainsbury, 2010). The data was included as it was provided when compiling the article submitted to Food Research International in 2012 on Consumer education on the health benefits of red meat – a multidisciplinary approach (**Chapter 8**). Since publication, the datasets received were statistically re-analysed to be comparable with the beef data generated through the analytical part of this thesis. Consequently, nutrient content values for South African lamb and mutton presented in the rest of the thesis differ slightly from these values presented in **Chapter 8**.

#### 9.4 CONCLUSIONS AND RECOMMENDATIONS

During this study the nutrient content of South African beef as currently produced was determined, and the effect of trimming was extrapolated. The results of the analytical study indicates that red meat in South African are lower in fat than previously reported, that trimming has a significant impact on reducing fat content, that red meat reflect favourably in terms of fat content to other animal source foods, and that beef produced on different production systems have unique nutritional profiles. Improving human nutrition is central to achieving sustainability goals, as improved nutritional status improves income generation capacity, education, gender equality as well as overall health. As a result, red meat can be considered sustainable from a nutrition perspective.

The current South African policy landscape supports the production of livestock to improve income generation and food security, and also promotes nutrient dense animal source foods as part of healthy diets. However, only limited data on the actual nutrient composition of the red meat produced as currently consumed has until now been available to inform programmes arising from these national policies. Future communication with policy developers and other relevant bodies on the findings of this study will have to be initiated.

Although red meat is often seen as contributing to nutritional problems, especially in the context of the increasing incidence of obesity and cardiovascular diseases, locally produced fresh red meat was found to be low in fat and high in other essential macronutrients such as protein and micronutrients including iron and zinc, especially when trimmed. Furthermore, production systems have been adapted in such a way to adhere to consumer demand, so that marketable beef, even when untrimmed, is significantly leaner today than it was in the past. The different production systems also influence nutritional quality, with grain fed beef being lower in total fat and saturated fats, but grass fed beef being higher in essential omega 3 fatty acids and conjugated linoleic acid, even when fully trimmed. The study clearly illustrates the non-homogenous nature of red meat, changing continuously and influenced by factors such as age and feeding regime. The data attests that in order to align policies, industry processes, as well as legislative and marketing strategies, with each other, continuous research on the physical

and nutritional composition of red meat needs to be performed to ensure that the baseline information remains relevant and accurate.

Considerations of the environmental impact of foods need to be quantitatively expressed in terms of nutrient density. The higher nutritional contribution of leaner South African red meat products needs to be offset against the high carbon footprint of beef and lamb production again against the context of marginal lands. This area of science is also a priority area for future research. Another area of research which could add value to the conversation includes food waste, and specifically related to red meat. The concept of nutrient bioavailability, in addition to nutrient content, could also feed into discussions surrounding sustainable, healthy diets. In particular, the bioavailability of nutrients found in red meat such as haem iron and complete amino acids profiles could be further investigated.

For the information generated to be effective in assisting the sustainable development of the South African livestock industry, the data needs to be successfully communicated to relevant audiences. These messages should firstly include the important role which social considerations need to play in addition to environmental and economic arguments of sustainable development. Furthermore, the role which nutrition plays within economic considerations as a direct link to food security needs to be effectively understood.

Once the importance of nutrition within sustainable development is realised, relevant data on the composition of locally produced food products (in this case red meat), can be used as scientific baseline information to align the relevant policies and programmes, and be fed into national food composition databases for future research, as well as national consumer education campaigns. The current consumer education campaign of Lamb and Mutton South Africa has a focused message on sustainability to which certain findings presented in this thesis can make a significant contribution. However, as the main research focus of this project was on the nutrient composition of beef, and the extrapolation of the findings in terms of red meat as a generic agricultural commodity, a generic consumer education campaign on the role of red meat as part of healthy, sustainable diets is justifiable.

Current consumer considerations on the sustainability of the South Africa livestock industry (environmental, economic and especially social) would provide valuable insights into targeting specific sustainability messages. It is thus recommended that a study to determine the perceptions of South Africans towards the sustainability of the livestock industry should be performed.

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## ADDENDUM 1

### **PUBLISHED POPULAR ARTICLE: *MEATLESS MONDAYS MIGHT BE HARMFUL***

#### ***IN SA***

*Mail & Guardian, 22 August 2014 SUPPLEMENT; by: Nicolette Hall, PhD candidate, University of Pretoria.*

Is skipping out on a meaty meal to save the environment doing more harm than good?

It began as a solidarity and social responsibility campaign during the World Wars to encourage the American people to tighten their belts “for the soldiers”, but Meatless Mondays are back. This time round, activists are telling us to eat less meat to save the environment. It is a small personal sacrifice to swop my steak for zucchini one day a week. But am I doing more harm than good?

A study at the University of Pretoria is evaluating the value of livestock in our daily lives, from livestock’s role in the economy, to its effects on sustainability and environmental stewardship and the nutritional benefit we derive. Farming is an important contributor to the South African economy and this study has found that meat production’s impact on the environment is sometimes overblown.

Livestock, particularly cattle and sheep, are often blamed for climate change. In 2006, the United Nation’s Food and Agriculture Organisation reported that the global livestock sector contributed almost a fifth of total greenhouse gas emissions. Since then, researchers globally have challenged this value, estimating that livestock’s greenhouse gas contribution is between 1% and 8%, overshadowed by transportation and energy sector’s contributions.

According to a study at Cornell University, global beef cattle population contributes to as little as 1% of greenhouse gas emissions; the researchers found that the daily production of greenhouse gas by one cow is equal to that of a car driven 3.2km. This

means that driving to the shop to buy groceries produces as much as 800 times more greenhouse gas than a hamburger with an 85g 100% pure beef patty.

In addition, South African farmers focus on breeds such as Nguni, Afrikaner and Bonsmara, which are adapted to our local conditions and have a lower impact on the environment because they are breeds that have better feed efficiency.

If you are considering limiting your red meat consumption for health reasons, the University of Pretoria study found that South African red meat products are much lower in fat than was thought.

In fact, trimming the outer fat layer from a steak reduces the fat content to less than 10%, which is often considered the benchmark for lower fat foods. The South African department of health promotes up to 90g cooked meat per day, and while South Africans are considered a meat-eating folk, recent food intake studies found that we consume significantly less than this as a population, eating less than 60g cooked meat per day on average.

A review of food intake studies between 2000 and 2010 found that adult South Africans consume on average between 44g and 60g of meat daily, which includes white meat, red meat, meat products and offal. According the Abstract of Agricultural Statistics 2012, there is about a 78g edible portion of meat available in South Africa per person per day.

In addition, many South Africans suffer from nutritional deficiencies, some obvious, others unseen. Many working women suffer from iron deficiencies resulting in low energy levels, while seeming well-fed or even overweight. The latest National Nutrition and Health Survey found that almost two in three South Africans were overweight or obese. Other deficiencies, such as vitamin A and protein deficiencies, are also present in overweight people who live on a repetitive diet of starchy staples such as maize

meal porridge and bread, fast foods and unhealthy snacks. These deficiencies damage brain and body functions. Eating red meat, which is high in these nutrients, could play an important role in improving the health of South Africans.

Also, the latest local research by the University of Pretoria and the Agricultural Research Council on the composition of South African lamb, mutton and beef found that locally produced meat has a higher nutritional content than previously available data reported. Data for sheep meat was traditionally borrowed from the United States, and those for beef were from a local study conducted in the 1990s before the current production and classification systems were implemented.

Fresh, local, red meat produced on South African soil is in fact healthier (lower in fat and higher in other nutrients such as protein and iron) than its overseas equivalents. This means that lean, local red meat has a similar fat content to white meat such as chicken.

Apart from crushing greenhouse gas and health myths, the study highlights that livestock production positively contributes to our food supply and the economy. According to the department of agriculture, fisheries and forestry, only 2.6% of land in South Africa can be used as high-potential arable land suitable for crop cultivation, while 11% can be used for extensive livestock farming.

The greatest limitation for crops is the availability of water. Livestock production on land that has low potential for crop cultivation, such as areas in the Karoo, positively contributes to our food supply, job creation and economic growth in the region. In the Karoo, for example, sheep farming has traditionally been the backbone of the agricultural economy in the semi-desert, which is characterised by low rainfall and extremes of heat and cold.



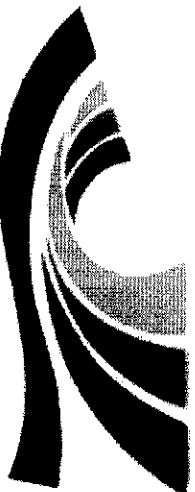
Livestock is also the largest agricultural sector in South Africa, contributing significantly to the employment of mainly unskilled labour. The 2013 Economic Review of the South African Agriculture showed that the value of agricultural production was estimated to be R180-billion annually, with animal products contributing nearly R84-billion or 46% of total agricultural production. Agriculture represents about 7% of formal employment, employing 8.5-million people in a country struggling with widespread unemployment.

During the World Wars, Meatless Mondays were a patriotic way for Americans to support the war effort, ensuring that soldiers had access to nutritious foods. But the University of Pretoria's research into the sustainability of the South African livestock industry highlights the important role that red meat plays and raises questions about whether this movement does more harm than good in South Africa.

## ADDENDUM 2

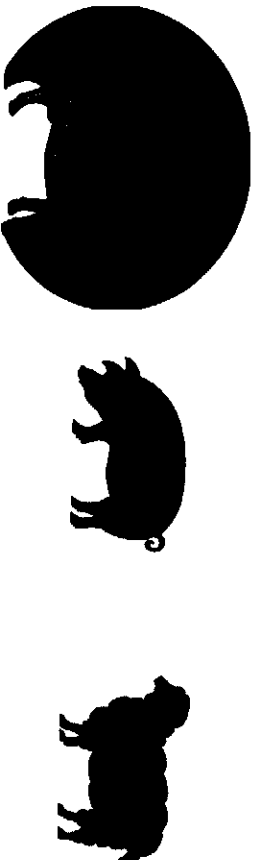
### ETHICAL APPROVAL FOR THE SLAUGHTERING OF BEEF ANIMALS FOR SAMPLE COLLECTION

The research project made use of samples obtained from animals slaughtered for the project “*The effect of a beta agonist and animal age on beef quality*” at the Agricultural Research Council. Ethical approval was granted by the ARC-API Ethics Committee on 10 June 2011. The reference number is APIEC11/030. Please see approval letter on the next page.



*Excellence in Research and Development*

**ARC • LNR**



Date: 10<sup>th</sup> June 2011

Dear Dr P. Strydom

**Re: Ethical evaluation of the project entitled “The effect of a beta agonist and animal age on beef quality”.**

Your application for the ethical evaluation of the project entitled “The effect of a beta agonist and animal age on beef quality” has been finalized and approved. Its Ref no. is **APIEC11/030**

I would like to inform you that the project was evaluated and found to be ethically acceptable. Please note that should any amendments or changes be made to the protocol, you are obliged to submit an application to the Ethics committee and that the protocol should be resubmitted for review annually.

Regards



Dr. A.T. Kanengoni (MSc, BVSc)

Chairperson ARC-API Ethics Committee

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