Physical and Nutrient Composition Data of Animal Source Foods in South Africa

by

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DECLARATION

I, Marina Bester, declare that the thesis, which I hereby submit for the degree MSc. 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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DEDICATION

I dedicate this thesis to my dearest teenage cousins Carla, Lize, Megan and Anke, who challenge me to keep up with their brilliant young minds and wit.

ABSTRACT

THE PHYSICAL AND NUTRIENT COMPOSITION OF ANIMAL SOURCE FOODS IN SOUTH AFRICA

by

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It has long been recognised that, as part of a balanced, moderate diet, animal source foods (ASFs) offer a wide range of benefits to human health. For many years our ancestors made ASFs part of the human diet by following their basic human instinct to hunt and eat animal flesh in order to survive. It is however important to understand that the challenges surrounding ASFs consumption in South Africa are multi-faceted. South Africa is a country rich in diversity but poor when it comes to the general populations' health. With a high prevalence of malnutrition in the forms of both under and over nutrition, it is clear that the consumption of adequate amounts of nutrient dense foods such as ASFs, is often lacking in diets of many South Africans. These nutrients include iron, zinc, high quality protein and B-vitamins.

Large parts of the South African population lives in poverty and cannot adhere to the current national food-based dietary guidelines. One of these guidelines recommends that animal source foods could be consumed every day**.** Affordable animal source foods, such as organ meats (offal), and the potential nutritional contribution thereof were further investigated in this study. This study found that all analysed lamb and mutton organ meats from the fifth

quarter of the carcass have the potential to contribute significantly to selected nutrients that were analysed and should be included in national dietary guidelines.

However assessing consumption of animal source foods (ASFs) and setting product specific guidelines can be a challenging task without accurate quantitative data on the physical composition, edible portions and yield factors of ASFs. Physical composition, edible portions and yield factors of different cooked marketplace servings (retail cuts) of lamb, chicken, beef, lamb offal, mutton offal and some processed meat products were determined in this study. This study further demonstrated the use of this dataset as a tool when communicating product specific and easy to understand dietary recommendations, set by the South African nutrition fraternity. The tools and data compiled in this study can further be utilised by policy makers, health professionals, the food service industry and economists to effectively evaluate, predict and measure consumption of animal source foods in South Africa.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADSA	Association for Dietetics in South Africa
ASFs	Animal Source Foods
APAP	Agricultural Policy Action Plan
CVD	Cardiovascular disease
DAFF	The South African Department of Agriculture, Forests and Fisheries
DoH	The South African Department of Health
FAO	Food and Agricultural Organisation
FBDG	Food-based Dietary Guidelines
FFP	Food fortification program
HDL	High-density lipoprotein
HSRC	Human Science Research Council
IARC	International Agency for Research on Cancer
ICN	International Conference on Nutrition
ICN2	Second International Conference on Nutrition
IFPRI	International Food Policy Research Institute
INFOODS	International Food Data System
MDG	Millennial Development Goals
MRC	Medical Research Council
NCDs	Non- communicable diseases
NDP	National Development plan
NFCS	National Food consumption survey
NPC	National Planning Commission
NRV	Nutrient Reference Value
RDs	Registered Dietitians
RPO	Red Meat Producers Organisation
SAAFoST	South African Association for Food Science and Technology
SAFOODS	South African Food Data System
SAJCN	The South African Journal of Clinical Nutrition
SAMPA	South African Meat Processors Association

SANHANES	South African National Health and Nutrition Survey
SANS	South African National Standards
SDGs	Sustainable Development Goals
USDA	United States Department of Agriculture
UN	United Nations
WEF	World Economic Forum
WHO	World Health Organisation

CHAPTER 1: INTRODUCTION AND OVERVIEW OF THE STUDY

This chapter serves as an introduction and background to the rest of the study. The content of this chapter will set the scene and justify the research objectives with the latest relevant literature in nutrition science.

1.1 Introduction

The Global Nutrition Report is an independent, comprehensive annual review by The International Food Policy Research Institute (IFPRI), reporting on the state of nutrition globally. In it's debut publication, in 2014, the report confirmed to the world the extent of nutrition related health issues of our time: severe global malnutrition combined with a high incidence of obesity and non-communicable diseases (NCDs) (IFPRI, 2014). The so called "double burden of disease". According to this report no single country was entirely free of malnutrition. The latest 2016 Global Nutrition Report continues to tell the story of a global population burdened with illnesses with insufficient nutrition being the number-one risk factor (IFPRI, 2016). In 2016 most countries were off course on efforts to solve these problems, still experiencing a combination of under-five stunting, adult overweight and anaemia.

Combatting malnutrition should be prioritised on the highest government level for it takes it's toll beyond the overall health status of a country. Malnutrition cripples a population in terms of low levels of literacy and a limited capacity to contribute to the economy, putting more pressure on public resources and having a further detrimental effect on the overall economy of a country (Wustefeld, Saba & Korenromp, 2015). In Africa and Asia 11% of gross domestic product is being lost to this epidemic a year (IFPRI, 2016). This vicious cycle needs to be reversed with a sustainable, long term resolutions to reach the six global nutrition targets (WHO, 2012) unanimously endorsed by member states at the 65th World Health Assembly (WHA) in 2012. The nutrition landscape has changed since the adoption of the millennium development goal agenda. Short term solutions such as fortification and supplementation must be accompanied with long term food-based solutions. Amidst a situation of rapid urbanisation, sedentary lifestyles and increased consumption of processed foods, food-based interventions should be implemented on an even larger scale (Wustefeld *et al.*, 2015). Ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture are part of the 17 goals set into action on the 1st of January 2016 in the new set of Sustainable Development Goals (SDGs) to be reached by 2030 (UN, 2015). This is in line with the objectives of the Second International Conference on Nutrition (ICN2), held in Rome in November 2014, where the importance of producing more nutrient dense foods (instead of more energy dense foods), including animal source foods (ASFs), to improve access and availability of nutrients was emphasised. Adequate supplies of these foods will contribute positively to improved food and nutrition security (FAO, 2014).

It is a well-known fact that the addition of animal source foods, even in moderate amounts such as 45-60g per day can play an important role in alleviating micronutrient deficiencies and conditions such as anaemia, vitamin A deficiencies and protein-energy malnutrition (Sharma, Sheehyt & Kolonel, 2013; Leroy & Frongillo, 2007; Valsta, Tapanainen & Mannisto, 2005; Neumann, Harris & Rogers, 2002). In addition to good quality protein, animal products contain retinol (the most bioavailable form of vitamin A), vitamins D and E, zinc and iron, and are also the best dietary source of vitamin B12 (Binnie, Barlow, Johnson & Harrison, 2014; McAfee, McSorley, Cuskelly, Moss, Walleace, Bonham & Fearon, 2010). Animal husbandry plays an important role in income generation, feeding into the economic considerations of food and nutrition security. For these reasons, the South African government has developed an Agricultural Policy Action Plan (APAP) to improve and expand livestock production and availability of animal source foods (DAFF, 2015)

Balance and moderation is the cornerstone of a healthy, nutritious, food-based diet (Klurfeld, 2015). Known amounts of specific foods consumed, in combination with quantitative data on edible portion and nutrient composition, are essential tools to effectively evaluate, monitor risks and improve the diets of a population (Westenbrink, Roe, Oseredczuk, Castanheira & Finglas, 2015). Nutrition researchers and health professionals urgently need to develop tools and strategies to prioritise and sequence nutrition relevant actions. Further insight into overall animal source foods consumption in South Africa must be obtained together with quantitative data on edible portions and tools to improve the accuracy of consumption data collected.

This introductory chapter serves as a justification for the rest of the study and sets the scene for the rest of the thesis. This chapter will give an overview of the current nutrition situation in South Africa, available data on the consumption of animal source foods, as well as the availability of compositional data on animal source foods to assist measuring the contribution of animal source foods to the South African population's nutritional state. **Chapters 2, 3, 4** and **5** are all separate scientific articles but with the central theme of working towards obtaining more insight into the current consumption of animal source foods by South Africans as well as the physical and nutritional composition of some available animal source foods in South Africa. Each of these chapters will also contain relevant literature in order to each be a standalone article which was already published, submitted or to be submitted to a scientific journal. Each chapter is presented in the format required by the journal it was published in or submitted to. **Table 1.1** summarises chapters included in this thesis.

1.2 Justification and background for the study

1.2.1 The current nutritional status of South Africans: A need for nutrient dense foods

The nutrition situation in the developing world remains ominous, hanging in the balance between a complex mix of NCDs and severe malnutrition (Eggersdorfer, Kreamer, Ruel, Van Ameringen, Biesalski, Bloem, Chen, Lateef & Manner, 2013; Caballero, 2005). NCDs are not stereotypical "diseases of affluence" and the consequences of mere overindulgence combined with sedentary modern behaviour of first world countries. NCDs extend beyond developed countries and are highly prevalent in developing- and third world countries (The NCD Alliance, 2012). Diet related NCDs such as diabetes and CVD are the cause of too many deaths worldwide, hampering growth potential and triggering extensive socioeconomic harm in developing countries (UN, 2015).

Table 1.1: Summary of articles comprising the thesis

Chapter	Title	Journal name	Publication status
1	Introduction and overview of the study	n/a	n/a
2	The relevance of food-based dietary guidelines to food and nutrition security: A South African perspective	Nutrition Bulletin, *The British Nutrition Foundation*	Published 2013
3	The nutrient content of South African lamb and mutton organ meats	Meat Science	Submitted to Meat Science
4	The compilation of quantitative food data on animal source foods and suggested use of the data in consumption studies	Presented as a poster at the 26th Congress of the Nutrition Society of South Africa	To be submitted to The South African Journal of Clinical Nutrition
5	Translating "meat and meat substitutes" exchanges into beef, lamb, chicken and processed meat marketplace servings	The South African Journal of Clinical Nutrition	To be submitted to The South African Journal of Clinical Nutrition
6	Conclusion and recommendations	n/a	n/a

Further complicating the situation is the high incidence of obesity currently observed in the developing world. Micronutrient deficiencies are now also found amongst apparently well fed and even overweight or obese individuals, a contradictory condition often referred to as a "hidden hunger" (Eggersdorfer, *et al.*, 2013). The United Nations commissioned a high level meeting in 2011 to discuss and take control of NCDs worldwide with a special focus on developing countries (WHO, 2013). Ways to reduce risk factors for NCDs were identified and included the directive that governments should be promoting health education, healthy diets and healthy lifestyle programmes (UN, 2011). Decreasing non-communicable diseases increases community wellness (DOH, 2013), which is a crucial component of economic and social development in South Africa in current times. The Strategic plan for the prevention and control of NCDs lists a series of aims to ultimately decrease NCDs in South Africa (DOH, 2013). It is however important to understand the key underlying behaviours and multi interacting causes and determinants such as poverty and living conditions involved with NCDs when planning and implementing any nutrition or health intervention (Popkin & Doak, 1998). Poverty, a key factor affecting all determinants of malnutrition according to the United Nation's Children fund conceptual framework for malnutrition (Engle, Menon & Haddad, 1999), is having a severe effect on the nutritional status of people in the developing world (Vorster, 2010). In search of better lives and incomes people of low socio economic status in developing countries are moving away from their traditional dwellings and villages, into cities, causing rapid urbanisation. Urbanisation is often blamed for a phenomenon observed in many developing countries referred to as the nutrition transition (Eggersdorfer, *et al*., 2013; WHO, 2012; Popkin, Adair & Ng, 2012; Kruger, Puoane, Senekal & Van Der Merwe, 2005). The nutrition transition includes a simultaneous lifestyle and diet transition from simple traditional living where nutritious indigenous foods were often prepared at home, to urban diets abundant in processed foods, saturated- and trans fats and refined sugars, low in fibre and micronutrients (MacIntyre, Venter, Kruger & Serfontein, 2012; SUNRAY, 2012; Vorster, 2010; Koon, Chow, Vaz, Rangarajan & Yusuf, 2009). Although it is believed that living standards generally improve with urbanization, lack of employment opportunities together with slowed pace of infrastructure - and social services development, often cause many individuals and families new to the urban population to live in overcrowded, informal slums (Koon et al., 2009; Ge, Jia & Liu, 2007). These individuals then have limited access to cooking facilities and often no access to own means of transport, leaving them reliant on the offerings of nearby stores and street vendors which are usually starch based deep fried, meals (SUNRAY, 2012). In some instances small stores in these rural urban communities ask even higher prices for fresh foods, when available, than formal traders in higher income neighbourhoods (NAMC, 2013). Based on these facts one can start to understand how the high incidence of NCDs, which was often thought to be a problem reserved for over indulging first world populations, is now also infiltrating lower income, third world communities already burdened with malnutrition. Such diets, lacking in biodiversity, fresh products and animal source foods, causes further deficiencies in nutrients of concern and increases the prevalence of NCDs.

South Africa, a developing country already burdened by food- and nutrition insecurity, poverty, and infectious diseases, is also experiencing an increased prevalence of NCDs such as diabetes, cardiovascular disease, obesity and cancer (Popkin, *et al*., 2012; Caballero, 2005). The South African national food consumption survey (NFCS), conducted in 1999, assessed the nutritional status of children aged 1 to 9 years (Labadarios, Maunder, Steyn, MacIntyre, Swart, Gericke & Dannhauser, 2001). The results of this survey confirmed the great need for more micronutrients in the South African diet. As a result of the findings of the NFCS a follow up consumption study, The National Food Consumption Survey, fortification baseline (NFCS:FB-I), was done to measure especially the micronutrient status of children aged 1 to 9 years as well as women of child bearing age (Labadarios, Swart, Maunder, Gericke, Kuzwayo & Kotze, 2007). The South African Nutrition and Health survey (SANHANES-1), conducted in 2012, provides valuable recent data on the nutritional status of the South African population and sadly the situation has not moved in a different direction from what was reported on in the NDCS and the NFCS:FB-I (Shisana, *et al*., 2014). In fact, the media release of the study states that it is clear that South Africa is "heading for a disaster" (HSRC, 2013). High blood pressure as well as hypertension has increased in males as well as females, but what is even more worrying is the fact that knowledge about this condition has not increased amongst the South African population over the past 15 years (Shisana, *et al*., 2014). The study found that 50,5% of men and women between the ages of 55 and 64 years suffered from high blood pressure whilst 63.6% of individuals above 65 years also suffered from this same condition. The risk for hypertension and CVD has not only increased in older individuals but it was found that over a third of individuals in the age group 15-25 years had blood pressure levels within the prehypertension range. With regards to high cholesterol at a national level for all participants above the age of 15 years, one out of four participants in the SANHANES-1 study had abnormally high low density lipoprotein (LDL)- cholesterol levels and one out of two had low high density lipoprotein (HDL)- cholesterol levels.

Obesity and overweight were found to be as high as 24.8% and 39,2% for adult females above the age of 15 years and 20.1% and 10.6% for males (Shisana, *et al*., 2014). According to the 2016 Global Nutrition Report South Africa, similar to the rest of the world is off course in decreasing overweight and obesity with 53.9% suffering from this form of malnutrition (IFPRI, 2016). The amount of overweight and obese children reported on in SANHANES-1 is devastating. Overweight and obesity amongst children was already identified as a major risk in the 1999 NFCS (Steyn, Labadarios, Maunder, Nel & Lombard, 2005). More than a decade later the percentage of preschool aged children in South Africa that are obese and overweight was found to be 22,9%, higher than in the United states where 12% of children aged 2 to 5 are overweight or obese (Shisana, *et al*., 2014). These numbers have increased since the NFCS of 1999 when 19% of children were found to be obese or overweight, putting them at risk of developing other NCDs later in life (Steyn, *et al.,* 2005).

Various nutrients found in animal source foods, including vitamin A, iron and good quality proteins are still lacking in the South African diet, especially amongst women and children (IFPRI, 2016). Although the vitamin A status of under 5 year old children has improved since the NFCS published in 2001, the SANHANES-1 reported 43,6% of children in this age group to still be vitamin A deficient, which poses a major public health threat. Although vitamin A deficiencies on a national level amongst women of reproductive age has decreased by more than 50% since the last NFCS it remains high at 13.3% which is still unacceptable due to the severe consequences thereof (Shisana, *et al*., 2014). Iron deficiency and anaemia, mostly caused by inadequate dietary sources which affects the absorption of iron, are common global nutritional deficiencies amongst women and children (IFPRI, 2016). The prevalence of iron deficiency anaemia amongst South African children between the ages of 0 and 5 years poses a public health problem being 10.7%, with a further 8.6% prevalence of mild anaemia (Shisana, *et al*., 2014). The prevalence of anaemia amongst all adult participants in SANHANES-1 was 17,5%. As expected, anaemia was high amongst women between the ages of 26 and 35 years included in this 2014 report with 24,2% suffering from anaemia. However the latest 2016 Global nutrition report indicated that these numbers have now increased to 27.6% of women of reproductive age (IFPRI, 2016).

According to a secondary anthropometric data analysis of the NFCS by Steyn *et al*., (2005), 19.3% of children between 1 and 9 years were stunted with a 24.4% prevalence amongst 0 to 3 year olds indicating inadequate consumption of good quality proteins (Steyn, Labadarios *et al*., 2005). Although SANHANES-1 reported a slight improvement in the prevalence of stunting since the NFCS (Labadarios, *et al*., 2001), the 2016 Global Nutrition Report identified South Africa as one of the countries who are still off course with no improvement in decreasing the 23.9 % overall prevalence of stunting (IFPRI, 2016).

1.2.2 Nutrition sensitive agriculture and the matter of nutrient dense food commodities

Diet is now the number one risk factor for the global burden for disease and it is the food system that enables a population to consume high, quality, healthy and nutritious diets (IFPRI, 2016). "Energy from non-staples" is amongst the Post-2015 Millennium Development Goals (MDGs) drivers and will be prioritised to reduce malnutrition, specifically amongst mothers and children (Smith & Haddad, 2015). Thus the production of nutrient dense foods needs to grow in tandem with the rapidly increasing population in order to eradicate malnutrition and to ensure food and nutrition security. However the current slow increase in nutritious food consumption is consistent with Africa's relatively low domestic food production being barely above the population growth rate meaning the demand for more food must be met by an increase in imports (FAO, 2011). Although 60% of the world's arable land can be found on the African continent, Africa remains a net importer of food worth billions of dollars (WEF, 2015). Furthermore the majority of foods that are imported are staple foods, which are energy dense foods not necessarily contributing nutrients of concern to the South African diet. The Agricultural Policy Action Plan (APAP) identified the need for the livestock industry to grow to not only generate income in the informal market, but also act as a Key Action Program to promote food security (DAFF, 2013). Hopefully this indicates that South Africa is on the right path to increase the availability of nutrient dense, animal source foods.

1.2.3 The need for consumption, composition and yield data on animal source foods for the formulation of adequate consumption guidelines

Food consumption data, food-based dietary guidelines and food composition data are all important aspects of human nutrition that should be developed and used in unison (Samman, Gimenez, Bassat, Lobo & Marcoleri, 2015; Westenbrink et al., 2015; Charrondiere, Rittenschober, Nawak, Stadlmayr, Wijesinha-Bettoni & Haytowitz, 2014). Clear indications of the food intake of a population, together with the nutritional and physical- composition of foods available and consumed are needed in order to successfully compile the necessary dietary recommendations and food-based interventions (Van Heerden, Schönfeldt & Hall, 2011).

No large scale, comprehensive national study has been done on food consumption by South African adults. A review of dietary surveys of South African adults from 2000-2015 revealed that South Africans continue to consume a monotonous diets. (Mchiza, et al., 2015). The only ASFs included in the 10 most consumed foods were eggs, milk and chicken. The limited animal source foods consumption information provided by the National Food Consumption Survey (NFCS) in 1999 revealed that children between the ages of 1 and 5 years consume a fairly high amount of red meat, specifically organ meats also known as offal (Labadarios, et al., 2005). However, the SANHANES-1 reported high incidences of anaemia, vitamin A- and iron deficiencies (Shisana, et al., 2014), despite the supposed high intake of organ meats as reported by the NFCS in 1999. This clear discrepancy between current reported animal source foods consumption and the health status currently observed amongst South Africans emphasises the need for more consumption data and research tools such as a country specific food data. Knowledge of the chemical composition of foods is the first essential in dietary treatment of disease or any quantitative study of human nutrition (McCance & Widdowson, 1940). This statement is still true despite years of advancements in science and technology. Therefore, a country's food composition database is one of the most important tools for nutrition research and food policy making (Westenbrink *et al*., 2015; Presser, Hinterberger, Weber & Norrie, 2015; Samman *et al*.,2015). It is the main mission of the South African Food Data System (SAFOODS) to be the leader in advancement in the science of food composition in South Africa (SAFOODS, 2015). SAFOODS has grown in leaps and bounds since the first set of South African food composition tables published in 1991. There have been some great successes in determining the nutritional composition of local South African foods that has a significant potential to contribute to local nutrition (Chetty, 2015). Examples of such foods are African green leafy vegetables (Van Jaarsveld, Faber, Van Heerden, Wenhold, Jansen Van Rensburg & van

Averbeke, 2014) and locally farmed lamb and mutton meat (Sainsbury, Schönfeldt & Van Heerden, 2011). However despite these advances, the nutritional composition of many important local foods has not yet been determined and many values in the South African food composition database are still borrowed from other countries (Wolmarans, Danster, Dalton, Rossouw & Schönfeldt, 2010). Therefore South African food science- and nutrition researchers are encouraged to further prioritise food composition activities and accurate compositional data collection in order to expand the country specific food composition database in South Africa (Wolmarans, Chetty & Danster-Christians, 2013)

Amongst the important missing local food composition values are organ meats from small stock (goat, lamb and mutton), which is widely consumed by urban as well as rural population groups. According to other international food composition databases, lamb and mutton organ meats are high in nutrients such as vitamin A, iron and zinc (Purchas & Wilkinson, 2013). It has however been found that the composition of South African lamb and mutton meat differs significantly from data previously sourced from other countries (Sainsbury *et al*., 2011).

Other than nutrient content of foods, there are also other aspects of food composition in need of closer investigation in South Africa. Amongst these is the need for more product specific information, such as portion sizes of foods sold at retail level as well as the size in which the same foods are consumed at home (Wolmarans *et al*., 2013; Wolmarans, Kunneke & Laubscher, 2009). Physical composition- and portion yield data are of utmost importance for accurate reporting in food consumption studies (Wolmarans *et al*., 2013). This is especially true for animal source foods. Fat, skin, bone and cartilage often also form part of an animal source food product but are not always consumed. Therefore it is difficult to estimate true consumption of animal source food products, such as in the case of rib cuts, and increases the risk of error when reporting on portion sizes and quantities consumed, over- or under reporting of quantities can easily occur. Many studies can be found on total carcass yield of South African chicken, beef, lamb, mutton and pork for breeding and feeding purposes, but there is limited information on the portion yield of animal source foods products as purchased and consumed.

Knowing the physical yield in terms of edible portion of certain cooked retail cuts will enable more accurate, product specific guidelines.

1.2.4 Defining portion sizes, servings and marketplace servings

After an extensive literature investigation on the topic of portion sizes it became evident that the terms “portion size” and “serving size” are often used interchangeably in popular articles and consumer communication. However these two terms have different meanings and should be defined clearly when used in scientific research.

Portion sizes consumed are often one of the biggest challenges in food consumption studies. The quantity of a certain food product consumed in one sitting can be defined as a "portion size". Portion sizes are up to individual discretion and therefore the amount of food a person serves (and consumes) themselves (Wansink, Van Ittersum & Painter, 2006).

“Serving sizes” are actual quantified recommendations for the consumption of a certain food product (Young & Nestle, 2003). Serving sizes are usually prescribed by health professionals based on official systems such as “The Food Exchange Lists System for Diabetic Meal planning” (The American Diabetes Association and The American Dietetic Association, 1995) national guidelines such as “The Food-Based Dietary Guidelines for South Africans” (Vorster, Badham & Venter, 2013), and the “USDA Food Guide Pyramid” (Shaw, Davis & Hogbin, 2014) and even on some food labels (Manore & Vannoy, 2004). The term serving sizes are therefore also used together with “number of servings” in dietary planning (Manore & Vannoy, 2004). Serving size recommendations are discussed further in Chapter 5 of this thesis.

“Marketplace servings”, “Retail servings”, “Marketplace portions” and “Retail Portions” are also important terms to define for the purpose of this thesis. It was observed that these terms are used interchangeably but have the same definition. It is defined as the physical product size as it is available on retail level (“on the market”) to the consumer (Young & Nestle, 2012; Peacock, 2005). The term “Marketplace servings” will be used in conjunction with this definition in this thesis. Examples of animal source foods (ASF) marketplace servings available in South Africa include chicken wings; lamb rib chops and beef T-bones. The physical composition and yield of some ASF marketplace servings in South Africa is determined and discussed further in Chapter 4.

It is important to understand that the suggested/recommended serving size indicated on a label or specified in a dietary recommendation does not necessarily reflect the actual portion size consumed by the individual, which also does not necessarily equal the marketplace serving (USDA, 2000). Manore and Vannoy (2004) used the simple example of a soda drink consumed by an individual to explain the difference between these terms. The soda drink marketplace serving equalled 2 litres. However the individual consumed a portion size of 1 litre while the maximum recommended serving size as indicated on the product label was 250ml.

1.3 Research aims and objectives

The overall aim of this thesis is to obtain a better understanding around certain aspects of animal source foods in South Africa. This study aims to yield new nutrition research tools and data on the composition of animal source foods currently available in South Africa in order to translate existing consumption guidelines set by the government as well as health professionals, in terms of portion size, into actual products currently available.

1.3.1 Chapter 2: The relevance of FBDG to food and nutrition security in South Africa

The objective of chapter 2 is:

- Investigate the relevance of the current "Food-based dietary guidelines for South Africans", especially guidelines on animal source foods, in terms of the relevance thereof to food- and nutrition security.

1.3.2 Chapter 3: The nutrient content of South African lamb and mutton organ meats (offal)

The objectives for chapter 3 are:

- Determine nutrient composition of South African lamb and mutton organ meats.

- Investigate the potential for South African lamb and mutton organ meats to contribute to food and nutrition security based on the contribution to recommended daily intakes of certain nutrients of concern in the South African context.

1.3.3 Chapter 4: The compilation of quantitative food data on animal source foods and suggested use of the data in food consumption studies

The objectives for chapter 4 are:

- Determine physical composition, edible portions, yields and cooking losses of different marketplace servings of animal source foods to be used as a tool in consumption studies to better determine portions/ quantities consumed.

1.3.4 Chapter 5: Translating "meat and meat substitutes" exchanges into beef, lamb, chicken and processed meat marketplace servings

The objectives for chapter 5 are:

- Investigate serving size recommendations currently used by the nutrition fraternity in South Africa.
- Translate these recommendations into fresh beef, chicken and lamb marketplace servings (**as determined in chapter 4**) as well as some processed meat products.

1.3.5 Chapter 6: Conclusion and recommendations

Chapter 6 serves as a conclusion to the thesis and recommendation will be made.

1.4 Conclusion

At the hand of persistent malnutrition, increased incidence in overweight and obesity together with the plethora of other diseases of lifestyle, it can be concluded that now is the time to re-evaluate consumption guidelines in South Africa. Public health guidelines (FBDG) should be geared towards promoting more nutrient dense foods such as animal source foods as part of a pro-active approach in eradicating malnutrition and NCDs (**Chapter 2**). Nutrition research tools such as nutrient- and physical composition datasets on local food security commodities such as lamb and mutton organ meats must be determined (**Chapter 3**). Furthermore product specific information such as physical composition of foods commonly consumed in South Africa is needed in order to compile more accurate product specific recommendations (**Chapter 3, Chapter 4 and Chapter 5**). Recommendations for portion sizes need to be standardised and translated into available animal source food products (**Chapter 5**). These guidelines should be communicated in a way easily understood by consumers (**Chapter 4 and 5**). All data generated from this thesis will be available to the Medical Research Council (MRC) for inclusion in the South African Condensed Food Composition Tables as well as the Food Quantities Manual.

1.5 References

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CHAPTER 2: THE RELEVANCE OF FOOD-BASED DIETARY GUIDELINES TO FOOD AND NUTRITION SECURITY: A SOUTH AFRICAN PERSPECTIVE

This article was originally written in response to wage grievances amongst South African farm workers in the Western Cape in 2013. Financial feasibility of the South African food-based dietary guidelines was investigated with a specific focus on the different protein sources included in the guidelines. The article was published in the News and Views section of the Nutrition Bulletin in June 2013 (Volume 38 pages 226-235). The article is presented as Chapter 2 of this thesis in the format and referencing style it was published in. The monetary values are presented as it was originally calculated in 2013.

2.1 Summary

Food-based dietary guidelines are often developed at country level to assist in bringing dietary intakes closer to nutrient intake goals and ultimately, to prevent nutrition-related diseases. However, high food prices, alongside growing inflation increasingly restrict food choices. This can leave those who are already vulnerable and less well-off more exposed to the associated health implications of a nutrient deficient diet. With food and nutrition security being a high priority on the global nutrition agenda, this paper explores the feasibility of food-based dietary guidelines to assist in improving food and nutrition security, focusing on nutritionally vulnerable groups in South Africa.

It is argued that increased food prices together with population growth, urbanization and inflation constrains everyday healthy food choices by a large proportion of South Africans. The South African food-based dietary guidelines released in 2012 advocates the consumption of a daily diet containing a variety of foods. Unfortunately, even when the most basic and low cost food items are selected to make up a recommended daily diet, the associated costs are well out of reach of poor individuals residing in South Africa. The average household income of the poor in South Africa equips many households to procure mainly low cost staple foods such as maize meal porridge, with limited added variety. Although the ability to procure enough food to

maintain satiety of all family members might categorise them as being food secure, the nutritional limitations of such monotonous diets may have severe implications in terms of their health, development and quality of life. Food-based dietary guidelines alone have little relevance in such circumstances where financial means limit food choice. Alternative interventions are therefore required to equip the poor to follow recommended healthy diets and to improve individual food intake and nutrition security.

Key words: food and nutrition security, food-based dietary guidelines, nutritionally vulnerable, South Africa, dietary diversity

2.2 Food-based dietary guidelines

At the International Conference on Nutrition (ICN) held in December 1992, 159 countries unanimously adopted a World Declaration and Plan of Action for Nutrition (FAO 1993). This declaration stressed the importance of all actions to work together to eliminate world hunger and all forms of malnutrition. Participating governments and other concerned parties [including the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) pledged to make all efforts to eliminate famine, starvation and nutritional deficiency diseases including iron and iodine and vitamin deficiency, as well as to reduce the incidence of hunger, undernutrition and nutritional deficiencies such as iron deficiency (amongst others) before the end of 2000 (FAO 1993).

At the time, the Food and Agricultural Organisation (FAO) offered to assist member countries to implement the Plan of Action, specifically towards the development of strategies and actions necessary to reach the overall objectives of the declaration. In addition to improving food quality and safety and controlling infectious diseases, a specific food-based strategic action was identified, namely, the promotion of appropriate diets and healthy lifestyles through the development and implementation of country-specific food-based dietary guidelines (FBDGs) (FAO 1993).

Ideally, all nutrition education and promotion within a country should be based on such a national set of guidelines (WHO 2010). These FBDGs should focus on disseminating nutrition information through sustainable food-based approaches; encouraging dietary diversity, while contributing to adequate and optimum diets. In order to be locally relevant, FBDGs should also consider local culture, ethnicity and indigenous and traditional foods specific to the country or region (Vorster *et al.* 2001)

The main goal of FBDGs is to bring population intakes closer to nutrient intake goals and as a result prevent nutrition-related diseases (WHO 2010). However, FBDGs as a food-based approach are unlikely to succeed as an independent action and should therefore form part of a national conglomerate of health-based actions (Love *et al.* 2009). These actions could include the promotion of breast feeding, controlling micronutrient deficiencies through supplementation and fortification programmes, controlling infectious disease and improving food quality, safety and overall household food security.

2.3 Global malnutrition

Despite the aforementioned Plan of Action for Nutrition undertaken in the early 1990's, malnutrition today is nearly equally distributed between the undernourished (more than 800 million) (FAO 2012) and the overweight or obese (1.4 billion) (WHO 2012). Globally, overweight has doubled since the 1980's, and what once was considered a high-income country problem (overweight and obesity) is now on the rise in developing countries, particularly amongst those residing in urban settings.

Looking at regional under-nutrition statistics, the reduction in the number and proportion of undernourished in Asia and Latin America in recent years suggests that they are roughly on track to achieve the Millennium Developing Goal (MDG) to reduce hunger by half by 2015 (FAO 2012). In stark contrast however, the number of undernourished in Africa, has increased from 17% to 27% over the last 20 years (from 1990/1992 to 2010/2012) (FAO 2012).

Although the recession is an obvious concern, the recent report by the FAO (2012) 'The State of Food Insecurity in the World', suggests that the rise in hunger during the period 2007 to 2010 (i.e. the period characterized by the economic crises and increasing food prices) was less severe than previously estimated. But higher food prices may inevitably have had other negative impacts on nutrition and health status, including the consumption of lower quality, less nutritious foods to sustain satiety.

The 1996 World Food Summit in Rome defined food security as when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO 2012). Lack of access to food and the availability thereof, are often considered the two key factors behind food insecurity (IFPRI 2004). Although these two factors remain central concerns in developing countries, households having access to sufficient food to sustain satiety are often considered food secure, while fundamental nutritional requirements are not being met by their often monotonous diets (PC 2002). As a result, a paradigm shift has been observed from health and agricultural policies and programmes focussing mainly on household food security and freedom from hunger, to food and nutrition security for the family and the individual (FAO 2010). In preparation for the International Conference on Nutrition (ICN) to be held in September 2013, an International Symposium on "Food and nutrition security: food-based approaches for improving diets and raising levels of nutrition" was held in 2010 to increase awareness of policy makers on the benefits of nutrition-sensitive, food-based approaches to improve diets and raise levels of nutrition (FAO 2010).

2.4 A South African case study

Although South Africa is regarded as being food secure on a national level, indications are that many individuals are not food and nutrition secure (Vorster 2010). Many families in Africa, including South Africa are faced with the harsh reality of being drawn deeper into poverty and food and nutrition insecurity. As population growth, urbanization and inflation continues to increase, the persistent rise in food prices are becoming a growing constraint in making healthy food choices. In 2003, 1 in 3 South Africans were at risk of hunger; with only 1 in 5 being recorded as food secure (NFCS-FB 2005). Due to the absence of a national surveillance system to monitor nutritional status, the National Department of Health, as well as other research councils and universities active in nutrition research, individually and often in partnership, have sporadically researched and reported on the nutrition situation in many regions and population groups in South Africa. Results of these studies have been reviewed by Steyn (2006), who reports similar results to those of an earlier review by Vorster *et al.* (1997), indicating that the nutritional status of many South Africans has been far from optimal for many years (Vorster 2010).

The significant difference in the health situation between households within the country is reflected in mortality rates between different demographic regions. A 7% mortality rate was observed in rural areas compared to a 4% rate in urban areas (DOH, 1998; Nkonki *et al.* 2011). Stunted growth rates are also consistently recorded as being higher for children living in rural areas and on commercial farms, as these households have even less access to food and often do not benefit from national fortification programmes (Kimani-Murage *et al*. 2010). This is because staples are often procured from small-scale, informal millers with no or limited access to fortification pre-mixes, ultimately affecting the availability of micronutrients in the final product (Kruger *et al*. 2008; Yusufali *et al*. 2012).

A significant difference in nutrient intake is also seen between different socio-economic groups within the country itself (Kimani-Murage *et al*. 2010). South Africans' socio-economic status is determined by a Living Standard Measurement (LSM) segmentation tool (Ungerer & Joubert 2012). This multi-attribute segmentation tool breaks down the population into ten manageable and meaningful sub-groups, based on access to services and durables, as well as geographic indicators as determinants of standard of living. The tool provides a useful way to classify the diverse South African population into groups from those with a low socio-economic status (LSM 1) to those with a high socio-economic status (LSM 10) (SAARF 2008). Those with a low socio-economic status (LSM 1 to LSM 4) are often the most severely affected by malnutrition, including over- and undernutrition, as well as being the population groups most vulnerable to food price increases (Schonfeldt *et al*. 2010).

In general, the inter-relationship between the causes and consequences of malnutrition is complex (Kimani-Murage *et al.* 2010). Poverty and high food prices reduce consumer purchasing power and can leave the nutritionally vulnerable even more powerless when it comes to acquiring healthy foods. Furthermore, it is well understood by nutritionists around the world that nutrition plays a fundamental role in the sustainable development of human capital (Vorster 2010). Malnutrition adversely affects both mental and physical development and significantly reduces the productivity and economic potential of an individual (Victora *et al.* 2008; Lanigan & Singhal 2009). Unfortunately, eradication of malnutrition is often neglected in poverty-alleviation programmes and poverty itself presents a significant constraint on many nutritionally vulnerable households to acquire nutritious foods recommended by FBDGs for optimal development. The rest of this paper will provide a snapshot of possible dietary scenarios that nutritionally vulnerable individuals in South Africa could employ (given their limited resources), as well as the effect this would have on their overall nutrient intake.

2.5 Current economic situation in South Africa

Despite significant development in the past 15 years, South Africa remains a country with a complex combination of developed and developing areas, in terms of its people, economy and infrastructure (Pretorius & Siliwa 2011). Average income per household is between $11,200 and $11,570 (US dollars) *per annum* [financial year 2010/2011 ($1(US) = £0.64 (GBP)]. South Africa has a consistently unequal economy where two thirds of the populations live in third world country conditions, with the rest living in first world conditions (Nkonki *et al*. *2011*). Furthermore, the wealthiest members of the population are in the minority (10%) but earn more than half of the total income (58%) (Leibbrandt *et al*. 2012).
Average earnings by a South African worker are $313 per month, while 25% of workers earn a monthly salary of less than $168 (financial year 2010/2011). With nearly a third of the population being unemployed (Stats SA 2011), the reality is that one salary often carries an

entire household. The poorest South Africans (30%) spend nearly 40% of their income on food (NAMC 2012a). Based on these statistics, a household with an income of $168 per month will spend roughly $67 per month on food, which amounts to $2.24 per household, per day.
Although the average household size in South Africa consists of 3.4 people (Stats SA 2011), numerous rural households (often observed in those most severely affected by poverty) typically have many household members who are unable to work. These extended families can include children, grand-children, older family members and in some cases the physically disabled. In a recent study performed in rural settlements in South Africa, most households consisted of 6 to 7 members and more than 50% of them were found to be severely food insecure (De Kock et al. 2011).

With only $2.24 available to feed a household with up to 7 family members per day, means that many South Africans have as little as $0.32 per person per day to meet all of their dietary requirements. Additionally, limited available income to spend on food can inevitably lead to an inadequate food basket that is largely dependent on the price of food (Schönfeldt et al. 2010).
With food price inflation being a global phenomenon, the price of staple foods has continued to increase over the past two years at a relatively high rate. Currently, the National Agricultural Marketing Council (NAMC) in South Africa is working in collaboration with the National Departments of Agriculture and Statistics to monitor and report trends in food prices. Results have shown that from January 2011 to January 2012, food inflation was 10.3%. Notably, the price of white maize, the most commonly consumed staple food in South Africa, increased by a staggering 90% in the same period (NAMC 2012b). Furthermore, it was also reported that in July 2012, rural consumers paid $2.00 more than urban consumers for the same food basket, comprised of maize meal (5kg), white bread (1 loaf), brown bread (1 loaf), full cream milk (1L), sunflower oil (750ml), margarine (500g), rice (2kg), black tea (62.5g) and white sugar (2.5kg) (NAMC 2012b).

2.6 Cost of a basic healthy diet in South Africa

Consumer food choices are often limited by their own knowledge, resources and access to food products. One of the common recommendations to remedy these limitations is public health information campaigns that communicate realistic healthy eating practises to consumers (OECD 2012). In 1998 the National Department of Health, in collaboration with other partners including the FAO, compiled a set of eleven FBDG's for South Africans. Following on from this, these guidelines were updated in 2012 (National Nutrition Week 2012). In **Table 2.1** the revised FBDG's (2012) are presented. The most significant changes made to the revised guidelines are the addition of dairy as a food group in its own right and the removal of any reference to alcohol consumption.

Table 2.1: The revised South African food-based dietary guidelines (NNW 2012)

Food-based dietary guidelines for South Africans (aged six years and older)
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!

The updated set of FBDGs serves as a recommendation on the type and quantities of foods to be consumed by adults and children aged five years and older (Vorster et al. 2001). Based on these FBDGs, four model diets for men and women (aged six years and older) were developed by the National Department of Health to serve as a guide for a healthy daily diet that can be adopted by all South Africans (aged six years and older) (**Table 2.1**) (NNW 2012). A model diet for a male and another for a female with a low socio-economic status (LSM 1 to LSM 4), and a model diet for a male and another for a female with a higher socio-economic status (LSM 5 and higher) were developed. The two diets differ in terms of the food products used to accommodate the previously reported variance of wealth observed between South African population groups.

As part of an exercise to visually document and report these recommended diets (as illustrated in **Table 2.1**), examples based on the recommendations for an adult male with a high socio-economic status, and an adult male with a low socio-economic status were designed and photographed by the authors (see **Figures 2.1** and **2.2**). Basic foods most commonly consumed by South Africans as reported in the latest national consumption survey, were chosen for this exercise (NFCS 1999).

To examine the ability of individuals to purchase the foods outlined in the recommended diets, the cost of the diets were determined. Cost was calculated using the sum of the cost of the food items as purchased at a typical urban store from one of the largest retail groups in South Africa (i.e. Shoprite, Northern Division). This particular retailer has easily accessible stores countrywide focussing specifically on the needs of lower income consumers (Babarinde 2012). Results showed that the cost of a basic, economical, daily diet developed for consumers with a low socio-economic status (i.e. LSM range 1 to 4) amounted to $2.39 per adult female and $2.77 per adult male. In contrast, the diet with a higher variety and containing more animal products [i.e. those proposed for men and women from higher socio-economic groups (**Table 2.2**) amounted to a cost of $4.05 per female and $4.61 per male per day. Within both of these diets, meat and dairy products contributed most to the higher costs incurred, while fortified maize meal porridge and white sugar contributed the least cost per portion in all scenarios (<$0.01 per portion).

Table 2.2: Recommended model diets for adult men and women (aged 6 years and older) (NNW 2012)

Food group	Diet recommended for an individual with a low socio-economic status (LSM 1 to LSM 4)				Diet recommended for an individual with a higher socio-economic status (≥LSM 5)			
	Female		Male		Female		Male	
	Portions	Suggestion	Portions	Suggestion	Portions	Suggestion	Portions	Suggestion
Starch	11	1 potato 6 portions maize meal porridge 4 slices of bread	15	2 potatoes 8 portions maize porridge 5 slices of bread	7	1 potato 4 portions maize meal porridge 2 slices of bread	10	2 potatoes 5 portions maize meal porridge 3 slices of bread
Protein	1	1 portion chicken breast with skin	1	1 portion chicken breast with skin	2	2 eggs 1 portion beef steak	2	2 eggs 1 portion beef steak
Dairy	1	1 portion maas (fermented milk)	1	1 portion maas	2	1 portion maas 1 portion milk	2	1 portion maas 1 portion milk
Legumes	1	1 portion soya mince	1	1 portion soya mince	1	1 portion baked beans	1	1 portion baked beans
Vegetables	2	1 portion spinach 2 portions fresh mixed vegetables	3	1 portion spinach 2 portions fresh mixed Vegetables	3	1 portion spinach 2 portions fresh mixed vegetables	5	3 portions spinach 2 portions fresh mixed vegetables
Fruit	1	1 banana	1	1 banana	2	1 orange 1 banana	2	1 orange 1 banana
Fats & oils	6	2 portions peanut butter 2 portions margarine 2 portions sunflower oil	8	3 portions peanut butter 3 portions margarine 2 portions sunflower oil	6	2 portions peanut butter 2 portions margarine 2 portions sunflower oil	8	2 portions peanut butter 3 portions margarine 3 portions sunflower oil
Sugars	6	6 teaspoons sugar	8	8 teaspoons sugar	6	6 teaspoons sugar	8	8 teaspoons sugar
Total Cost		$2.39		$2.77		$4.05		$4.61

Table 2.3: Financial and nutritional implications* of substituting chicken breast with other options within the same food group as recommended for an adult male

Component	Cost	Energy	Proteins	Fat	Fe	Na	Vit A
Unit	**US$**	**kJ**	**G**	**g**	**mg**	**mg**	**UgRE**
Basic recommended diet (adult male)	2.77	7555	73.2	87.4	18.6	2950	2521
Substituting chicken breast with chicken heads and feet	2.42	7969	60.3	80.7	-	-	-
Substituting chicken breast with bones containing 10% edible portion	2.35	7585	51.0	74.8	17.9	2901	2506
Substituting chicken breast with bones containing 50% edible portion	3.01	7741	54.5	77.4	18.0	2917	2507
Substituting chicken breast with take-away fried chicken breast*	3.01	8940	76.2	94.4	19.5	3254	2541
Substituting chicken breast with minute steak	3.33	8523	72.1	90.4	18.7	2995	2507

*Nutrient values used were calculated from raw, uncooked foods (Wolmarans et al. 2010) and the addition of salt or other spices are not considered, with the exception of the take-away fried chicken breast.

Table 2.4: Nutritional implications of introducing some variety to a maize-meal based daily diet for South Africans within daily available means ($2.24 per household per day; $0.32 per person* per day)

	Cost per house hold*	Nutrients supplied per individual per day						Contribution to RDA#		
		Energy	Protein	Fat	Iron	Sodium	Vitamin A	Protein	Iron	Vitamin A
	US$	kJ	g	g	mg	mg	ugRE^	%	%	%
Maize meal porridge (850g cooked, soft per person per meal)	1.10	5100	25.5	10.2	15.3	51.0	281	45.5	85.0	31.2
Maize meal porridge plus 2 portions (250g raw) of chicken breast with bone and skin per family	2.20	5133	33.9	15.1	15.6	71.4	286	60.6	86.4	31.7
Maize meal porridge plus 5 portions (750g raw) of chicken heads and feet per family	2.11	5527	35.6	16.9	NA	NA	NA	63.6	NA	NA
Maize meal porridge plus 1 portion beef steak (125g raw) per family	2.20	5278	29.5	13.2	15.4	68.6	281	52.7	85.8	31.2
Maize meal porridge plus 8 portions of beef bones with 10% edible portion (1.2kg raw bones) per family	2.17	5270	29.3	13.1	15.4	68.0	281	52.4	85.8	31.2
Maize meal porridge plus 6 large eggs per family	2.05	5408	31.8	15.4	16.2	114	313	56.8	90.0	34.8
Maize meal porridge plus 2 portions (500g) of maas (cultured milk) per family	2.11	5325	28.3	13.3	15.4	110	313	50.5	85.4	34.8
Maize meal porridge plus 8 portions of spinach (3 bunches) per family	2.20	5343	30.5	10.6	23.5	1716	1154	54.5	130	128.3
Maize meal porridge plus 15 portions of chopped vegetables per family (900g raw)	2.20	5327	26.9	10.4	16.0	73.0	1924	48.0	88.6	213.8

*Family with 6 members (De Kock *et al*. 2011)
#Contribution to RDA (Recommended Dietary Allowance) was calculated as nutrients supplied per person divided by the RDA for protein (56g/day), iron (18mg/day) and vitamin A (900ugRE)
^RE: Retinol Equivalents
NA: Not available

Figure 2.1: Recommended basic daily diet for an adult male (6 years and older) with a low socio-economic status (LSM 1 to LSM 4) as recommended in Table 1 ($2.77)

Figure 2.2: Recommended daily diet for an adult male (age 6 years and older) with a higher socio-economic status (LSM 5 and higher) as recommended in Table 1 ($4.61)

2.7 Dietary limitations of the nutritionally vulnerable in South Africa

High food prices can affect food consumption, including both food basket composition and consumption quantities. In order for vulnerable South African households to survive, they need to employ certain food coping strategies. Unfortunately, many of these food coping strategies have increasingly negative consequences on nutritional status. For example, in the poorer South African households, food coping strategies employed include eating less and/or cheaper food as well as limiting food portion sizes, or even skipping meals for the entire day (Kruger *et al*. 2008; Maxwell *et al*. 2003).

The cost of the diet recommended for a male with a lower socio-economic status ($2.77) is well out of reach of the previously reported $0.32 available for food per person (LSM 1 to 4) per day. In order to determine whether these less well-off consumers can somehow afford the recommended diet, the authors replaced the most expensive products within the diet (**Table 2**) with alternative, cheaper options within the same food group (**Table 3**). This strategy is similar to employing the food coping strategies of eating less preferred food as demonstrated by Wolmarans *et al*. (2010). These included substituting the chicken breast recommended in the diet (**Table 2**) with a portion of chicken heads and feet (often eaten by low income consumers in South Africa), resulting in a saving of $0.35 per person. Substituting the chicken breast with a portion of beef soup bones (150g raw) containing only 10% edible meat portion reduced the cost of the diet by $0.42 per person. It should be noted that significantly less nutrients will be obtained from 150g bones containing only 15g edible portion and 125g bones compared to consumption of a 125g chicken breast containing as much as 100g edible portion and only 25g bones. Substituting the chicken breast with bony meat containing 50% edible meat portion would increase the cost of the daily diet by $0.24 per person. Choosing a portion of minute steak (125g raw) without bone in the place of the chicken breast would increase the cost of the daily diets' by $0.56 but would provide similar nutrients (**Table 3**).

Changing consumption patterns amongst South African consumers, especially children and adolescents, have been observed in various studies carried out in the past five years, such as opting for readily available street foods and take always (Feeley *et al*. 2011). A very common scenario observed amongst poor urban individuals in South Africa is the consumption of deep-fried chicken portions (Madiba & Roberts-Lombard 2011). In the above illustration, substituting the raw chicken portion (and the boiling thereof at home) with a take-away fried chicken breast, would increase the cost of the basic daily diet by $0.24 per person.

From this case study it can be seen that substituting one food type for another within the same food group can change the cost while still comparing somewhat positively to dietary guidelines, but the effect on nutrient contribution needs to be considered further for each of these scenarios (**Table 3**). In addition, although substituting a portion of chicken breast with a cheaper alternative might release $0.35 per person per day the total cost of the diet according to today's food prices remains well out of reach for those South African's most in need of a healthy, balanced diet. It is therefore, considered unlikely that low income households in South Africa can maintain a healthy, balanced diet that adheres to national FBDGs and meet all of their dietary needs on a daily basis. When only $2.24 is available per household per day to feed all family members, meeting dietary guidelines seem problematic. It should also be considered that the situation reported in this case study was based purely on an urban setting and it is projected that individuals from rural areas in South Africa will be even less equipped to adhere to these guidelines due to even more restricted funds and higher food prices (NAMC, 2012b).

When considering the limited resources available to the most nutritionally vulnerable individuals, the low cost of the starch-based staple foods (regardless of steep inflation), often make them the only ingredients in many South African diets. Feeding as many as six family members with up to 850g cooked soft maize meal porridge (6.8 portions) per person per meal (Nel & Steyn 2002) three times a day will cost only $1.28/day to eliminate hunger for the whole household (all six family members), compared to $2.77 needed per male household member, and $2.39 per female household member, to purchase the healthy, recommended daily diet as described in **Table 2**. Although this calculation does not consider the cost of salt, clean water or other overhead costs to procure or prepare the porridge, the reality is that these large portions of maize meal porridge are the only option available to poor South Africans to facilitate satiety and alleviate hunger rather than address their nutritional needs.

Although having access to enough food to alleviate hunger is often used as a simple benchmark to define being food secure, a diet dominated by low cost staples is far from being nutritionally adequate or capable of meeting basic FBDGs. Following on from this, the nutritional implications of consuming such a monotonous diet with low nutrient density are considered in **Table 4**, in which, examples of how to add some variety to a typical South African starch-based diet (within a household mean of $2.24 per household per day) are presented. Accordingly, the data clearly illustrates the nutritional inadequacy dictated by a limited household income, despite large volumes of staples being consumed. Simply put, in order to meet nutritional needs there is a requirement to spend more money on food that is not at the disposal of these individuals. Furthermore, although it is now mandatory that all commercial maize meal porridge in South Africa is fortified, consuming large amounts of fortified porridge for each meal throughout the day (850g per person per meal) contributes to only 45.5% of the Recommended Dietary Allowance (RDA) for protein, 85% of the RDA for iron, and 31.2% of the RDA for vitamin A per household member. Adding five portions of chicken heads and feet (750g) to the households daily food supply would increase the cost of the families' daily diet to a barely affordable $2.20, but improve nutrient quality in terms of protein from 45.5% RDA to 63.6% of RDA. Adding three bunches of spinach to the households daily food supply would increase cost to $2.20, but would increase the nutritional composition to such an extent that each family member would meet 130% of their RDA for iron and nearly 130% of their RDA for vitamin A, but only slightly improve their protein intake. From **Table 4** it is clearly seen that introducing variety to a starch-based diet can significantly improve nutrient intake, highlighting the importance of dietary diversity. Adding vegetables significantly improves the intake of vitamin A and iron, whereas animal-based foods contribute to a notable increase in protein intake. Although fortification contributes meaningfully to the overall total micronutrient intake of the diet, the bioavailability of micronutrients from different food sources should also be taken into consideration. For example, the form of iron found in animal products is significantly more readily absorbed into the human body than the form of iron found in plant foods or fortification mixes (Schönfeldt & Hall 2011).

Overall, from the results presented in **Table 4** it seems highly unlikely that households falling into the lower socio-economic groups (i.e. LSM range 1 to 4) will be able to procure daily diets supplying all of their nutrient needs. These household members will undoubtedly be unable to adhere to the FBDGs, irrespective of their level of awareness of the need to obtain a nutritionally adequate diet or their degree of willingness to make the recommended healthy food choices.

2.8 Conclusions and recommendations

With a paradigm shift in the global focus from food security to food and nutrition security, focus is increasingly being placed on meeting all the nutritional needs of the growing population in addition to alleviating hunger. The promotion of appropriate dietary intake and lifestyles for the prevention and management of malnutrition is often considered an integral initiative as part of such policies or programmes aimed at improving food and nutrition security. Many countries have thus developed sets of national guidelines on healthy diets (FBDGs) applicable to the population to be used in promotional and educational campaigns.

As suggested in the guidelines for developing national plans of action for nutrition (FAO 1993), the first step in defining future policies should be to assess existing national plans and policies in the light of the overall objectives, i.e. to improve food and nutrition security. In the light of the findings of this paper, the feasibility for nutritionally vulnerable individuals in South Africa to adhere to the developed set of FBDGs and recommended diets, even those diets specially developed with low socio-economic individuals in mind, seem unlikely. This is due to limited financial resources in the midst of ever-increasing food prices.

Sadly, it seems that education on how to consume a healthy diet through FBDGs will not enable individuals with limited financial resources to make healthier food choices. In addition, mandatory fortification of staple foods has only a limited ability to increase micro-nutrient intake in such individuals, even when these staple foods are consumed in large quantities and dietary diversity needs to be improved. As such, alternative interventions are required, in addition to FBDGs and fortification programmes, as part of a long term strategy to improve food and nutrition security for all South Africans.
Such interventions should aim to enable low socio-economic consumers to achieve healthy, nutritionally adequate daily diets as recommended by the FBDGs. Possible interventions

include, increasing the availability of a variety of nutrient-dense foods. The establishment of integrated farming systems could also enable the sustainable production of diverse food products such as traditional and seasonal fruit and vegetable varieties, whole and unrefined grains and indigenous animal breeds. The increase in local food types available from this would not only improve dietary diversity, but simultaneously preserve the environment through the promotion of biodiversity. Furthermore, policies to reduce post-harvest or post-slaughter losses to limit waste and add value, as well as the implementation of appropriate processing methods could make these foods more affordable and nutritious, while also improving sustainability of the food supply chain. Furthermore, going forward nutrition education should place more emphasis on the importance of dietary diversity to meet all the nutritional needs of the household, instead of simply to sustain satiety (via starch-based staple foods). Additionally, national monitoring programmes are required to observe the efficacy of such initiatives in improving the food and nutrition security of all socio-economic groups within the population.

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CHAPTER 3: THE NUTRIENT CONTENT OF SELECTED SOUTH AFRICAN LAMB AND MUTTON ORGAN MEATS (OFFAL)

A great need for science based, local South African data on the nutritional composition of lamb and mutton organ meats was identified by the South African red meat industry. This resulted in a project proposed to the National Research Foundation's Research Technology Fund (RTF) as well as the RMRD SA to determine the nutritional composition of organ meats. Funding was rewarded by both organisations and enabled the author of this thesis to determine the nutritional composition of lamb and mutton organ meats. The data generated in this study was accepted as oral presentations at the 2015 annual conference of the South African Association for Food Science and Technology (SAAFoST) in Durban and the International Food Database Conference in Hyderabad, India, 2015. This article has been published in the scientific journal, Food Chemistry in May 2017 (available online: https://doi.org/10.1016/j.foodchem.2017.05.075)

3.1 Introduction

Organ meats, also known as edible by-products or organ meats, have been overlooked in the past in dietary guidelines and recommendations, irrespective of their potential contribution to food and nutrition security in South Africa. Limited information is available on the composition of South African organ meats as cooked and consumed at home. This limited information includes a recent study done by Van Heerden & Morey (2014) investigating the nutrient content of South African C2* beef organ meats. This study confirmed that significant amounts of iron and zinc can be found in some beef organs which compared favourably with beef muscle meat cuts and that beef organ meats can be recommended as a good, low cost, nutritious food product (Van Heerden & Morey, 2014). Small ruminants (goats and sheep) are an integral part of small holder farming systems in South Africa (Tshabalala, Strydom, Webb, & De Kock, 2003) and could potentially play a positive role in food and nutrition security in these communities.

In view of rapid population growth in a disease- and poverty-ridden world, the availability of affordable, nutrient dense animal source foods such as organ meats needs to be investigated closely. Known composition data on these foods will enable better consumption recommendations to be made as part of pro-active approaches in eradicating malnutrition and non-communicable diseases (NCDs). Therefore the potential nutritional contribution of these animals' organ meats should also be determined.

Nutrients of concern and generally lacking in South African diets are vitamin A, iron, zinc and B vitamins (Shisana, et al., 2014). Meat is an important nutrient dense food commodity which contributes to nutrients of concern in the South African diet (McAfee, et al., 2010). Meat is however also one of the most expensive items in the food basket. It is believed that organ meats, often also referred to as "offal" or the "fifth quarter", are affordable, alternative nutrient dense animal source foods. The South African National Food Consumption Survey (NFCS), published in 2005, reported that large amounts of organ meats are consumed by children in lower income households in both urban and rural regions (Labadarios, et al., 2005). However the report did not specify which organs were consumed.

The purpose of this study was to determine the nutrient content of selected lamb and mutton organ meats and to determine the possible contribution to the South African diet. This article reports on the nutritional content of raw and cooked A2* lamb and C2* mutton tongues, intestines, stomachs, spleens, lungs, kidneys and livers and the potential contribution of these products to better, affordable, nutrition in South Africa. Nutrients analysed in this study were Crude Protein, Fat, Calcium, Phosphorus, Magnesium, Iron, Manganese, Zinc, Potassium and Sodium.

***A2 lamb and C2 beef and mutton referred to in this article describes the products' age and fatness as per "The South African Red Meat classification system"** (South African Meat Industry Company, 2016). *"A" refers to a young animal with no permanent incisors whereas "C" refers to an animal with a full set of teeth. A fatness code of "2" refers to a "lean" animal.*

3.2 Materials and Methods

In South Africa, lamb and mutton meat are regarded as two distinctly different products. Although they are derived from same species of animal, significant compositional differences have been found by previous studies between sheep of different ages (Sainsbury, Schönfeldt, & Van Heerden, 2011). The nutrient content of different organ meats from both lamb A2 class carcasses and mutton C2 class carcasses was determined and will be reported separately.

3.2.1 Sample Procurement

Unlike most commercial lamb and mutton retail cuts, where distinction is made between “lamb” and “mutton” on a retail level, organ meats from these animals are usually just labelled “sheep” offal in store. However many abattoirs in South Africa sell offal directly to surrounding communities. Thus the abattoir is an important point of sale and therefore, for this study, lamb- and mutton organ meat samples were procured directly from two abattoirs in Gauteng, South Africa in the Pretoria and Bronkhorstspruit areas. This was also deemed the best method of sample procurement to ensure that samples were lamb or mutton organ meats according to official abattoir classification, and also with the classifications A2* and C2* respectively. The lamb and mutton organ meats included in this study were hearts, livers, lungs, kidneys, tongues, spleens, stomachs, intestines. Six samples of each lamb- and mutton organ meat were procured based on availability (n=8x6).

3.2.2 Sample Preparation

All lamb and mutton organs were washed, scrubbed and cleaned with water to remove all remaining manure and stomach contents, as would be done by the consumer on household level. Three samples, from three different animals, of each organ meat (n=8x3) were selected for raw analysis, placed in airtight bags, labelled, frozen and stored at the University of Pretoria in the freezer of the Department of Animal and Wildlife sciences. The remaining three samples of each organ (n=8x3) were prepared for cooking. Three samples of each of the eight lamb organ meat products, and eight of each of the mutton organ meat products were cooked according to a standardised moist heat cooking method. The samples were cooked and prepared in the experimental kitchen of the Department of Consumer Science at the University of Pretoria. The cooking method used, was developed to simulate the cooking processes used at home by most South Africans. The cooking methods most commonly used were derived from research done with a focus group by Duvenage, Schönfeldt & Vermeulen (2011), amongst the lower income population groups in the Limpopo Province (Duvenage, Schönfeldt, & Vermeulen, 2011) as well as a consumer survey on perceptions towards red meat in the Gauteng province (Vermeulen, Schönfeldt & Pretorius, 2014). Stewing and braising were the cooking methods most commonly used to cook meat products in South Africa according to both studies. Stewing and braising involves cooking and serving food in a small amount of liquid and thus retaining more nutrients than food cooked in water. Organ meats naturally contain a significant amount of fluids and fat. At the hand of this information it was decided to cook each organ it its own small disposable aluminium oven pan, covered securely with aluminium foil that it would cook in its own liquids. Each organ meat product was cooked to an internal temperature of 75°C, which is the internal temperature recommended for human consumption of organ meats (Brown, 2010). The covered foil pans were placed on the middle oven racks of the experimental kitchen's built in AEG Competence ovens using a convection oven setting of 160°C. These ovens are maintained and calibrated for scientific use. Samples were weighed before and after cooking to obtain cooking data and yield factors. Cooked samples were dissected and weighed as separate edible and inedible fractions. Yield factors were calculated as the percentage of the difference between total raw weight and cooked edible portion weight of each organ.

3.2.3 Nutrient Analysis

For raw nutritional analysis all cartilage, excessive subcutaneous fat and inedible matter were removed from each sample. Thereafter the raw samples were cubed, ground, placed in airtight freezer bags and frozen. The cooked samples were cooled to room temperature, dissected into fat, cartilage and meat for physical composition data. Edible fractions (meat and fat) were cubed, ground and placed in airtight freezer bags. All nutrient analysis was done at the NutriLab of the University of Pretoria. The details and references for each method of analysis can be found in **Table 3.1.**

3.2.4 Moisture Content and Freeze Drying

Each raw ground sample was thawed and homogenized before moisture analysis was carried out. Moisture content analysis of the cooked samples was done on the same day as cooking and grinding. Moisture content analysis was done in duplicate for both raw and cooked samples. All samples were freeze dried to obtain a homogenous sample for the rest of the analyses.

3.2.5 Statistical Analysis

Data was collected, captured and prepared for statistical analysis in Microsoft Excel. Descriptive statistics were done by a qualified statistician using *GenStats* software (Windows Genstats, 2000). All data were analysed by analysis of variance.

Table 3.1: Methods of analysis references (AOAC, 2000)

General Analyses	
Moisture Determination	AOAC, 2000. Official method of analysis 934.01 (17th Edition) Volume I. Association of Official Analytical Chemists, Inc., Maryland, USA
Dry Matter Ashing (inorganic fraction)	AOAC, 2000. Official method of analysis 932.05 (17th Edition) Volume I. Association of Official Analytical Chemists, Inc., Maryland, USA
Crude protein (CP)	AOAC, 2000. Official method of analysis 968.06 (17th Edition) Volume I. Association of Official Analytical Chemists, Inc., Maryland, USA
Ether Extraction (EE) for crude fat	AOAC, 2000. Official method of analysis 920.39 (17th Edition) Volume I. Association of Official Analytical Chemists, Inc., Maryland, USA
Mineral Analysis	
Sample preparation (Ca, Mg, Cu, Mn, K, Na, Fe, Zn)	AOAC, 2000. Official method of analysis 935.13 (17th Edition) Volume I. Association of Official Analytical Chemists, Inc., Maryland, USA
Sample preparation (P)	AOAC, 2000. Official method of analysis 968.08.D.b (17th Edition) Volume I. Association of Official Analytical Chemists, Inc., Maryland, USA
Mineral content (Ca, Mg, Cu, Mn, K, Na, Fe, Zn)	Giron, H. C., 1973. Atomic Absorption Newsletter 12, 28. Perkin Elmer Atomic Spectrophotometer
Phosphorus (P)	AOAC, 2000. Official method of analysis 965.17 (17th Edition) Volume I. Association of Official Analytical Chemists, Inc., Maryland, USA

3.3 Results and Discussion

3.3.1 Cooking data and yield factors

Cooking data and yield factors for mutton and lamb organs are presented in **Table 3.2**. Raw weights for mutton organs range between 80g (kidneys) and 2 189g (stomachs) and for lamb organs between 51g (kidneys) and 2 009g (intestines). Cooked mutton edible portions ranged between 29.1g (kidneys) and 1 289g (stomachs). There was no significant difference (in terms of weight in grams) between the edible portions of cooked mutton hearts, kidneys, spleens, lungs and tongues which can be seen as the group of smaller organs from a sheep carcass, yielding between 29.1g (kidneys) and 318g (lungs). The larger organs, namely intestines, livers and stomachs, had edible portion yields between 477g (livers) and 1 289g (stomachs) and did not differ significantly from each other but did differ significantly from the smaller organs (hearts, kidneys, spleens, lungs and tongues).

As was found in a study done in New Zealand on lamb organs (Purchas & Wilkinson, 2013), it was difficult to distinguish between subcutaneous fat, intermuscular fat and muscle meat in cooked organs, and therefore fat was included in the "edible portion" in **Table 3.3.** Cooked lamb edible portions ranged between 28.6g (kidneys) and 713g (stomachs). Similarly to the small mutton organs, edible portions of cooked lamb hearts, kidneys, spleens, lungs and tongues did not differ significantly in terms of weight in grams, ranging between 28.6g (kidneys) and 259g (lungs). Furthermore there was a significant difference between the cooked edible portions of lamb livers (130g) and lamb intestines (896g). There was no significant difference between the cooked lamb livers and stomachs (714g) and also not between the intestines (896g) and stomachs.

Yield factors presented in **Table 3.2** for mutton organs ranged between 36.3% (kidneys) and 76.3% (livers). Yield factors for lamb organs in **Table 3.2** ranged between 55.1% (kidneys) and 83.8% (livers). Although cooked lamb and mutton livers did not yield the largest edible portion in terms of weight they had the largest yield factor and thus had the lowest percentage cooking losses. This is consistent with what was found by the New Zealand study on the yield of cooked lamb organs (Purchas & Wilkinson, 2013). Higher cooking losses were reported than observed in other South African studies reporting on yields and cooking losses of meat cuts.

3.3.2 Proximate and mineral composition per 100g raw and cooked lamb and mutton organ meats

The results of the proximate analysis and the mineral content of raw mutton organs per 100g are presented in **Table 3.3** and for raw lamb organs in **Table 3.4**. Significant differences were found between organs for all nutrients tested in both raw lamb and raw mutton organs. The results of the proximate analysis and the mineral content of cooked mutton organs are presented in **Table 3.5** and for cooked lamb organs in **Table 3.6**.

Table 3.2: Cooking data and yield factors for mutton organ meats

	Raw weight		Cooked edible portion		Yield factor*	Cooking loss
Mutton						
n=3	**g**	**±s.d**	**g**	**±s.d**	**%**	**%**
Intestines	1 837[a]	*(±244)*	782[b]	*(±112)*	42.5	57.5
Lungs	610[b]	*(±158)*	318[cd]	*(±116)*	51.1	48.9
Hearts	187[bc]	*(±7.44)*	132[d]	*(±16.6)*	70.4	29.6
Livers	624[b]	*(±106)*	477[bc]	*(±100)*	76.3	23.7
Stomachs	2 189[a]	*(±223)*	1289[b]	*(±178)*	59.3	40.7
Kidneys	80.0[c]	*(±4.87)*	29.1[d]	*(±2.50)*	36.3	63.7
Spleen	109[c]	*(±8.21)*	65.0[d]	*(±15.8)*	58.9	41.1
Tongue	92.0[c]	*(±5.51)*	56.9[d]	*(±13.3)*	61.7	38.3
Note: Means with different superscripts in column differ significantly						
Lamb						
n=3	**g**	***(±s.d)***	**g**	***(±s.d)***	**%**	**%**
Intestines	2 009[a]	*(±141)*	896[a]	*(±107)*	44.5	55.5
Lungs	459[c]	*(±9.9)*	259[c]	*(±23.8)*	56.4	43.6
Hearts	192[e]	*(±15.1)*	130[c]	*(±9.7)*	68.0	32.0
Livers	696[c]	*(±97.2)*	583[b]	*(±77.2)*	83.8	16.2
Stomachs	1 130[b]	*(±58.7)*	714[ab]	*(±174)*	62.7	37.3
Kidneys	52.1[e]	*(±4.9)*	28.6[c]	*(±8.1)*	55.1	44.9
Spleen	72.0[e]	*(±22.3)*	42.5[c]	*(±18.9)*	56.0	44.0
Tongue	94.2[e]	*(±13.7)*	70.0[c]	*(±6.8)*	75.0	25.0
Note: Means with different superscripts in column differ significantly						

** retained after cooking and trimming*

** retained after cooking and trimming*

Significant differences were found between raw mutton organs for moisture, ash, protein and fat values, as well as for all minerals tested (**Table 3.3**). Similarly for raw lamb, significant differences were found between organs for moisture, ash, protein and fat values, as well as for all minerals tested (**Table 3.4**).

Animal source foods contain good quality proteins in a bioavailable form. Referring to **Table 3.5** the cooked mutton organs with the highest protein value per 100g were kidneys (32.7g/100g), with the other cooked mutton organs ranging between 15.3g/100g (intestines) and 27.8g/100g (spleen). Spleens were the cooked lamb organs with the highest amount of protein (29.5g/100g), with the other organs ranging between 14.3g/100g (intestines) and 24.8g/100g (stomachs).

In terms of the mineral composition of cooked lamb and mutton organs, values differed significantly between all organs with the exception of magnesium in cooked lamb organs. No significant difference in magnesium content could be found between cooked organs (**Table 3.6**).

Values for iron and zinc in cooked lamb and mutton organ meats, which are nutrients of concern for the South African population (Shisana, et al., 2014), are presented in **Table 3.5** and **Table 3.6**. The iron content of cooked mutton organs (**Table 3.5**) differed significantly between the different organs ranging from 1.69mg/100g (intestines) to 11.7mg/100g (spleens). The iron content of lamb organs (**Table 3.6**) differed to a lesser extent between the organs, ranging between 1.4mg/100g (intestines) and 22.8mg (spleen).

The phosphorus content of mutton organs ranged between 112mg/100g (intestines and stomachs) and 414mg/100g (spleens) and for lamb organs between 124mg/100g (intestines) and 423mg/100g (livers). Low levels of manganese, potassium, sodium and calcium were found in all lamb and mutton organs.

Table 3.3: Proximate composition and mineral content of 100g edible portion (without bone and cartilage) raw mutton organ meats

	Moisture	Ash	Protein	Fat	Calcium	Phosphorus	Magnesium	Iron	Manganese	Zinc	Potassium	Sodium
	g/100g (±s.d)	g/100g (±s.d)	g/100g (±s.d)	g/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)
Intestines	64.5^{cd}	0.28^{d}	6.96^{e}	28.6^{a}	11.0^{b}	79.0^{d}	14.67^{e}	1.29^{b}	0.04^{b}	0.92^{d}	88.0^{e}	39.6^{c}
	(±6.12)	*(±0.15)*	*(±1.29)*	*(±8.16)*	*(±3.50)*	*(±23.6)*	*(±4.00)*	*(±0.30)*	*(±0.03)*	*(±0.23)*	*(±28.1)*	*(±5.94)*
Lungs	79.3^{a}	1.08^{b}	16.7^{b}	2.41^{e}	8.00^{b}	225^{abc}	17.0^{de}	7.76^{b}	0.01^{b}	1.70^{c}	285^{bc}	149^{a}
	(±0.60)	*(±0.17)*	*(±0.61)*	*(±0.19)*	*(±1.30)*	*(±25.5)*	*(±3.00)*	*(±1.81)*	*(±0.01)*	*(±0.09)*	*(±20.2)*	*(±4.08)*
Hearts	70.3^{b}	1.10^{b}	16.3^{b}	11.7^{cd}	7.60^{b}	186^{bcd}	23.1^{abc}	3.47^{b}	0.03^{b}	1.71^{c}	256^{cd}	109^{b}
	(±2.83)	*(±0.16)*	*(±1.42)*	*(±2.65)*	*(±4.00)*	*(±16.9)*	*(±2.40)*	*(±0.28)*	*(±0.001)*	*(±0.17)*	*(±44.9)*	*(±28.4)*
Livers	69.9^{bc}	1.87^{a}	19.9^{a}	4.33^{de}	6.33^{b}	259^{ab}	26.8^{a}	15.3^{b}	0.28^{ab}	4.02^{a}	334^{b}	63.0^{c}
	(±1.01)	*(±0.60)*	*(±1.13)*	*(±0.72)*	*(±1.00)*	*(±183)*	*(±1.40)*	*(±2.93)*	*(±0.05)*	*(±0.39)*	*(±39.0)*	*(±23.6)*
Stomachs	70.9^{b}	0.39^{d}	10.3^{d}	18.5^{bc}	26.5^{a}	88.2^{d}	15.5^{de}	4.10^{b}	0.78^{a}	1.57^{c}	134^{e}	53.0^{c}
	(±3.89)	*(±0.08)*	*(±1.07)*	*(±3.97)*	*(±5.70)*	*(±14.6)*	*(±2.10)*	*(±3.67)*	*(±1.00)*	*(±0.28)*	*(±20.4)*	*(±7.62)*
Kidneys	80.5^{a}	1.03^{bc}	14.9^{b}	3.03^{e}	8.50^{b}	224^{abc}	20.3^{bcd}	2.97^{b}	0.09^{b}	1.87^{c}	249^{cd}	150^{a}
	(±1.07)	*(±0.06)*	*(±0.80)*	*(±0.42)*	*(±0.80)*	*(±14.9)*	*(±1.20)*	*(±0.35)*	*(±0.01)*	*(±0.32)*	*(±30.0)*	*(±9.35)*
Spleen	77.6^{a}	1.34^{b}	19.6^{a}	2.86^{e}	6.50^{b}	317^{a}	25.1^{ab}	97.4^{a}	0.02^{b}	2.69^{b}	464^{a}	106^{b}
	(±0.70)	*(±0.08)*	*(±0.87)*	*(±0.26)*	*(±1.20)*	*(±45.8)*	*(±2.60)*	*(±43.6)*	*(±0.02)*	*(±0.13)*	*(±37.9)*	*(±4.79)*
Tongues	64.1^{d}	0.61^{cd}	12.9^{c}	21.7^{ab}	6.83^{d}	129^{cd}	20.2^{cd}	1.52^{b}	0.01^{b}	1.65^{a}	218^{a}	102^{b}
	(±3.30)	*(±0.09)*	*(±0.74)*	*(±3.57)*	*(±0.98)*	*(±8.6)*	*(±3.70)*	*(±0.17)*	*(±0.02)*	*(±0.16)*	*(±20.8)*	*(±10.8)*
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<0.001	<0.001	<0.001

Note: Means with different superscripts in a column differ significantly

Table 3.4: Proximate composition and mineral content of 100g edible portion (without bone and cartilage) raw lamb organ meats

	Moisture	Ash	Protein	Fat	Calcium	Phosphorus	Magnesium	Iron	Manganese	Zinc	Potassium	Sodium
	g/100g (±s.d)	g/100g (±s.d)	g/100g (±s.d)	g/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)
Intestines	55.2^{cd}	0.46^{e}	7.01^{e}	26.5^{a}	9.33^{ab}	95.0^{e}	11.3^{e}	1.37^{c}	0.08^{b}	1.00^{e}	94.3^{d}	43.0^{e}
	(±7.16)	*(±0.19)*	*(±1.41)*	*(±7.41)*	*(±3.14)*	*(±16.2)*	*(±1.75)*	*(±0.18)*	*(±0.04)*	*(±0.11)*	*(±13.0)*	*(±1.79)*
Lungs	74.1^{a}	1.05^{bc}	17.3^{ab}	2.50^{d}	7.00^{bc}	164^{d}	15.7^{d}	15.8^{ab}	0.02^{cd}	1.77^{cd}	252^{c}	166^{a}
	(±0.69)	*(±0.35)*	*(±0.72)*	*(±0.84)*	*(±0.00)*	*(±44.7)*	*(±1.21)*	*(±5.44)*	*(±0.01)*	*(±0.24)*	*(±20.9)*	*(±14.2)*
Hearts	65.1^{b}	0.87^{cd}	17.2^{ab}	11.8^{bc}	4.83^{c}	199^{cd}	23.2^{ab}	3.93^{c}	0.00^{d}	1.83^{c}	280^{bc}	118^{bc}
	(±0.32)	*(±0.52)*	*(±1.26)*	*(±0.62)*	*(±1.17)*	*(±16.2)*	*(±2.40)*	*(±0.76)*	*(±0.00)*	*(±0.06)*	*(±30.0)*	*(±13.8)*
Livers	61.2^{bc}	1.40^{a}	18.5^{a}	8.90^{cd}	5.50^{c}	349^{a}	21.2^{abc}	5.11^{bc}	0.15^{a}	3.02^{a}	310^{b}	66.8^{de}
	(±3.42)	*(±0.12)*	*(±0.50)*	*(±5.28)*	*(±0.55)*	*(±24.0)*	*(±0.75)*	*(±0.51)*	*(±0.02)*	*(±0.19)*	*(±9.14)*	*(±5.78)*
Stomachs	49.6^{d}	0.43^{e}	10.0^{d}	15.7^{bc}	11.5^{a}	92.0^{e}	11.7^{e}	2.27^{c}	0.05^{bc}	1.48^{d}	129^{d}	57.7^{de}
	(±2.15)	*(±0.02)*	*(±0.91)*	*(±1.78)*	*(±2.26)*	*(±5.56)*	*(±0.52)*	*(±0.83)*	*(±0.03)*	*(±0.07)*	*(±7.10)*	*(±7.79)*
Kidneys	65.8^{b}	1.10^{b}	15.2^{c}	3.20^{d}	6.33^{bc}	227^{bc}	18.0^{c}	3.42^{c}	0.09^{b}	2.06^{c}	269^{bc}	155^{a}
	(±0.21)	*(±0.08)*	*(±0.34)*	*(±0.25)*	*(±0.52)*	*(±10.7)*	*(±0.98)*	*(±0.20)*	*(±0.01)*	*(±0.04)*	*(±6.90)*	*(±4.51)*
Spleen	67.1^{ab}	1.18^{b}	17.9^{ab}	2.00^{d}	4.33^{c}	258^{b}	20.0^{bc}	19.7^{a}	0.02^{cd}	2.41^{b}	403^{a}	95.0^{c}
	(±0.10)	*(±0.08)*	*(±0.36)*	*(±0.12)*	*(±0.82)*	*(±32.2)*	*(±0.89)*	*(±13.9)*	*(±.0.001)*	*(±0.25)*	*(±18.4)*	*(±4.34)*
Tongues	63.7^{b}	0.83^{d}	16.0^{bc}	17.7^{b}	7.33^{bc}	171^{d}	24.2^{a}	1.77^{c}	0.04^{cd}	1.99^{c}	298^{b}	112^{bc}
	(±2.82)	*(±0.07)*	*(±1.34)*	*(±16.75)*	*(±7.0)*	*(±12.6)*	*(±2.64)*	*(±0.16)*	*(±0.003)*	*(±0.19)*	*(±36.5)*	*(±15.4)*
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Note: Means with different superscripts in a column differ significantly

Table 3.5: Proximate composition and mineral content of 100g edible portion (without bone and cartilage) cooked mutton organ meats

	Moisture	Ash	Protein	Fat	Calcium	Phosphorus	Magnesium	Iron	Manganese	Zinc	Potassium	Sodium
	g/100g (±s.d)	g/100g (±s.d)	g/100g (±s.d)	g/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)
Intestines	48.2^{d}	0.74^{d}	15.3^{d}	37.9^{a}	16.6^{b}	112^{c}	16.9^{cd}	1.69^{e}	0.0002^{e}	2.55^{b}	50.2^{d}	29.5^{e}
	(±6.68)	*(±0.23)*	*(±2.40)*	*(±7.71)*	*(±0.80)*	*(±40.6)*	*(±2.90)*	*(±0.12)*	*(±0.00)*	*(±0.22)*	*(±16.8)*	*(±7.68)*
Lungs	71.1^{a}	1.21^{c}	23.2^{bc}	3.97^{d}	10.99^{bc}	250^{b}	19.4^{bcd}	10.7^{a}	0.0010^{a}	2.62^{b}	285^{bc}	190^{b}
	(±0.94)	*(±0.11)*	*(±1.11)*	*(±0.87)*	*(±1.60)*	*(±18.6)*	*(±1.70)*	*(±0.26)*	*(±0.00)*	*(±0.18)*	*(±31.3)*	*(±37.6)*
Hearts	57.6^{bc}	1.34^{bc}	20.4^{cd}	20.2^{c}	6.00^{c}	223^{b}	24.8^{ab}	4.54^{c}	0.0005^{c}	2.74^{b}	275^{bc}	97.5^{cd}
	(±4.98)	*(±0.28)*	*(±3.57)*	*(±1.89)*	*(±2.30)*	*(±38.0)*	*(±4.40)*	*(±1.13)*	*(±0.0001)*	*(±0.42)*	*(±62.0)*	*(±18.9)*
Livers	64.5^{ab}	1.59^{bc}	23.1^{bc}	6.27^{d}	5.60^{c}	399^{a}	26.2^{ab}	7.96^{b}	0.0008^{d}	4.38^{a}	326^{bc}	78.7^{cde}
	(±2.00)	*(±0.12)*	*(±0.20)*	*(±0.93)*	*(±1.50)*	*(±7.00)*	*(±1.60)*	*(±1.11)*	*(±0.0001)*	*(±0.54)*	*(±19.2)*	*(±8.45)*
Stomachs	53.1^{cd}	0.61^{d}	17.8^{d}	27.3^{bc}	24.6^{a}	112^{c}	15.9^{d}	2.70^{de}	0.0002^{de}	3.37^{ab}	104^{d}	58.7^{de}
	(±6.58)	*(±0.12)*	*(±2.79)*	*(±3.25)*	*(±7.90)*	*(±33.6)*	*(±4.60)*	*(±1.00)*	*(±0.0001)*	*(±1.35)*	*(±32.7)*	*(±17.7)*
Kidneys	57.2^{bcd}	2.36^{a}	32.7^{a}	7.77^{e}	15.6^{b}	400^{a}	30.7^{a}	4.34^{cd}	0.0004^{cd}	4.49^{a}	279^{bc}	270^{a}
	(±1.49)	*(±0.18)*	*(±3.06)*	*(±1.15)*	*(±0.75)*	*(±36.3)*	*(±3.40)*	*(±0.67)*	*(±0.0006)*	*(±0.17)*	*(±57.7)*	*(±57.5)*
Spleen	66.2^{ab}	1.69^{bc}	27.8^{ab}	5.23^{e}	6.00^{c}	414^{a}	31.4^{a}	11.7^{a}	0.0011^{a}	3.61^{ab}	472^{a}	112^{cd}
	(±3.10)	*(±0.21)*	*(±2.83)*	*(±0.68)*	*(±0.60)*	*(±41.8)*	*(±2.70)*	*(±0.96)*	*(±0.0009)*	*(±0.38)*	*(±51.1)*	*(±10.2)*
Tongues	52.6^{cd}	0.71^{d}	15.8^{d}	33.2^{ab}	8.70^{c}	142^{c}	23.3^{bc}	1.81^{e}	0.0002^{e}	2.91^{b}	235^{c}	122^{c}
	(±8.72)	*(±0.18)*	*(±1.51)*	*(±7.47)*	*(±0.60)*	*(±15.4)*	*(±2.61)*	*(±0.34)*	*(±0.00003)*	*(±0.36)*	*(±22.7)*	*(±13.0)*
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Note: Means with different superscripts in a column differ significantly

Table 3.6: Proximate composition and mineral content of 100g edible portion (without bone and cartilage) cooked lamb organ meats

	Moisture	Ash	Protein	Fat	Calcium	Phosphorus	Magnesium	Iron	Manganese	Zinc	Potassium	Sodium
	g/100g (±s.d)	g/100g (±s.d)	g/100g (±s.d)	g/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)	mg/100g (±s.d)
Intestines	55.2^{cd}	0.67^{c}	14.3^{d}	31.2^{a}	18.6^{b}	124^{e}	21.9^{a}	1.40^{c}	0.01^{c}	2.60^{c}	75.1^{d}	38.4^{f}
	(±1.81)	*(±0.37)*	*(±2.22)*	*(±4.06)*	*(±8.79)*	*(±16.6)*	*(±8.80)*	*(±0.28)*	*(±0.01)*	*(±0.33)*	*(±30.0)*	*(±13.2)*
Lungs	74.1^{a}	1.46^{ab}	21.1^{bc}	6.53^{b}	8.90^{b}	271^{c}	22.2^{a}	8.37^{b}	0.00^{c}	2.59^{c}	298^{b}	160^{b}
	(±0.45)	*(±0.19)*	*(±0.67)*	*(±5.51)*	*(±0.78)*	*(±18.1)*	*(±3.30)*	*(±0.41)*	*(±000)*	*(±0.19)*	*(±13.2)*	*(±24.5)*
Hearts	65.1^{b}	1.46^{ab}	19.3^{cd}	13.5^{b}	5.12^{b}	195^{d}	29.0^{a}	3.84^{bc}	0.044^{c}	2.49^{c}	261^{b}	101^{cd}
	(±3.29)	*(±0.54)*	*(±1.81)*	*(±4.59)*	*(±0.28)*	*(±18.5)*	*(±9.20)*	*(±0.19)*	*(±0.14)*	*(±0.15)*	*(±13.6)*	*(±5.91)*
Livers	61.2^{bc}	1.78^{a}	23.6^{bc}	8.39^{b}	5.03^{b}	423^{a}	28.3^{a}	6.07^{bc}	0.27^{a}	4.17^{a}	315^{b}	70.8^{e}
	(±3.97)	*(±0.18)*	*(±0.39)*	*(±4.49)*	*(±0.26)*	*(±18.8)*	*(±10.2)*	*(±0.82)*	*(±0.03)*	*(±0.11)*	*(±26.2)*	*(±6.78)*
Stomachs	49.6^{d}	0.87^{bc}	24.8^{ab}	29.9^{a}	52.7^{a}	170de	25.3^{a}	4.85^{bc}	0.19^{b}	3.90^{a}	155^{c}	79.5^{de}
	(±9.00)	*(±0.20)*	*(±5.75)*	*(±6.50)*	*(±17.4)*	*(±49.0)*	*(±8.30)*	*(±0.99)*	*(±0.07)*	*(±0.81)*	*(±38.1)*	*(±20.2)*
Kidneys	65.8^{b}	1.45^{a}	24.4^{abc}	12.1^{b}	9.38^{b}	330^{b}	30.6^{a}	4.44^{bc}	0.05^{c}	3.67^{a}	310^{b}	234^{a}
	(±3.92)	*(±0.15)*	*(±0.66)*	*(±0.84)*	*(±1.63)*	*(±5.80)*	*(±3.61)*	*(±0.83)*	*(±0.03)*	*(±0.35)*	*(±20.0)*	*(±13.9)*
Spleen	67.1^{ab}	2.02^{a}	29.5^{a}	6.62^{b}	7.57^{b}	406^{a}	30.8^{a}	22.8^{a}	0.00^{c}	3.60^{ab}	409^{a}	112^{c}
	(±1.45)	*(±0.27)*	*(±1.68)*	*(±0.80)*	*(±1.36)*	*(±31.2)*	*(±2.70)*	*(±8.98)*	*(±0.00)*	*(±0.25)*	*(±45.4)*	*(±6.22)*
Tongues	63.7^{b}	0.78^{c}	19.2^{cd}	16.8^{b}	17.7^{b}	184^{d}	24.0^{a}	1.50^{bc}	0.00^{c}	2.83^{ab}	276^{b}	102^{cd}
	(±4.76)	*(±0.08)*	*(±1.49)*	*(±4.04)*	*(±10.8)*	*(±29.4)*	*(±1.50)*	*(±0.17)*	*(±0.00)*	*(±0.94)*	*(±31.4)*	*(±8.49)*
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.132	<0.001	<0.001	<0.001	<0.001	<0.001

Note: Means with different superscripts in a column differ significantly

3.3.3 Potential nutritional contribution of cooked lamb and mutton organs per recommended serving

Nutrient reference values (NRVs) as per R429 amendment of the Foodstuffs, Cosmetics and Disinfectants Act (54/1972) (DOH, 2014), are presented in **Table 3.7** together with the percentage contribution of a portion of each lamb and mutton organ to the NRV of each of the nutrients analysed as well as the nutritional content claims that can be made in accordance with the Foodstuffs, Cosmetics and Disinfectants Act (54/1972) (DOH, 2014). The recommended portion size for meat according to the South African Food-Based Dietary Guidelines is 90g edible portion (Schönfeldt, Pretorius, & Hall, 2013).

NRVs, as presented in **Table 3.7**, are calculated for individuals from 37 months of age and older (DOH, 2014). By comparing the nutrient data found in this study, with the recommended NRVs, the' potential nutritional contribution per 90g serving of these organs can be determined. For example 90g of mutton kidneys, containing 29.4g of crude protein may contribute up to 52% of an adult's daily protein allowance of 56g. According to the Foodstuffs, Cosmetics and Disinfectants Act (54/1972) a food product must contain between 15% and 30% of a given nutrient in order to be able to make the claim that a serving of that food product is "a source of" that given nutrient (DOH, 2014). Furthermore a food product must contain between 30% and 60% of a nutrient per serving to qualify as being "high in" that specific nutrient and more than 60% per serving for it to be "very high" or an "excellent source" of a certain nutrient (DOH, 2014). Based on these claim guidelines together with the values presented in **Table 3.7**, all lamb and mutton organ meats can make a significant nutritional contribution (whether it is a "source of" at least one nutrient or an "excellent source" of another). The different claims that can be made regarding lamb and mutton organ meats are presented in **Table 3.7**.

Table 3.7: Contribution to NRV's and nutrient content claims per 90g cooked offal meat

[I]*NRV according to the Foodstuffs, Cosmetics and Disinfectants act* (DOH, 2014)

	Protein	Calcium	Phosphorus	Magnesium	Iron	Manganese	Zinc	Potassium	Sodium
NRV[I]	56g	1300mg	1250mg	365mg	13mg	2.3mg	10mg	4700mg	2000mg
Mutton	% of NRV per 90g serving[II III]								
Intestines	25[IV]	11	8	0	12	0	23[IV]	1	1
Lungs	37[V]	7	18[IV]	0	74[VI]	0	24[IV]	5	9
Hearts	33[V]	0	16[IV]	0	31[V]	0	25[IV]	5	4
Livers	37[V]	0	29[IV]	0	55[V]	0	39[V]	6	4
Stomachs	29[IV]	2	8	0	19[IV]	0	30[V]	2	3
Kidneys	52[V]	1	29[IV]	0	30[V]	0	40[V]	5	12
Spleen	45[V]	0	30[V]	0	81[VI]	0	32[V]	9	5
Tongues	25[IV]	1	10	0	13	0	26[IV]	4	5
Lamb	% of NRV per 90g serving[II III]								
Intestines	23[IV]	1	9	0	10	0	23[IV]	1	2
Lungs	34[V]	1	19[IV]	0	58[V]	0	23[IV]	6	7
Hearts	31[V]	0	14	0	27[IV]	2	22[IV]	5	5
Livers	38[V]	0	30[V]	0	42[V]	10	38[V]	6	3
Stomachs	40[V]	4	12	0	34[V]	8	35[V]	3	4
Kidneys	39[V]	1	24[IV]	0	31[V]	2	33[V]	6	11
Spleen	47[V]	1	29[IV]	0	158[VI]	0	32[V]	8	5
Tongues	31[V]	1	13	0	10	0	25[IV]	5	5

[II] *90g is the prescribed portion size for lean meat according to the Food-based dietary guidelines for South Africans* (Schönfeldt, Pretorius, & Hall, 2013)

[III] *Values do not take bioavailability into account*

[IV] *" Source of" as per the Foodstuffs, Cosmetics and Disinfectants act (DOH,2014)*

[V] *"" High in" as per the Foodstuffs, Cosmetics and Disinfectants act (DOH,2014)*

[VI] *" Excellent source" as per the Foodstuffs, Cosmetics and Disinfectants act (DOH,2014)*

3.3.4 Reducing food waste with the consumption of lamb and mutton organs

Apart from having the potential to be promoted as affordable animal source foods with a high yield percentage and low cooking losses, the consumption of organ meats is also directly related to minimising overall food waste (Jayathilakan, Sultana, Radhakrishna, & Bawa, 2012). "Offal", which is the name given to organ meats, can be translated in plain English as "leftovers". Organ meats are the edible by-products left over after a carcass has been slaughtered and into desired cuts for formal sale. The 2011 *Foresight report* published in the UK with the title "*Future of food and farming: Challenges and choices for global sustainability",* explores the challenges relating to balancing sustainable food systems and public health matters (Government Office for Science, 2011). The report identified the need to change consumption patterns and improve the use of food by-products to reduce food waste. Organ meats have a high percentage edible portion fraction, containing no bone and minimal cartilage. In the light of the current nutrition situation in South Africa together with the global fight against food waste this nutrient dense food product such as offal meat products that often goes to waste, needs to be developed as food commodities.

3.4 Conclusion and Recommendations

The results of this study found that lamb and mutton organ meats are nutrient dense animal source foods. In the correct portion size, each organ proved to be either a "source of" high in or an "excellent source of" at least three different nutrients (included in the study). In the case of protein, zinc and iron, three nutrients of concern in South Africa, all lamb and mutton organ meats were at least a source of two out of these three nutrients with lamb and mutton spleens and lamb and mutton lungs being excellent sources of protein.

This data will also aid in the compilation of more accurate quantitative portion size recommendations. For example a single mutton kidney yields on average 29.1g of edible portion (**Table 3.2**) which would mean that individuals would have to consume about 3 kidneys to adhere to the recommended portion size of 90g cooked.

Considering the high levels of crude protein found in cooked lamb and mutton offal cuts, it is recommended that further research should be carried out on the amino acid profiles of these cuts to determine their protein quality. Furthermore, fatty acids also need to be determined in order that the contribution of offal to essential fatty acid intake can be determined. Knowledge of haem iron will also give an indication of the bioavailability of iron in offal.

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CHAPTER 4: THE COMPILATION OF QUANTITATIVE FOOD DATA ON ANIMAL SOURCE FOODS AND SUGGESTED USE OF THE DATA IN FOOD CONSUMPTION STUDIES

The South African Medical Research Council (MRC), compiled a food quantities manual in 1991 containing quantitative measures and weights of various food products. This chapter aims to contribute a set of new data on the physical composition (yield, edible portions, cooking losses and fractions) for different cooked animal source foods as available in the retail market. This data generated in this chapter will be submitted to SAFOODS of the MRC and will be made available to the International Food Data System (INFOODS) network. Data from this chapter was presented as a poster at the 26the Congress of the Nutrition Society of South Africa and the 14th Congress of the Association for Dietetics in South Africa (ADSA) in 2014. An article *will be submitted to The South African Journal for Clinical Nutrition and therefore this chapter is presented in the form required by the journal.*

Abstract

Background: Accurate consumption data is a key aspect of assessing the health of a population. However, assessing consumption of animal source foods (ASFs) has proved to be a challenging task, especially without accurate quantitative data on the physical composition and yield factors of ASFs.

Objective: The objective of this study was to generate quantitative food data including physical composition data on edible portions and yield factors (to convert raw to cooked weight) for different chicken, beef, lamb marketplace servings (also referred to in some literature as "retail portions") as well as lamb and mutton organ meats.

Design: Different samples of chicken, beef and lamb marketplace servings were purchased, cooked and dissected into meat, bone and fat fractions to determine physical composition. Yield factors (edible and lean edible) and cooking losses were calculated for these marketplace servings, as well as lamb and mutton organ meats using raw and cooked weights.

Subjects and setting: Six samples of each chicken, beef and lamb marketplace servings, and three of each organ meat, were selected to determine physical composition and to calculate edible portions and yield factors.

Results: Data on the physical composition of different beef, lamb and chicken marketplace servings were generated in this study to determine edible portions and calculate yield factors. Cooked edible portions from beef marketplace servings ranged from 55g/100g to 63g/100g. Lamb marketplace servings yielded between 46g/100g and 85g/100g edible portion and chicken marketplace servings between 57g/100g and 63g/100g. Edible portions from lamb and mutton organ meats ranged from 36g/100g and 84g/100g Yield factors calculated in this study were compared to some values from the *United States Department of Agriculture's (USDA) Table of Cooking Yields for Meat and Poultry* and showed a noticeable difference between the yields of some cuts, proving the importance of generating country specific yield factors.

Conclusion: The dataset presented can potentially offer assistance to South African food consumption research projects where only raw products as purchased could be reported on. Furthermore, by ensuring more accurate conversions between raw and cooked composition, more accurate, independent, research based consumption estimations can be made in reports that informs decision-making by stakeholders in the food and agricultural industry.

Keywords: *Food composition; Quantitative food data; marketplace servings; Food consumption studies; Animal source foods*

4.1 Introduction and Background

Food consumption data, dietary recommendations and food composition data are important aspects of human nutrition that should be developed in unison (1,2,3,4). These tools should be utilised to effectively evaluate, monitor and improve the diets of a population (1,2,5). The Global Nutrition Report emphasised this need on a global level and states that researchers and practitioners urgently need to develop tools and strategies to prioritise and sequence nutrition relevant actions (6).

Food composition data provides essential information for effective monitoring of food and nutrition and therefore the activities of the International Network of Food Data Systems (INFOODS) had been prioritised as a central function within the Food and Agricultural Organisation (FAO) (7). The South African Food Data System (SAFOODS), of the MRC, is the responsible body for food composition activities in South Africa and has achieved great successes in collecting and compiling a robust body of food composition data, including unique local foods (8). In fact, 36.9 % of the 1 472 food items included in the *Condensed Food Composition Tables for South Africa*, published in 2010, is of South African origin (8), with less than 22% data originating from the USDA, which is generally seen as the ultimate source of food composition data.

Quantitative food data goes hand in hand with the nutrient composition tables used in a given country, providing supporting information on the food items included in the nutrient composition tables (8). Good quality nutrient composition and quantitative food data play an integral role in reporting nutrient intake of a population as well as to interpret results of some epidemiological research (4). Furthermore, insufficient quality nutrient composition data, as well as quantitative data, may lead to incorrect dietary advice and recommendations (4).

Nutrient values in nutrient composition tables are presented as per 100g and without supporting quantitative values on food products, nutrient contribution cannot be calculated accurately. In South Africa, the Medical Research Council's (MRC) Food Quantities Manual (9) provides quantitative and physical composition data to be used in conjunction with South African nutrient composition tables (9,10). The food quantities data in this manual are presented as the weight of the edible portion of the food product and/or the translation thereof into household measurements (cups, teaspoons, tablespoons, etc.). Cooking methods, specific preparations such as trimming and peeling and manufacturer names are also specified for some food products. Correct quantitative data on different fractions (meat, fat and bone) of an ASF product are also essential in analysing dietary intake (11). Furthermore, this data is a helpful tool for refining product specific dietary recommendations for animal source foods that consumers can understand easily. However there are currently limited data on marketplace servings for ASFs in the MRC's *Food Quantities Manual* (9).

The reporting of consumption of ASFs has proved to be a challenging task due to many factors of which the most important is the nature of the product. Most ASFs products consist of more than just edible meat, creating a great risk for error when reporting on meat consumption quantities and nutrient intake. Fat, skin, bone and cartilage form part of most animal products as purchased by the consumer, but are not always consumed. Including the weight of inedible parts of meat in total consumption can cause overestimations and a skewed representation of nutrients ingested. In an agricultural context, by not taking inedible parts of a carcass in consideration, meat from ASFs available in South Africa can also be overestimated. The values currently included in the Condensed Food Composition Tables for South Africa (8) refer to "100g edible portion" which includes meat and subcutaneous fat (unless otherwise specified) and not necessarily a marketplace serving of the product such as "one lamb chop" or "one mutton heart".

Extensive research has been done on total carcass size, meat quality, carcass composition and conformation of South African chicken, beef and lamb for breeding, feeding and wholesale pricing purposes (12,13). Research in these fields is ongoing to constantly improve production, classification systems and product quality. However, limited information is available on physical composition of marketplace servings (often also retail portions) which is the animal source food product as available to consumers from commercial retailers in South Africa.

In this study, meat, fat and bone fractions per cooked marketplace servings (also referred to as "retail portions" in some databases) of fresh beef and lamb cuts were determined. In the case of chicken marketplace servings, meat, bone and skin fractions of fresh chicken portions were determined. Furthermore, yield factors, for converting raw to cooked product in studies where only raw product animal source food could be captured, were determined for cooked chicken, beef, lamb edible and lean edible portions, as well as edible portions of lamb and mutton organ meats. The chapter will present a new set of quantitative data on cooked chicken, beef, lamb and organ meat marketplace servings. The data presented in this article and will also be submitted to the SAFOODS to be considered for inclusion in the MRC's *Food Quantities Manual*.

4.2 Methodology

4.2.1 Sampling

The types of meats and cuts selected for the study were guided by the results of a survey commissioned by Red Meat Research and Development South Africa (RMRD SA) to investigate the perception of South African's consumers towards red meat (14). Classification according to the National Carcass Classification System (15), was not considered in this study. The reason for the exclusion of the classification system was the fact that none of the chosen retailers referred to the National Classification System to indicate age and fatness of the meat on their labels. Mutton meat cuts were not included in this study due to the fact that the majority of sheep meat on the South African market is lamb.

Chicken, beef and lamb retail cuts sampling

Samples of different retail cuts of chicken (breasts, thighs, wings and drumsticks); beef (brisket chops, blade steaks, prime ribs, shin bones, short ribs and T-bones) and lamb (chump chops, knuckles, loin chops, neck steaks, riblets and rib chops) were procured through convenience sampling from four different, multinational, commercial retailers in Gauteng, South Africa. Twelve similar samples of each chicken, beef and lamb retail cut were selected of which six of each cut were used for raw dissection and six were cooked to determine yield factors and final edible portions.

Lamb and mutton organ meats sampling

Lamb and mutton organ meats samples were procured directly from two abattoirs in Gauteng, South Africa in the Pretoria and Bronkhorstspruit areas. These two abattoirs source carcasses from across South Africa and their products can be considered representative of meat of products offered in the market. This was deemed the best method of sample procurement to ensure that samples were lamb or mutton organ meats according to official abattoir classification, and also falls within the classifications A2 and C2 classes respectively. The lamb- and mutton organ meats included in this study were hearts, livers, lungs, kidneys, tongues, spleens, stomachs, intestines. Six samples of each lamb- and mutton organ meat were procured based on availability. The organs were washed, scrubbed and cleaned with tap water. Inedible cartilage and remaining stomach and intestine content were removed and weighed but not included in further analysis. Three samples of each organ were prepared for raw nutrient analysis while three samples of each were cooked prior to nutrient analysis.

4.2.2 Cooking methods

Sample preparation and cooking for this study took place in the Experimental Laboratory at the Department of Consumer Science at the University of Pretoria. Each meat marketplace serving, as purchased, was weighed and placed in its own small disposable aluminium oven pan and covered securely with aluminium foil in order to retain as much nutrients as possible. No liquids were added and the meat cooked in its own juices, therefore this is considered a dry heat cooking method similar to roasting where the only possible cooking losses occur by means of evaporation through the foil containers and covers. The covered foil pans were placed on the middle oven racks of the *AEG Competence* built in ovens preheated to 160°C on the convection setting. These ovens are maintained and calibrated for scientific use. Organ meats were left to cook to an internal temperature of 75°C, beef and lamb cuts to 70°C (medium), and chicken to 75°C (16). Samples were weighed before and after cooking to obtain cooking data to further calculate yield factors. Cooked samples were dissected in edible and inedible fractions and weighed. Yield factors were calculated as the percentage of the difference between total raw weight and cooked edible portion weight of each organ.

4.2.3 Determining meat, bone and fat fractions of cooked chicken, beef and lamb marketplace servings

Physical dissection is deemed the best way to determine physical composition of food products (7). Raw, as well as cooked samples were weighed and then dissected into bone, meat, intramuscular fat and subcutaneous fat fractions to determine physical composition. In some cases it was difficult to separate some fractions from others, such as the subcutaneous fat and skin on some chicken portions.

4.2.4 Calculation of yield factors for edible and lean edible portions

Yield factors were calculated for beef, chicken and lamb retail cuts, as well as lamb and mutton organ meats, using the formula that was used by the U.S Department of Agriculture to compile the USDA Table of Cooking Yields for Meat and Poultry (17). Yield factors can be used to convert raw product quantities to edible or lean edible portion, simply explained as the edible quantity left after cooking and trimming. Yield factors are especially important when determining dietary contribution of specific ASFs in studies where more information regarding raw products purchased could be obtained (17). The formula to calculate yield factors is as follow (7):

$$\frac{\text{Cooked edible portion per marketplace serving}}{\text{Total raw mass per marketplace serving}} \times 100$$

Edible portion yields refer to the meat, intramuscular and subcutaneous fat fractions. Lean edible portion yields refer to meat and the intra muscular fat fraction, therefore, trimmed of subcutaneous fat.

4.2.5 Calculation of percentage trimming and cooking loss

Cooking and trimming losses were calculated in this study as a percentage of the total raw product (7). Knowing how much of a product is lost during cooking and by trimming is an important consideration in meal planning and setting dietary recommendations. Percentage trimming and cooking loss were calculated as follow:

$$\frac{\text{Total raw mass per marketplace serving} - \text{Cooked edible portion per marketplace serving}}{\text{Total raw mass per marketplace serving}} \times 100$$

4.2.6 Statistical analysis

Results were captured in Microsoft Excel and were statistically analysis by a qualified statistician using *GenStats* analytical software (18). Descriptive statistics presented in this article include average values as well as the standard deviations of the mean values.

4.3 Results and Discussion

Physical composition, including average meat, bone and fat fractions weights, as per different chicken, beef and lamb marketplace servings are presented in **Table 4.1** to **Table 4.3**. Meat, bone and fat fractions per 100g of the total cooked weight of each cut were calculated and presented together with the fraction weights per marketplace serving. Organ meats were not dissected into separate fractions because there are no bones present in organ meats and all inedible parts, as well as the subcutaneous fat surrounding the organs, were already removed, as is common practice, at the abattoir or during the cleaning process. Yield factors, to convert raw to cooked product, are presented **in Table 4.4** and **Table 4.5**.

4.3.1 Physical composition of cooked chicken, beef and lamb marketplace servings

Meat, bone and skin (including subcutaneous fat) fractions of cooked chicken marketplace servings are presented in **Table 4.1**. Most subcutaneous fat on chicken marketplace servings lies directly under the skin and therefore, skin and subcutaneous fat were dissected and weighed together. Chicken marketplace servings had minimal intramuscular fat which was difficult to dissect and separate from the meat fractions on the different cuts.

With regards to the total cooked weight of the different chicken marketplace servings there was a significant difference found between different cuts ($p<0.001$), chicken breasts weighed the most (152g) and chicken thighs the least (67.4g). Bone fractions for chicken marketplace servings ($p<0.001$) ranged between 9.27g (thighs) and 30.2g (breasts). Chicken thighs also had the lowest bone fraction in terms of grams per 100g of the total cooked weighed (14g/100g) while drumsticks had the largest bone fraction in terms of grams per 100g of the total cooked weight (28.2g/100g). Fat and skin fractions per marketplace serving ($p<0.001$) ranged between 7.91g (thighs) and 20.9g (wings). In terms of grams per 100g thighs and drumsticks yielded 11.7g/100g fat and skin whilst chicken wings had 23.4g/100g fat and skin. The meat fractions ($p<0.001$), which in this case can also be referred to as the lean edible portion, from cooked chicken marketplace servings ranged between 16g (chicken wings) and 103g (chicken breasts) per marketplace serving. However it is interesting to note that although chicken thighs had the lowest total weight, bone, subcutaneous fat and skin fractions per marketplace serving, it's lean edible portion percentage (meat per 100g of total cooked weight) was the highest, being 74.5%, yielding a bigger lean edible portion than wings and drumsticks. One chicken thigh yields 74.5g meat per 100g of the total cooked weighed, which makes it the chicken marketplace serving which offers the best value for money.

Meat, bone, subcutaneous fat and intramuscular fat fractions of cooked beef marketplace servings are presented in **Table 4.2.** Total cooked weights for beef marketplace servings (p<0.001) ranged between 126g (short ribs) and 297g (prime ribs). However the beef t-bones' meat fraction was bigger than a prime ribs' meat fraction in terms of marketplace servings (182g) as well as meat per 100g of the total cooked weight (68.7g/100g). Short ribs had the smallest meat portion per marketplace serving (73.3g) and brisket chops had the smallest meat fraction in terms of grams per 100g cooked weight (51.8g/100g). Bone fractions for beef marketplace servings (p=0.002) ranged between 30g (short ribs) and 73.5g (prime ribs). However in terms of grams per 100g of the total cooked weight, t-bones had the lowest bone fraction per 100g of the total cooked weight (17.8g/100g) and shin bones had the highest fraction per 100g of the total cooked weight (30.9g/100g). T-bones also remained the leanest cut after subcutaneous fat has been trimmed in terms of it's meat to intramuscular fat ratio (68.7g/100g meat and 1.3g/100g intramuscular fat). Other beef cuts with a high meat to intramuscular fat ratio were blade steaks (63.5g/100g meat and 3.44/100g intramuscular fat) and shin bones (63.4g/100g meat and 3.81g/100g subcutaneous fat). As expected brisket chops had the highest intramuscular fat fraction per marketplace serving (47.7g) as well as in terms of grams per 100g cooked weighed (25.2g/100g).

Meat, bone, subcutaneous fat and intramuscular fat fractions for cooked lamb marketplace servings are presented in **Table 4.3**. Total cooked weighed for lamb marketplace servings (p<0.001) ranged between 38.3g (riblets) and 91.1g (chump chops). Lamb chump chops had the largest meat fraction (58.2g) per marketplace serving and riblets the smallest (21.3g).

Lamb knuckles had the highest meat to intramuscular fat ratio in terms of grams per 100g of the total cooked weight, with 74.3/100g meat and 2.18g/100g intramuscular fat. Knuckles also had the smallest subcutaneous fat fraction per marketplace serving as well as per 100g of total weight.

Rib chops had smallest meat to subcutaneous fat ratio yielding 32.6g/100g meat and 35g/100g subcutaneous fat. Rib chops also had the largest bone fraction per marketplace serving (24g) as well as in terms of bone per 100g of the total weight (32g/100g). However no intramuscular fat could be dissected from rib chop marketplace servings. The lamb marketplace serving with the highest amount of intramuscular fat, in terms of fraction weight (14.8g) and grams per 100g of cooked weighed (17.9g/100g), was loin chops.

The data presented in **Tables 4.1-4.3** shows the importance of asking a consumption study respondent what specific species' meat they ate but also which cut. For example "one piece of beef" can mean anything from a short rib with an average 96g edible portion or a prime rib with a 223g portion. Furthermore a "lamb chop" can be a "chump chop", a "loin chop" or a "rib chop" with meat fractions ranging from 24.2g per marketplace serving to 58.2g per marketplace serving and subcutaneous fat ranging from 10.2g to 26g **(Table 4.3)**. It is thus evident that generalisation and lack of product specific consumption information can lead to possible over- or underestimation of half of the meat and fat consumed. Field workers collecting consumption data should be trained to ask the respondent which species, cut and fractions they consumed. If the respondents cannot recall the name of the specific cut they can be asked to draw a simple picture, explain the shape of the bone in the cut or choose from a set of visual aids, such as photographs, to indicate what the cut looked like.

4.3.2 Yield factors for cooked marketplace servings of edible and lean edible portions of beef, chicken, lamb and lamb and mutton organ meats

Yield factors for the conversion from raw product weight to edible of beef, chicken and lamb marketplace servings are presented in **Table 4.4**. Yield factors for the conversion from raw product weight to edible portions of lamb and mutton organ meats are presented in **Table 4.5**. Yield factors facilitate conversions from raw to cooked products by taking into account weight changes due to loss of moisture (evaporation loss) and drip loss during cooking. Compiling food composition data is costly and, therefore, nutrient values for cooked foods are often unavailable or limited to values for uncooked foods. As a result many food databases as well as the private sector use cooking yields in the nutrient calculation process in order to have values for cooked foods in their databases (16). Similarly, in consumption studies, yield factors are used to calculate the actual quantity of cooked edible or lean edible portion that was consumed if the only available information that the respondent could give, was on the raw product as it was purchased.

In this study yield factors calculated for marketplace servings were compared to the yield factors for similar products published in the USDA Table of Cooking Yields for Meat and Poultry (16), where possible.

Table 4.1: Meat, bone and fat fractions of cooked chicken marketplace servings

		Total cooked weight	Meat		Bones		Subcutaneous fat + skin	
Cut:	*N*	*(g) (±SD)*	*per marketplace serving (g) (±SD)*	*g/100 of total cooked weight*	*per marketplace serving(g) (±SD)*	*g/100g of total cooked weight*	*per marketplace serving(g) (±SD)*	*g/100g of total cooked weight*
Breasts	6	152[a] *(±41.4)*	103 [a] *(±37.7)*	67.9	30.2 [a] *(±7.33)*	20.2	18.7 [a] *(±4.31)*	12.3
Drumsticks	6	71.9[b] *(±15.4)*	43.3[b] *(±10.5)*	60.2	20.2 [b] *(±4.54)*	28.2	8.38 [b] *(±2.00)*	11.7
Thighs	6	67.4 [b] *(±22.4)*	50.2 [b] *(±16.2)*	74.5	9.27 [c] *(±3.67)*	14.0	7.91 [b] *(±4.36)*	11.7
Wings	6	89.1 [b] *(±23.9)*	16.0 [c] *(±17.3)*	50.4	22.13 [b] *(±1.88)*	26.0	20.9 [a] *(±6.27)*	23.5
P-value		<0.001	<0.001	/	<0.001	/	<0.001	/

Note: Means with different superscripts in a column differ significantly

Table 4.2: Meat, bone and fat fractions of cooked beef marketplace servings

Cut:	*n*	Total Cooked Weight *(g) (±SD)*	Meat *per marketplace serving (g) (±SD)*	Meat *g/100 of total cooked weight*	Bones *per marketplace serving (g) (±SD)*	Bones *g/100 of total cooked weight*	Subcutaneous fat *per marketplace serving (g) (±SD)*	Subcutaneous fat *g/100 of total cooked weight*	Intramuscular fat *per marketplace serving (g) (±SD)*	Intramuscular fat *g/100 of total cooked weight*
T-bones	6	265[ab] *(±47.5)*	182[a] *(±35.8)*	68.7	47.2[ab] *(±12.0)*	17.8	32.3[a] *(±14.6)*	12.2	3.50[c] *(±4.18)*	1.32
Prime ribs	6	297[a] *(±66.3)*	173[a] *(±51.8)*	58.3	73.5[a] *(±19.1)*	24.8	17.0[ab] *(±6.72)*	5.72	33.2[ab] *(±12.6)*	11.2
Blade steaks	6	189[bc] *(±30.8)*	120[ab] *(±14.3)*	63.5	50.3[ab] *(±10.9)*	26.6	11.5[bc] *(±9.85)*	6.08	6.5[c] *(±6.61)*	3.44
Brisket chops	6	189[bc] *(±31.1)*	97.8[b] *(±34.9)*	51.8	43.7[ab] *(±16.1)*	23.1	n/a*	n/a*	47.7[a] *(±15.6)*	25.2
Short ribs	6	126[c] *(±56.6)*	73.3[b] *(±35.6)*	58.2	30.0[b] *(±21.9)*	23.8	7.30[bc] *(±3.67)*	5.79	14.8[bc] *(±2.32)*	11.8
Shin bones	6	175[bc] *(±32.2)*	111[ab] *(±31.8)*	63.4	54.0[ab] *(±8.46)*	30.9	4.17[bc] *(±4.67)*	2.38	6.67[c] *(±3.14)*	3.81
P-values		<0.001	<0.001	/	0.002	/	<0.001	/	<0.001	/

Note: Means with different superscripts in a column differ significantly

*fat trimmed prior to retail packaging

Table 4.3: Meat, bone and fat fractions of cooked lamb marketplace servings

		Total Cooked Weight	Meat		Bones		Subcutaneous fat		Intramuscular fat	
Cut:	*n*	*(g) (±SD)*	*per marketplace serving* ***(g)*** *(±SD)*	*g/100 of total cooked weight*	*per marketplace serving* ***(g)*** *(±SD)*	*g/100 of total cooked weight*	*per marketplace serving* ***(g)*** *(±SD)*	*g/100 of total cooked weight*	*per marketplace serving* ***(g)*** *(±SD)*	*g/100 of total cooked weight*
Chump chops	6	91.1^{a} *(±12.7)*	58.2^{a} *(±15.0)*	64.0	15.2^{ab} *(±5.27)*	16.7	10.2^{ab} *(±3.06)*	11.12	7.50^{abc} *(±6.66)*	8.24
Knuckles	6	53.7^{ab} *(±18.7)*	39.9^{ab} *(±18.7)*	74.3	10.3^{ab} *(±4.23)*	19.2	2.33^{b} *(±3.88)*	4.34	1.17^{bc} *(±2.86)*	2.18
Loin Chops	6	82.7^{a} *(±25.6)*	39.2^{ab} *(±12.1)*	47.4	5.67^{b} *(±2.58)*	6.86	23.0^{a} *(±15.1)*	27.9	14.8^{a} *(±4.12)*	17.9
Neck steaks	6	85.7^{a} *(±26.9)*	41.0^{ab} *(±20.3)*	47.8	20.2^{ab} *(±13.0)*	23.6	16.3^{ab} *(±12.1)*	19.0	8.17^{ab} *(±3.87)*	9.53
Riblets	6	38.3^{b} *(±8.9)*	21.3^{b} *(±5.6)*	55.6	8.33^{b} *(±5.75)*	21.8	4.00^{b} *(±3.29)*	10.4	4.67^{bc} *(±1.51)*	12.2
Rib chops	6	74.2^{ab} *(±18.8)*	24.2^{b} *(±4.8)*	32.6	24.0^{a} *(±8.53)*	32.4	26.0^{a} *(±9.06)*	35.0	n/a *n/a*	n/a
P-value		<0.001	<0.001	/	<0.001	/	<0.001	/	<0.001	/

Note: Means with different superscripts in a column differ significantly

*fat trimmed prior to retail packaging

Table 4.4: Yield factors for cooked beef, chicken and lamb marketplace servings

	Cut:	n	Total raw mass per marketplace serving	Edible portion (meat, subcutaneous and intramuscular fat): Cooked edible portion per marketplace serving*	Yield factor[$]	Cooking and trimming losses[L] per edible portion
			(g)	(g)	(%)	(%)
Beef	TBone	6	352	217	62	38
	Prime Rib	6	356	223	63	37
	Blade Steaks	6	249	138	55	45
	Brisket Chops	6	239	146	61	39
	Short Ribs	6	155	96.0	62	39
	Shin Bones	6	215	121	56	44
Chicken	Thighs	6	93.8	58.1	62	38
	Breasts	6	195	122	63	37
	Wings	6	107	67.1	63	37
	Drumstick	6	91.5	51.7	57	43
Lamb	Chump chops	6	93.1	75.8	81	19
	Knuckles	6	51.4	43.3	84	16
	Loin chops	6	90.6	77.0	85	15
	Neck steaks	6	96.1	65.5	68	32
	Riblets	6	65.0	30.0	46	54
	Rib chops	6	95.6	50.2	53	47

**Cooked edible portion per marketplace serving= meat+ intramuscular fat+ subcutaneous fat*

[$]Yield factors calculated as:

$$\frac{Cooked\ edible\ portion\ per\ marketplace\ serving}{Total\ raw\ mass\ per\ marketplace\ serving} \times 100$$

[T]Trimming and cooking losses calculated as:

$$\frac{Total\ raw\ mass\ per\ marketplace\ serving - Cooked\ edible\ portion\ per\ marketplace\ serving}{Total\ raw\ mass\ per\ marketplace\ serving} \times 100$$

[&]Subcutaneous fat was removed prior to retail packaging: edible portion= lean edible portion, or no distinction could be made between meat and subcutaneous fat

Table 4.5: Yield factors for edible portions of cooked lamb and mutton organ meats

				Edible portion (meat, subcutaneous and intramuscular fat)		
			Total raw mass per marketplace serving	Cooked edible portion per marketplace serving*	Yield factor[$]	Cooking and trimming losses[L] per edible portion
		n	(g)	(g)	(%)	(%)
Lamb Organs	Intestines	3	2 009	896	45	55
	Lungs	3	459	259	56	44
	Hearts	3	192	130	68	32
	Livers	3	696	583	84	16
	Stomachs	3	1 130	714	63	37
	Kidneys	3	52.1	28.6	55	45
	Spleen	3	72.0	42.5	56	41
	Tongue	3	94.2	70.0	75	26
Mutton Organs	Intestines	3	1 837	782	43	57
	Lungs	3	610	318	51	48
	Hearts	3	187	132	70	29
	Livers	3	624	477	76	24
	Stomachs	3	2 189	1 289	59	41
	Kidneys	3	80.0	29.1	36	64
	Spleen	3	109	65.0	59	40
	Tongue	3	92.0	56.9	62	38

**Cooked edible portion per marketplace serving= meat+ intramuscular fat+ subcutaneous fat*

^Cooked lean edible portion per marketplace serving= meat+ intramuscular fat

[$]Yield factors calculated as:

$$\frac{Cooked\ edible\ portion\ per\ marketplace\ serving}{Total\ raw\ mass\ per\ marketplace\ serving} \times 100$$

[T]Trimming and cooking losses calculated as:

$$\frac{Total\ raw\ mass\ per\ marketplace\ serving - Cooked\ edible\ portion\ per\ marketplace\ serving}{Total\ raw\ mass\ per\ marketplace\ serving} \times 100$$

[&]Subcutaneous fat was removed prior to retail packaging: edible portion= lean edible portion, or no distinction could be made between meat and subcutaneous fat

Edible portions for beef marketplace servings include meat, intramuscular fat and subcutaneous fat (**Table 4.4**). Beef prime ribs had the largest edible portion (217g) of all the beef marketplace servings, and remained the largest after trimmed of subcutaneous fat (lean edible portion). Yield factors for edible portions (including meat, intramuscular fat and subcutaneous fat) of beef marketplace servings are presented in **Table 4.4** and ranged between 55% (blade steaks) and 63% (prime rib). The yield factor for lean beef brisket in the USDA database was 69%. Yield factors reported on in the USDA tables for "separable lean" (trimmed of subcutaneous fat) beef retail cuts cooked with a dry heat method (roasting, broiling, grilling) to internal temperatures between 60°C and 65°C, ranged between 68% and 86%. Although this is a basic comparison, it is still evident that yield factors for beef retail cuts in the USDA database (17) are higher than those found in this study on South African beef retail cuts cooked with dry heat. This might be due to many variables such as the lower internal temperature that the marketplace servings were cooked to. Regardless the reason for these higher yields, the great variation in the two countries' data reveals the importance of having country specific data to avoid overestimation in nutrient composition calculations, as well as in food consumption studies.

Yield factors for chicken marketplace servings cooked to an internal temperature of 75°C (edible portion with skin) as presented in **Table 4.4** ranged between 57% (drumsticks) and 63% (breast and wings), with chicken thighs having a yield factor of 62%. Yield factors for chicken marketplace servings, with skin, cooked with dry heat to an internal temperature of 71°C, reported on in the USDA database were between 69% (thighs) and 76% (drumsticks), with a yield factor of 72% for chicken breasts and 74% for chicken wings (17). It is evident that yield factors for chicken marketplace servings in the USDA database are higher for each chicken marketplace serving than those reported on in this South African study, with the biggest difference being between chicken drumsticks in the respective databases being 76% in the USDA database but only 57% in this study. This can be due to different breeding practices that influence carcass composition or the difference in internal temperature of the cooked samples but once again this proves the importance of having country specific yield factors for chicken marketplace servings.

Edible portions for lamb marketplace servings ranged between 30g (riblets) and 75.8g (chump chops). Yield factors for the edible portions of lamb marketplace servings presented in **Table 4.4** ranged between 46% (lamb riblets) and 85% (loin chops). There were fewer values and information for lamb marketplace servings included in the *USDA Table of Cooking Yields for Meat and Poultry* than the amount of beef and chicken marketplace servings included in the tables. The only comparable lamb data included in the tables was an average yield factor for “lamb roasts” and “lamb retail cuts” cooked with dry heat cooking methods. The reported average yield factor for these roasted/ baked cuts was 74% with values ranging between a minimum yield factor of 53% and a maximum yield factor of 88%. There was no mention whether these yield factors were for the entire edible portion of the cuts or the lean edible portions. However these if the yield factors were for cooked edible portions (meat, intramuscular fat and subcutaneous fat) the values are very comparable to the values found in this study.

Yield factors for lamb and mutton organ meats are presented in **Table 4.5.** In the case of lamb organ meats, the intestines had the lowest yield factor (45%). Lamb livers had the highest yield factor, namely 84%. The same was found amongst mutton organ meats with liver having the highest yield factor (76%) while the kidneys had the lowest yield factor (36%). The USDA tables have various values for beef by-products and tripe cooked with moist cooking methods, but no information on lamb or mutton organ meats. Yield factors for beef “by products” and “tripe” ranged between 53% (beef kidneys) and 85% (beef brain) showing a wide variation between different market place servings similar to what was found in lamb and mutton organ meats. However despite the difference in species and cooking method the yield factor for beef liver in the USD database and mutton liver in this study was very similar being 73% and 76% respectively.

4.4 Conclusion

Unique quantitative data presented in this article included physical composition data in terms of meat, bones, subcutaneous fat and intramuscular fat as well as edible portions, lean edible portions yield factors and cooking losses for chicken, beef and lamb retail cuts. These datasets will aid in collecting more accurate ASFs consumption data without expecting the respondents to be able to report on their consumption in terms of grams. Although this dataset will ease the collection of ASFs consumption data, field workers need to be trained to ask the right questions regarding the ASFs product consumed. It is of utmost importance that the respondent specifies the specific marketplace serving (retail portion) consumed instead of only naming the species consumed. Generalisation can lead to over- or underestimating on the consumption of ASFs. The differences in yield factors found between those in the USDA tables and the yield factors in this South African study prove the importance of determining country specific yield factors.

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CHAPTER 5: TRANSLATING "MEAT AND MEAT SUBSTITUTES" EXCHANGES INTO BEEF, LAMB, CHICKEN AND PROCESSED MEAT MARKETPLACE SERVINGS

The data generated and presented in the previous chapter of this thesis can be used both to accurately asses dietary intake in food consumption studies and to refine consumption recommendations for animal source foods. This article translates recommendations based on The Diabetic Exchange Lists, used by some South African Dietitians, into data for animal source foods marketplace servings as presented in Chapter 4. This article will be submitted to the South African Journal of Clinical Nutrition, and is presented in the format required by the journal.

Abstract

Background: The important role of high quality protein foods, such as animal source foods (ASFs), as nutrient dense food commodities in diets around the world cannot be denied. To balance the benefits and risks of consuming ASFs, consumption guidelines must be defined, and also communicated to consumers, in an easily understandable and practical manner.

Objective: The objective of this study was to translate "Meat and Meat Substitutes" exchanges based on "The Exchange List System for Diabetic Meal Planning" into marketplace servings (cooked edible portion serving sizes) of different ASFs available to South African consumers.

Design: To translate recommendations for "Meat and Meat Substitutes" exchanges, physical composition data for various chicken, beef, lamb and processed meat marketplace servings were compiled and presented in this study together with secondary data regarding the nutritional composition of these ASFs, obtained from various recent South African food consumption studies and the South African Medical Research Council's (MRC) "Condensed Food Composition Tables for South Africa".

Subjects and setting: Six samples of each selected chicken, beef, lamb and processed meat marketplace serving were used to determine average cooked edible portions.

Results: According to "The Exchange List System for Diabetic Meal Planning", one "meat and meat substitutes" exchange contain 7g protein. Beef marketplace servings included in this study ranged between 4 (short ribs) and 9 (t-bones) exchanges per marketplace serving. Lamb marketplace servings ranged between 1 (riblets) and 3 (chump chops and loin chops) exchanges per marketplace serving. Chicken marketplace servings ranged between 1 (wings) and 5 (breasts) exchanges per marketplace serving. Family sized processed meat marketplace servings ranged between 9 (chopped ham roll) and 20 (mini picnic ham) exchanges with the rest of the processed meat marketplace servings all amounting to a single exchange. The fat classifications which form part of this exchange system very lean, lean, medium fat and high fat meat and meat substitutes varied for different ASFs marketplace servings and were calculated and presented together with the amount of exchanges in this study.

Conclusion: This study provided a new, unique dataset that can be utilised by South African health professionals who use "The Diabetic Exchange System" to make product specific serving size recommendations for meat and meat substitutes.

Keywords: Animal source foods; dietary recommendations; consumption guidelines; food composition

5.1 Introduction and Justification for the Study

There is currently a growing body of conflicting literature on the role of ASFs in human health. What cannot be denied is that animal source foods are nutrient dense food commodities contributing critical nutrients of concern in diets of many people around the world (1,2). Red meat, which is particularly high in heme iron and zinc has, according to Binnie *et al* (3), been unnecessarily restricted in diets and this may have unintended health consequences. Binnie *et al* also suggest that there is a great need for a paradigm shift in dietary advice when it comes to red meat consumption (3).

Compiling consumption recommendations for animal source foods, that are consumer friendly and understandable, is not as simple as quantifying them in terms of household measurements, grams or ounces. Meat and meat substitutes often consist of more than just meat, with bone, cartilage, skin and fat also contributing to the total weight. For example, it is challenging for consumers to estimate a prescribed recommendation of 30g cooked muscle meat from products such as a chicken wing, lamb rib chop or a beef t-bone which are usually served as entire units containing bone, fat and meat fractions.

The purpose of this study was to develop a new, science based, product specific resource in the form of a reference database/list which health professionals and policy makers can use in conjunction with their current “exchanges system”. This database can be used in dietary planning and also to communicate existing consumption recommendations specifically regarding recommended serving sizes for different animal source foods, in a practical manner. The physical composition (edible portions), of fresh beef, chicken and lamb marketplace servings was determined in this study. The edible portion weights of processed meat products were obtained from product labels. Secondary data for the nutritional composition of fresh beef, chicken and lamb meat was used in this study, obtained from various recent South African food composition studies and the South African Medical Research Counsel’s (MRC) Condensed Food Composition Tables for South Africa (4). The nutrient composition of selected processed meats was obtained from product labels. The process of compiling this database, the results and application thereof are presented and discussed in this article.

Defining portion sizes, servings and marketplace servings

After an extensive literature investigation on the topic of portion sizes it became evident that the terms “portion size” and “serving size” are often used interchangeably in popular articles and consumer communication. However these two terms have different meanings and should be defined clearly when used in scientific research.

The quantity of a certain food product consumed in one sitting can be defined as a "portion size". Portion sizes are determined by individual discretion and is therefore the amount of food a person serves (and choose to consume) themselves (3). Portion sizes consumed are often one of the biggest challenges in food consumption studies. The portion sizes that are actually consumed are often among the biggest challenges researchers encounter in food consumption studies.

“Serving sizes” are actual quantified recommendations for the consumption of a certain food product (5). Serving sizes are usually prescribed by health professionals based on official systems such as the “USDA Food Guide Pyramid” (6) “The Food Exchange Lists System for Diabetic Meal Planning” (7) and the “National Food-based dietary guidelines for South Africans” (8), and even on some food labels. The terms “serving sizes” are therefore also used together with “number of servings” in dietary planning (6).

“Marketplace servings”, “Retail servings”, “Marketplace portions” and “Retail Portions” are all synonyms and also important terms that must be defined for the purpose of this study. It was observed that these terms are used interchangeably but have the same definition; it is the physical product size as it is available on retail level (“in the market”) to the consumer (9,10). The term “Marketplace servings” will be used in conjunction with this definition in this article. Examples of animal source foods (ASF) marketplace servings available in South Africa include chicken wings; [lamb rib chops and beef t-bones also known as “secondary meat cuts”.

It is important to understand that the suggested/recommended serving size indicated on a label or specified in a dietary recommendation does not necessarily reflect the actual portion size consumed by the individual, which also does not necessarily equal the marketplace serving (11,12,13). Manore and Vannoy (2004) used the simple example of a carbonated soda drink consumed by an individual to explain the difference between these terms. The soda drink **marketplace serving** equalled 2 litres. However the individual consumed a **portion size** of 1 litre while the maximum recommended **serving size** as indicated on the product label was 250ml.

Correspondence with different individual Registered Dietitians (RDs) in the country indicated that South African RDs are taught to base their calculations for prescribed diets on a system called “The Exchange List System for Diabetic Meal Planning” (7). In this study marketplace servings of fresh beef, chicken and lamb will be translated into the system used by dietitians to plan prescribed diets called the “The Food Exchange Lists” System for Diabetic Meal Planning” (7) . According to these lists, one “Meat and Meat substitutes” exchange contains a minimum of 7g protein. Furthermore this category is grouped into four groups **(Table 5.1)** according to total fat content "very lean"; "lean"; "medium fat" and "high fat". Calculations for exchanges will be discussed in the methodology section of this chapter.

Table 5.1: The Food Exchange List System for Diabetic Meal Planning: Meat and Meat Substitutes (5)

	Protein (g)	Fat (g)
Very Lean	7	between 0 and 1
Lean	7	max 3
Medium Fat	7	max 5
High Fat	7	max 8

5.2 Materials and Methods

5.2.1 Meat and Meat Substitutes Exchanges Survey

To verify the application of specifically the "Meat and Meat Substitutes" group exchange lists, a short survey was conducted amongst South African dietitians. The survey was compiled on Survey Monkey*, on the "Select" package which includes statistical feedback which was exported into Excel. The survey was distributed via the Association for Dietetics in South Africa (ADSA) newsletter, "The ADSA Newsflash" in May 2015 and correspondents were given until the end of June 2015 to complete the survey. The survey was further also distributed through email correspondence with individuals as well as on a closed social media group for dietitians where their status as registered dietitians is verified by the group administrators. In this survey, dietitians were ask to specify the amount of protein, in grams, that one exchange "Meat and Meat Substitutes" must contain, as well as the amount of total fat and kilojoule content per exchange. This was an open-ended question. The majority of participants (78%) indicated that one "Meat and Meat Substitutes" exchange should contain 7g of protein, thus confirming that the majority of the group uses "The Exchange Lists System for Diabetic Meal Planning" to determine portion sizes in prescribed eating plans. The remaining 22% of respondents did not answer the question.

**Survey Monkey- A free online survey tool available at https://www.surveymonkey.com/*

5.2.2 Sampling of fresh chicken, beef and lamb marketplace servings

The types of fresh chicken, beef and lamb marketplace servings selected for the study were guided by the results of a survey commissioned by Red Meat Research and Development South Africa (RMRD SA) to investigate the perception of South African consumers in relation to red meat (14). Samples of different retail cuts of chicken (breasts, thighs, wings and drumsticks); beef (brisket chops, blade steaks, prime ribs, shin bones, short ribs and t-bones) and lamb (chump chops, knuckles, loin chops, neck steaks, riblets and rib chops) were procured through convenience sampling from four different, multinational, commercial retailers in Gauteng, South Africa. Six samples of each were cooked to determine the final edible portions of each marketplace serving.

5.2.3 Sampling of processed meat products

Processed meat products available from four major South African food retail chains were sampled on retail level in Pretoria, Gauteng. Inclusion criteria for processed meat products in this study were as follows:

- The specific products had to be listed and available from all four major retail chains that stock different brands of processed meats in addition to their own house brand (Shoprite, Checkers, Spar and Pick 'n Pay) in Gauteng
- The products had to fall within the definition for "processed meat" according to SANS885 (15) as defined in **Table 5.3**
- The product had to fall within the definition for "ready to eat" (RTE) as per SANS885 (13) and therefore need no further cooking (defined in **Table 5.3**)

5.2.4 Preparation of cooked chicken, beef and lamb marketplace servings

Sample preparation and cooking of fresh meat cuts for this study took place in the Experimental Laboratory at the Department of Consumer Science at the University of Pretoria. For this study each meat marketplace serving was placed in its own small disposable aluminium oven pan and covered securely with aluminium foil to retain as many nutrients as possible. No liquids were added and the meat cooked in its own fat, therefore this is regarded as a dry heat cooking method similar to baking or roasting where the only possible cooking losses occur by means of evaporation through the foil containers and covers. The covered foil pans were placed on the middle oven racks of the AEG competence ovens which are installed in the experimental laboratory. A convection oven setting of 160°C was used for the cooking process. These ovens are maintained and calibrated for scientific use. Organ meats were left to cook to an internal temperature of 75°C, beef and lamb cuts to 70°C (medium), and chicken to 75°C (16). Samples were weighed before and after cooking to obtain cooking data to further calculate yield factors. Cooked samples were dissected into edible and inedible fractions and weighed.

Physical composition and edible portions of food products are best determined by means of physical dissection (17). In this study cooked samples were dissected into bone, meat, intramuscular fat and subcutaneous fat fractions. The respective fractions were weighed to determine the edible portion (muscle meat+ intramuscular fat+ subcutaneous fat).

5.2.5 Nutrient content of fresh beef, chicken and lamb marketplace servings

To translate "Meat and Meat Substitutes" exchanges into beef, chicken and lamb marketplace servings, nutrient composition data, which had been compiled in this study, had to be used together with physical composition data. The sources of local nutrient composition data of ~~on~~ primary cuts, which were used in this study to calculate the nutrient contents of different marketplace servings, are shown in **Table 5.2**.

The nutrient composition data of primary beef cuts which was used in this study was compiled by Schönfeldt *et al.* (18) and it is also the data for cooked beef primary cuts currently included in The Condensed Food Composition Tables of South Africa (2). These primary cuts included the loin, rib, chuck, brisket, rib and shin. A beef t-bone marketplace serving is a secondary cut from the primary "Beef Loin" cut (18). Therefore the nutrient composition data for beef loin was used to calculate the number of "Meat and Meat Substitutes" exchanges that equal a beef t-bone. Nutrient composition data for the primary cut "Beef Prime Rib" was used for beef prime ribs and short ribs. Nutrient composition data for "Beef Brisket" was used for brisket chops marketplace servings and "Beef Shin" nutrient composition data was used for shin bones marketplace servings. Blade steaks are cut from the primary cut "Beef Chuck" (19) and therefore the nutrient composition data for "Beef Chuck" was used for blade steaks marketplace servings.

Nutrient composition data for South African lamb compiled by Schönfeldt *et al.* (20), was used in this study to translate "Meat and Meat Substitutes" exchanges into lamb marketplace servings. Lamb loin chops, rib chops and riblets are secondary cuts from the primary cut "Lamb Loin" (20). The nutrient composition data compiled by Schönfeldt *et al.* (20) for lamb loin was used to calculate the nutrient content of these secondary cuts. Chump chops and knuckles are cut from the primary leg cut (17) and therefore the data for the lamb leg primary cut compiled by Schönfeldt *et al* (18) was used. Neck chops are cut from the lamb shoulder primary cut (17) and therefore lamb shoulder nutrient composition data from the same study published by Schönfeldt *et al* (18) was used for neck chop marketplace servings.

The nutrient composition data used in this study for chicken marketplace servings was compiled by Van Heerden *et al*. (21). This data was also included in the MRC's Condensed Food Composition Tables for South Africa (4). Nutrient composition data for white chicken meat cooked (roasted) was used for chicken wings and chicken breasts. Nutrient composition data for dark chicken meat (roasted) was used for chicken thighs and drumsticks.

5.2.6 Nutrient content of processed meat products

The composition of processed meats, the methods used to determine nutritional composition and adherence to strict definitions for different product categories is governed by SANS 885 (15) and compliance is regulated through random sampling by a third party organisation on retail level. The general manager of the South African Meat Processors Association (SAMPA) confirmed this in personal correspondence (22). Some relevant terminology used on the labels of processed meat products' nutrient content tables and ingredient lists, as defined by SANS 885 (15), is summarised in **Table 5.3**. The nutrient composition as shown on product labels was used to translate "Meat and Meat Substitutes" exchanges into various processed meat products marketplace servings. Personal correspondence with the respective companies' quality controllers and confidential information relating to third party laboratory analysis of the products confirmed that the processed meat products selected in the study brand are subjected to routine compositional analysis and whenever protocols or labels are changed.

5.2.7 Meat and meat substitute s exchanges calculations

Protein, as well as fat, are the two main nutrients used in calculations to determine the number of "Meat and Meat Substitutes" exchanges per marketplace serving. The calculations for the number of exchanges per marketplace serving of beef, lamb, chicken and processed meats are firstly based on the protein content of one marketplace serving, with 7g of protein being equal to one exchange. Thereafter, based on the number of exchanges calculated from the protein content, a "fat classification" as summarized in **Table 5.1** can be specified. As an example, the calculation is broken down into steps below using data for a beef t-bone as shown in **Table 5.4**:

- One beef t-bone yields **218g cooked edible portion per marketplace serving** (**Table 5.4**)
- A t-bone is cut from the beef loin primary cut which contains **29g protein per 100g** cooked edible portion (16)
- Therefore the protein content of one cooked t-bone marketplace serving was calculated as follows:

  $\frac{29}{100} \times 218 = 63.2$**g protein per marketplace serving**
- To further determine the number of exchanges per marketplace serving, the protein content of one marketplace serving was divided by 7 (1 exchange contains 7g protein):

  $\frac{63.2}{7} = 9$ **exchanges**
- To determine the fat classification per exchange as shown in **Table 5.1,** the fat content per marketplace serving was calculated in the same manner as protein per marketplace serving, using the values for fat per 100g [space?] cooked edible portion of the primary cut, which in this case was beef loin:

  $\frac{16.6}{100} \times 218 = 36.2$**g fat per marketplace serving**
- Die amount of fat per marketplace serving was then divided by the amount of exchanges calculated above to determine die amount of fat per exchange:

  $\frac{36.2}{9} = 4$**g fat per exchange**

- A classification (very lean, lean, medium fat or high fat) is then given as shown in **Table 5.1 Therefore one beef T-bone equals 9 "medium fat meat and meat substitute exchanges"**

Table 5.5 shows ~~is~~ the physical (edible portion) and nutritional content of selected, ready to eat, processed meat products marketplace servings, translated into "Meat and Meat Substitutes" exchanges according to the "The Exchange Lists System for Diabetic Meal Planning". To take the new salt reduction regulations (effective from 1 July 2016) into consideration, the sodium content per marketplace serving was also calculated and these results are presented in **Table 5.5.** The number of exchanges and fat classification per marketplace serving were calculated in the same way as fresh beef, lamb and chicken marketplace servings shown in **Table 5.4**.

The picnic ham and chopped ham of both brands which were included in the study, were only sold in a block or roll, referred to in **Table 5.5** as "family size", weighing 500g (chopped ham, brand 1 and brand 2); 750g (picnic ham, brand 2) and 1 000g (picnic ham, brand 1), therefore resulting in high numbers of "Meat and Meat Substitutes" exchanges as presented in **Table 5.5.** Regardless of the high number of exchanges per marketplace serving, picnic ham from both brands could be classified as "lean fat" exchanges, which contained more protein than fat per marketplace serving. Both brands of red Viennas and smoked Viennas equalled one medium fat exchange per marketplace serving, with the sodium content of these products ranging between 450mg (red Viennas, brand 2) and 507mg (smoked Viennas, brand 2) per marketplace serving. Both brands of cheese grillers, Frankfurters, chopped ham, French polony, russians and chicken Viennas, equalled one high fat exchange per marketplace serving.

Table 5.2: Summary of primary meat cuts data used to calculate nutritional content of marketplace servings

	Marketplace Serving	*Primary Cut**	*Reference*
Beef	**T-bone**	Loin	Schönfeldt, Naudé and Boshoff (2010)
	Prime rib	Prime Rib	
	Blade steak	Chuck	
	Brisket chop	Brisket	
	Short rib	Prime Rib	
	Shin bone	Shin	
Lamb	**Chump chop**	Leg	Schönfeldt, Van Heerden, Sainsbury and Gibson (2011)
	Knuckle	Leg	
	Loin Chop	Loin	
	Neck Steak	Shoulder	
	Riblet	Loin	
	Rib chop	Loin	
Chicken	**Breast**	White Meat	Van Heerden, Schönfeldt, Smith and Jansen van Rensburg (2002)
	Drumstick	Brown Meat	
	Thigh	Brown Meat	
	Wing	White Meat	

Table 5.3: Terminology used for processed meat products as defined in SANS885

	Definitions (13)
Cured product	Product with added curing agents (nitrates)
Fat	Edible lipids from animal or plant origin or combinations thereof
Heat treated product	A pasteurized product or product that has been subjected to a heat treatment which results in a core temperature of at least 72°C during processing for the appropriate time
Meat	Sound skeletal musculature (excluding the lips, snout, scalp and ears), of healthy food animals, with or without connective tissue, blood vessels, lymphatic and nerve tissue, bone, fat, cartilage, pork rinds and defeathered skin, that are naturally associated with such musculature in the dressed carcass and head and should be qualified by species.
Processed meat	Meat that has undergone any action that substantially altered its original state including, but not limited to, heating, smoking, curing, fermenting, maturing, drying, marinating (surface application), extraction or extrusion or any combination of all these processes.
Ready-to-eat product (RTE)	Food which is normally consumed in its raw state or any food handled, processed, mixed, cooked, or otherwise prepared into a form in which it is normally consumed without further processing

Table 5.4: Beef, lamb and chicken marketplace servings translated into meat and meat substitutes exchanges

		n	*Total raw mass per marketplace serving (g)*	*Edible portion per cooked marketplace serving (g)*	*Protein per cooked marketplace serving* (g)*	*Protein* (g/100g)*	*Fat per cooked marketplace serving* (g)*	*Fat* (g/100g)*	*"Number of "Meat and Meat Substitutes" exchanges[&] and fat classification^ per marketplace serving*
Beef	**T-bone**	6	352	218	63.2	29.0	36.2	16.6	9 exchanges, medium fat
	Prime rib	6	356	223	61.2	27.4	40.6	18.2	9 exchanges, medium fat
	Blade steak	6	249	153	41.0	26.8	23.1	15.1	6 exchanges, medium fat
	Brisket chop	6	239	169	37.3	22.1	47.9	28.4	5 exchanges, high fat
	Short rib	6	155	112	30.7	27.4	20.4	18.2	4 exchanges, medium fat
	Shin bone	6	215	122	35.2	28.9	17.4	14.3	5 exchanges, lean fat
Lamb	**Chump chop**	6	93.1	75.9	17.5	23.1	7.48	9.86	3 exchanges, lean fat
	Knuckle	6	51.4	43.4	10.6	24.5	3.33	7.67	2 exchanges, lean fat
	Loin Chop	6	90.6	79.0	22.0	27.8	6.16	7.80	3 exchanges, lean fat
	Neck Steak	6	96.1	65.4	15.1	23.1	6.46	9.86	2 exchanges, lean fat
	Riblet	6	65.0	30.0	8.30	27.8	2.34	7.80	1 exchange, lean fat
	Rib chop	6	95.6	50.2	14.0	27.8	3.92	7.80	2 exchanges, lean fat
Chicken	**Breast**	6	195	122	35.8	29.4	4.38	3.60	5 exchanges, very lean fat
	Drumstick	6	91.5	51.7	13.2	25.1	5.06	9.80	2 exchanges, lean fat
	Thigh	6	93.8	58.1	14.8	25.1	5.69	9.80	2 exchanges, lean fat
	Wing	6	107	36.9	10.8	29.4	1.33	3.60	1 exchange, lean fat

[&] Calculated on protein content: 1 Meat and Meat Substitutes exchange= 7g (rounded up to the next number if protein content > 50% of 7g; rounded down if protein content < than 50% of 7g)
^ Refer to **Table 5.1** for Meat and Meat Substitutes fat classifications
*Data obtained from the Condensed Food Composition Tables for South Africa (4) based on the primary cut from which the specific marketplace serving was cut

Table 5.5: Beef, lamb and chicken marketplace servings translated into meat and meat substitutes exchanges

	Edible portion per marketplace serving (g)	*Protein per marketplace serving (g)*	***Protein (g/100g)***	*Fat per marketplace serving (g)*	***Fat* (g/100g)***	*Sodium per marketplace serving (mg)*	*Sodium (g/100g)*	*"Number of "Meat and Meat Substitutes"[?] exchanges[&] and fat classification^ per marketplace serving*
Cheese Griller, Traditional, Brand 1	42.0	7.30	17.4	6.10	14.5	521	1 241	1 exchange, high fat
Cheese Griller, Traditional, Brand 2	50.0	9.10	18.2	9.50	19.0	454	908	1 exchange, high fat
Frankfurter, Traditional, Brand 1	63.0	9.10	14.4	6.60	10.5	718	1 140	1 exchange, high fat
Frankfurter, Traditional, Brand 2	62.5	8.60	13.8	6.10	9.80	514	822	1 exchange, high fat
Polony, French, Lunchbox, Brand 1	80.0	9.60	12.0	7.50	9.40	816	1 020	1 exchange, high fat
Polony, French, Lunchbox, Brand 2	80.0	10.4	13.0	6.40	8.00	880	1 100	1 exchange, high fat
Russians, Smoked, Brand 1	62.0	8.70	14.0	10.4	16.8	472	761	1 exchange, high fat
Russians, Smoked, Brand 2	62.5	9.80	15.7	6.20	9.90	544	870	1 exchange, high fat
Viennas, Chicken, Brand 1	42.0	4.80	11.4	5.30	12.6	378	900	1 exchange, high fat
Viennas, Chicken, Brand 2	41.7	5.70	13.7	7.50	18.0	389	933	1 exchange, high fat
Viennas, Red, Brand 1	42.0	5.80	13.8	3.40	8.10	483	1 150	1 exchange, medium fat
Viennas, Red, Brand 2	41.7	6.80	16.3	3.10	7.40	450	1 080	1 exchange, medium fat
Viennas, Smoked, Brand 1	42.0	6.00	14.3	4.40	10.5	479	1 141	1 exchange, medium fat
Viennas, Smoked, Brand 2	41.7	5.70	13.7	4.00	9.60	507	1 216	1 exchange, medium fat
*Ham, Chopped Roll, Brand 1	500*	79.5	15.9	38.0	7.60	4 830	966	11 exchanges, high fat
*Ham, Chopped Roll, Brand 2	500*	65.0	13.0	70.0	14.0	6 200	1240	9 exchanges, high fat
*Ham, Mini Picnic Block, Brand 1	1000*	146	14.6	43.0	4.30	5 000	500	20 exchanges, lean fat
*Ham, Mini Picnic Block, Brand 2	750*	104	13.9	37.5	5.00	1 875	250	14 exchanges, lean fat

[&] Calculated on protein content: 1 Meat and Meat Substitutes exchange= 7g (rounded up to the next number if protein content > 50% of 7g; rounded down of protein content < than 50% of 7g)

^ Refer to **Table 5.1** for Meat and Meat Substitutes fat classifications

*A marketplace serving equalled one unit of the product; for example: one Vienna or one polony

Consumption of high quality proteins is crucial to human health throughout all the stages of life and recommendations regarding protein consumption should be followed as strictly as possible to keep up with the specific physiological needs of each life stage. This was the main focus at the International Meat Secretariat's (IMS) Symposium on Protein Requirements for optimal health throughout all life stages in Granada in September 2013 (23). There was consensus, in general, that it is ideal to consume 25g-30g of protein three times a day. This recommendation translates into 3-4 "Meat and Meat Substitutes" exchanges three times a day.

5.3 Conclusion and Recommendations

Although the salt content of the samples was not part of this study, salt levels in processed meats are often a concern for health professionals. In South Africa, salt levels in commercially processed meats are strictly regulated by SAMPA. There is currently also an Inter-laboratory salt analysis test for processed meats underway to ensure accurate testing of sodium levels in view of the fact that new regulations limit sodium content in processed meat to 1 300mg per 100g. The 1 300mg limit is an amendment which was made after the industry and stakeholders submitted motivations to the Department of Health explaining that lower levels of sodium in processed meats are not sufficient to ensure preservation (24).

This study found that ASFs are nutrient-dense food commodities which, even when consumed in small quantities can still make significant contributions to the daily nutrient intake of the population. In many cases a single marketplace serving provided the daily recommended amount of ASFs that should, if possible, be consumed to ensure adequate intakes of essential nutrients.

It is therefore important that recommendations regarding the amounts and types of ASFs consumed must be refined and product specific to prevent under or over consumption of ASFs. This study generated a resource that can be used by health professionals and policy makers in dietary planning to make more refined, product specific, dietary recommendations that are easily-understood by consumers, available.

5.4 Limitations of the study

The survey which was done to verify the use of the exchange lists system was limited to dietitians who received and read the ADSA North Gauteng branch newsletter. It would be advisable to repeat the survey and also to discuss the exchange system at continuing professional development seminars to determine if the proposed system can be used consistently. This study relied on nutrient composition data for processed meat products as indicated on the labels and verified through personal correspondence with the food technologists responsible for the two brands selected. Although conducts regular independent compositional tests, further independent laboratory testing and statistical analysis of the nutrient content of these products should be done to verify the nutrient values indicated on their labels.

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CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

This chapter serves as a conclusion to the thesis.

6.1 Overview of the study

Protein is a crucial nutrient for optimal human health throughout all life stages. Consumption recommendations for high quality protein foods such as animal source foods (ASFs) are of utmost importance and should be adhered to, to keep up with the specific physiological demands of each life stage. This was the main focus at the International Meat Secretariat's (IMS) *Symposium on Protein Requirements for Optimal Health Throughout all Life Stages* in Granada in September 2013 (International Meat Secretariat, 2013) and remains an important topic of discussion in the international nutrition and health arena. It is therefore important to understand the different ASFs that are available for human consumption in a country, their affordability and the potential contribution these ASFs can make to nutrients of concern amongst the general population.

The study was focussed around four scientific papers, each with its own set of objectives to obtain a better understanding of the physical and nutrient composition, as well as the potential nutritional contribution of ASFs, when used in the correct amounts, to South African diets.

The objective of the first scientific paper produced by this study (**Chapter 2**) was to investigate the relevance of the current Food-Based Dietary Guidelines for South Africans. Special emphasis was placed on guidelines relating to ASFs, particularly the cost associated with eating according to the guidelines and the relevance of the guidelines to food- and nutrition security. The study concluded that the first step in defining future nutrition policies and guidelines should be to assess existing national plans and policies in the light of overall objectives, i.e. to improve food and nutrition security. Furthermore it was found that the feasibility for nutritionally vulnerable individuals in South Africa to adhere to the current set of FBDGs and recommended diets seems unlikely. The dire economic climate which South Africans, particularly those of low socio economic status, currently have to face, is probably the main reason for the problem that nutritionally vulnerable individuals cannot meet the recommendations of the Food-based Dietary Guidelines for South Africans.

Organ meats (offal) have been overlooked in the past in dietary guidelines and recommendations, irrespective of their potential contribution to food and nutrition security in South Africa. Limited information is available on the composition of South African lamb and mutton organ meats as cooked and consumed at home. Lamb and mutton intestines, stomachs, heart, lungs, tongues, spleens, kidneys and livers were analysed as described in **Chapter 3**. Based on the results of the analyses, South African lamb and mutton offal can be considered a good source of protein and a nutrient dense food. In view of the current disturbing state of nutrition in South Africa, as well as efforts to reduce food waste, lamb and mutton organ meats were found to be important food commodities and it was suggested that the promotion of offal should be prioritised.

Quantitative food data goes hand in hand with the nutrient composition tables used in a given country, because it provides supporting information on the food items included in the nutrient composition tables. Good quality nutrient composition and quantitative food data play an integral role in reporting the nutrient intake of a population, as well as interpreting results of certain epidemiological research (EuroFIR, 2005). A new set of quantitative data on the physical composition (meat, bone and fat fractions) and yield of different ASF marketplace servings was generated to assist researchers in collecting more precise, product specific data to measure nutrient exposure provided by ASFs in South African food consumption studies (**Chapter 4**). The significant differences between yield factors for different marketplace servings which were identified in this chapter also proved how easily over- and under- estimations of nutrient intake can occur in a consumption study if product specific physical composition data is unavailable.

Quantitative data on the physical composition (edible portions) which was generated in **Chapter 4** was subsequently used in **Chapter 5** to yield a product specific resource in the form of a reference database/list for health professionals and policy makers. It was envisaged that health professionals and policy makers will be able to use this reference database/list in dietary planning and to communicate their existing consumption recommendations regarding prescribed serving sizes for different animal source foods in a practical manner. For example how many “meat and meat substitutes” exchanges according to the “The Exchange list system for diabetic meal planning” as used by dietitians for dietary planning, does one specific marketplace serving of beef, lamb, chicken or processed meat product amount to?

6.2 Limitations of the study

The first published articled in this thesis (**Chapter 2)** which determined the relevance of Food-Based Dietary Guidelines to food and nutrition security in South Africa was based on food prices which were applicable in 2012 and 2013. It would be advisable to update this study using current 2016 food prices, so that the ongoing drought that has a negative effect on food prices, could also be taken into account.

Due to financial constraints it was only possible to analyse three raw samples and three cooked samples, of each organ meat as reported in the article on the nutrient content of South African lamb and mutton organ meats **(Chapter 3)**. It was also suggested by peer reviewers during the review process of the article for the Journal of Food Chemistry that amino acid and fatty acid analyses should have been done for this study. Unfortunately small sample sizes and funding limitations made this impossible for the purpose of this thesis.

The survey which was done for the article translating “Meat and Meat substitutes” exchanges into beef, lamb, chicken and processed meat marketplace servings” (**Chapter 5),** to verify the use of the “The Exchange list system for diabetic meal planning” was limited to dietitians who received and read the newsletter of the Gauteng-North branch of the Association for Dietetics in South Africa. It would be advisable to repeat the survey with a larger sample of dietitians and also to discuss the exchange system at continuing professional development seminars to determine if this system can be used consistently. This study relied on nutrient composition data for processed meat products as indicated on their labels and as verified through personal correspondence with the food technologists responsible for the respective brands. Although South African Meat Processors Association conducts regular independent compositional tests, further independent laboratory testing and statistical analysis on the nutrient content of these products should be done to verify the nutrient values indicated on these labels.

6.3 Conclusion and recommendations

Although there is currently a growing body of conflicting literature on the role of animal source foods in human health it cannot be denied that animal source foods are nutrient dense food commodities contributing to critical nutrients of concern in the diets of millions of people throughout the world and that these foods should remain an important part of the human diet (Wyness, et al., 2011; McAfee, et al., 2010). Red meat, which is particularly high in heme iron and zinc has sometimes been unnecessarily restricted in diets and could potentially have unintended health consequences, such as anaemia in pregnant women, adolescents and children. It is suggested that there is a great need for a paradigm shift in dietary advice in relation to red meat consumption (Binnie, Barlow, Johnson, & Harrison, 2014).

Food consumption data, dietary recommendations and food composition data are important aspects of human nutrition that should be developed in unison, with strong scientific support and the specific dietary needs and economic situation of the relevant population in mind. Furthermore, the importance of reliable, science based information must be emphasized in a world where consumers are vulnerable to being misled by the plethora of information that is freely available to them on the internet and in their hands in the form of cell phone applications (“apps”). The data used by popular diet apps and health programmes on the internet must be verified, the integrity thereof must be questioned and where possible, science based, country specific data must be provided. Consumers and health professionals must have open access to solid, robust, science based dietary information. This information, such as food composition data and dietary recommendations, including portion size data, must be packaged in the form of understandable, product specific health messages.

The tools and data compiled in this study can further be utilised by policy makers, health professionals and economists to effectively evaluate, predict and measure consumption and to compile accurate guidelines regarding the consumption of animal source foods for South Africans.

6.4 References

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