Cape Peninsula University of Technology

DIETARY ADJUSTMENTS THAT CONSUMERS IN THE PROFESSIONAL SECTOR IN THE CITY OF CAPE TOWN ARE LIKELY TO MAKE, IN ORDER TO ENHANCE THEIR PHYTOCHEMICAL INTAKE

by

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DECLARATION

I, Shelley Kim Mager, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed **Date**

SUMMARY

The prevalence of nutrition-related chronic diseases of lifestyle (CDL) is escalating in South Africa (SA). Studies suggest that poor nutrition plays a major role in the aetiology of these diseases. Phytochemicals present in plant foods, namely fruit, vegetables, whole grains and tea, may prevent the onset of CDL. Most South African diets appear to be deficient of these plant foods. Achieving enhanced phytochemical intake amongst South Africans may therefore have to be supported in other ways. The objectives of this research were to determine whether consumers in the professional sector in the City of Cape Town would be (i) likely to consume proficient home-cooked category prepared dishes and (ii) purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake and, if so, (iii) which dietary source adjustment category/categories and (iv) food vehicle category/categories they would be likely to consume, and (v) who would be likely to consume them.

After obtaining ethical approval, a survey was conducted amongst 184 white collar workers (87% response rate) representing the professional sector (professional, technician and associate professional) occupational groups. The respondents were approached for voluntary participation based on their occupation and age, representing adulthood to the elderly life stage as a risk factor for the development of lifestyle diseases. A pilot-tested questionnaire was used to obtain information regarding the respondents awareness of phytochemicals, whether or not they were involved in the preparation of food at home, their degree of 'likelihood' to consume proficient home-cooked and commercially manufactured category prepared dishes for enhanced phytochemical intake, their current daily intake of fruit, vegetables, whole grains and tea, and demographic, health and lifestyle information. The frequencies of the respondents' consumption of phytochemical-rich dietary sources pertaining to the stages of change model were assessed using Pearson's chi-squared analysis to determine significant associations/differences ($p < 0.05$) between the data sets. The repeated measure analysis of variance (ANOVA) on Bonferroni correction was used to assess the 'likeliness' scale (from 'extremely unlikely' as '1' to 'extremely likely' as '5') for the household and commercial dietary source adjustment and food vehicle categories.

The respondents were mostly female (58.7%), 31 to 44 years of age (67.9%) and of White ethnicity (72.3%). The majority (61.5%) had obtained grade 12 and a diploma (29.4%) or a degree (32.1%). Almost half were married or living together with children (48.9%) and were English (48.9%) or Afrikaans (47.3%) speaking. The majority of respondents were non-smokers (69%), and approximately half (54.4%) consumed alcohol less than three times per week (54.4%). About fifty percent used dietary supplements (50.5%) and exercised (59.2%) regularly.

A small percentage of the respondents were obese (7.6%), had diabetes mellitus (4.4%) or cardiovascular disease (CVD) and cancer (2.2% or four respondents each). Cancer was most prevalent (36.4%) within the respondents' family, followed by diabetes mellitus (29.9%), CVD (26.6%) and obesity (7.6%). The majority (77.7%) were not aware of phytochemicals and about half (55.4%) could not indicate the role these compounds play in the human diet. Half of the respondents consumed the recommended two to four servings of fruit daily, very few (10.9%) consumed the recommended three to five servings of vegetables daily, only about 10% (9.2% or 17 respondents) consumed the recommended three servings of whole grains daily, and about a third (36.4%) consumed two to three cups of tea daily.

The respondents who considered phytochemicals to be very necessary to support health were more likely to consume rooibos herbal tea added to category prepared dishes than those who considered phytochemicals to be necessary to support health ($p < 0.05$) and those who did not know the role phytochemicals played in the diet ($p < 0.05$). The likelihood to consume category prepared dishes with added vegetables and added fruit respectively was lower ($p < 0.05$) amongst those respondents who consumed none to one serving of vegetables daily than amongst those who consumed two to four servings of vegetables daily. The respondents who did not consume tea were less likely to consume category prepared dishes with added rooibos herbal tea than those who consumed one cup ($p < 0.05$) or two to three cups ($p < 0.001$) daily. Furthermore, the respondents who did not consume tea were also less likely to consume category prepared dishes with added herbs than those who consumed one cup ($p < 0.05$), two to three cups ($p < 0.001$) or four to six cups ($p < 0.05$) daily. The likelihood to consume category prepared dishes with fruit additions was lower amongst those respondents who did not consume tea than amongst those who consumed two to three cups ($p < 0.05$) or four to six cups ($p < 0.05$) daily.

The respondents were more likely ($p < 0.05$) to consume herb, vegetable and fruit additions respectively than rooibos herbal tea addition, and more likely to consume vegetable additions than herb ($p < 0.05$) or fruit ($p < 0.001$) additions as dietary source adjustment options. Furthermore, vegetable additions to category prepared dishes were more likely to be consumed by the respondents than fruit additions ($p < 0.001$), and starch-based dishes more likely to be consumed than vegetable-based dishes ($p < 0.001$) or fruit-based dishes ($p < 0.05$) for the addition of rooibos herbal tea. The respondents were likely to consume the food vehicle categories egg and chicken for added herbs in comparison to other starch ($p < 0.05$) and vegetables ($p < 0.001$) respectively. Chicken was a likely option over pasta for added broccoli ($p < 0.05$). Crêpe was a likely option over compote for added mixed berries ($p < 0.001$). Potato was a likely option over vegetables ($p < 0.05$) as well as other starch over vegetables ($p < 0.05$)

for added herbs. Carrot salad with raisins was a likely option above carrot salad with raisins and parsley ($p < 0.05$). Poached pear in red grape juice was a likely option over poached pear in rooibos herbal tea ($p < 0.001$). Tomato ($p < 0.001$) and broccoli ($p < 0.05$) were more likely to be consumed than spinach, while spinach ($p < 0.05$) and roasted butternut ($p < 0.05$) respectively were likely options over onion as vegetables added to a quiche. Onion was a less likely option over broccoli ($p < 0.001$), tomato ($p < 0.001$) and roasted butternut ($p < 0.001$) as respective vegetables in a soup. Tomato soup was a likely option over tomato soup with rooibos herbal tea ($p < 0.001$). Roasted butternut soup was a likely option over butternut and orange soup ($p < 0.001$) and butternut and rosemary soup ($p < 0.001$). Berries as fruit addition were a likely option over pome fruit as pear ($p < 0.05$) and citrus fruit ($p < 0.001$), and furthermore citrus fruit over pome fruit as pear ($p < 0.05$). Raw apple with its skin on was a more likely option over chicken breast salad with apple pieces ($p < 0.001$), and chicken breast salad with apple a likely option over chicken and apple casserole ($p < 0.001$). Parsley was a likely option over basil ($p < 0.001$), and mixed herbs ($p < 0.001$) and rosemary ($p < 0.001$) respectively were likely options over basil as herb addition.

Commercially manufactured category prepared dishes likely to be purchased and consumed by the respondents included category prepared dishes with added fibre more than added herbs ($p < 0.05$), fruit ($p < 0.001$), vegetables ($p < 0.001$) or tea ($p < 0.001$), and added herbs than added vegetables ($p < 0.05$) or tea ($p < 0.05$). Pizza/pasta was a likely option over beverages ($p < 0.05$), grains/bake ($p < 0.001$) and dairy ($p < 0.001$) respectively, and baked goods than grains/bake ($p < 0.001$), dairy ($p < 0.001$) and beverages ($p < 0.05$) respectively as food vehicles. A baked dish with added fibre was more likely to be consumed than with added fruit ($p < 0.001$), tea ($p < 0.001$) or vegetables ($p < 0.001$), and added fruit more likely to be consumed than added vegetables ($p < 0.05$). Pasta incorporating vegetables was a more likely option than pasta incorporating fruit ($p < 0.001$). Shortbread with added fruit was a likely option over added herbs ($p < 0.05$), and a muffin with bran ($p < 0.001$) or blueberries ($p < 0.001$) a likely option over a muffin with spinach. Fruit juice incorporating rooibos herbal tea ($p < 0.001$) or herbs ($p < 0.001$) were likely options over fibre incorporation. The female respondents were more likely to consume category prepared dishes with added fruit than the male respondents ($p < 0.05$), while the older respondents (55 to 64 years) were more likely to consume category prepared dishes with added herbs than the younger respondents (31 to 44 years) ($p < 0.05$). The older respondents were also more likely to consume category prepared dishes with fruit additions than the younger respondents aged 31 to 44 ($p < 0.05$) and 45 to 54 ($p < 0.05$) respectively. The respondents involved in the preparation of food at home were more likely to consume category prepared dishes with the addition of rooibos herbal tea ($p < 0.05$), herbs ($p < 0.05$) and fruit ($p < 0.05$) respectively than those who were not involved in preparing food at home.

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LIST OF OPERATIONAL TERMS AND CONCEPTS

Term	Definition
Category prepared dish	For the purpose of this research, a category prepared dish is a dish enhanced with phytochemicals provided by a category of phytochemicals, i.e. fruit, vegetables, whole grains, tea or herbs as the phytochemical provider.
Dietary adjustments	For the purpose of this research, dietary adjustments are added ingredients or ingredient modifications made utilising dietary source adjustment categories to create a proficient home-cooked category prepared dish or a commercially manufactured category prepared dish for enhanced phytochemical content.
Dietary source adjustment category	For the purpose of this research, a dietary source adjustment category is the category of phytochemicals i.e. fruit, vegetables, whole grains, tea or herbs utilised as the provider to enhance the phytochemical content of a dish.
Dish	Prepared food consisting of two or more ingredients intended for immediate consumption but which can also be chilled or frozen for consumption at a later stage (Williams & Carter, 2010: 326). For the purpose of this research, beverages and water are contained within this classification.
Food vehicle	For the purpose of this research, a food vehicle is a food, beverage or water to which ingredients are added to create a proficient home-cooked category prepared dish or commercially manufactured category prepared dish for enhanced phytochemical intake.
Food vehicle category	For the purpose of this research, a food vehicle category is the category grouping of foods or beverages (egg, chicken, fish, potato, etc.) to which a dietary adjustment

	is made for enhanced phytochemical content.
Fruit	The edible parts of plants, with the exclusion of cereal grains, nuts and seeds, which consist of the seeds and pulpy surrounding tissue (Vainio & Weiderpass, 2006: 111).
Herbs	Herbs are the leaves and stems of plants (Lampe, 2003: 579S) used to flavour food through their essential oils and oleoresins (Craig, 1999: S419).
Lifestyle diseases	Diseases that occur due to lifestyle-related factors (Kirch, 2008: 993).
Non-communicable diseases	Diseases commonly derived from genetic predisposition and/or certain lifestyle characteristics that are not contagious (Kirch, 2008: 993).
Phytochemicals	Bioactive non-nutrient plant compounds found in fruits, vegetables and other plant-based foods that have been linked to the reduction in the risk of major chronic diseases (Liu, 2004: 3479S).
Professional sector	The sector that links education and income. Education credentials are attained which enable employment in certain jobs and a salary is earned (Barbeau *et al*., 2004: 269). For the purpose of defining the sample population for this research, the International Standard Classification of Occupations (ISCO) structure, as compiled by the International Labour Organisation (ILO) (Bureau of Statistics, 2009), was used. The ISCO structure consists of 10 major occupation groups, of which the groups professional (as Major Group 2) and technicians and associate professionals (as Major Group 3) represented the professional sector as the population for this research. Each occupation group is aligned to the tasks and duties performed within the specified occupation.

Refined grains	Refined grains have the endosperm separated from the grain bran and germ before milling (Jensen *et al*., 2004: 1492), with only the endosperm remaining, and thus provide fewer nutrients and phytochemicals than whole grains (Steffen *et al*., 2003: 383).
Rooibos herbal tea	Rooibos herbal tea is a hotwater infusion prepared from the leaves of the shrub-like plant rooibos (*Aspalathus linearis*) (Da Silva Pinto, 2013: 559) native to the Cederberg Mountains in the Western Cape (McKay & Blumberg, 2007: 2).
Tea	Tea is a hotwater infusion prepared from the leaves of the *Camellia sinensis* L. plant (McKay & Blumberg, 2002: 1).
Vegetables	The edible parts of plant foods, with the exclusion of cereal grains, nuts and seeds. Parts of the plant used in cooking include the stem and stalk, roots, tubers, bulbs, leaves, flowers and some fruits and pulses (Vainio & Weiderpass, 2006: 111).
Whole grains	Whole grains comprise three layers that include the outer bran layer, the endosperm and the germ (Lang & Jebb, 2003: 123). The bran layer and germ are abundant in nutrients and phytochemicals (Steffen *et al*., 2003: 383). The milling process determines how much of the whole grain is retained, with varying retention levels impacting on the nutrient and non-nutrient components of the end product (Lang & Jebb, 2003: 123).

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation/Acronym	Definition
ANOVA	Analysis of variance
BMI	Body mass index
CDL	Chronic diseases of lifestyle
CHD	Coronary heart disease
COPD	Chronic obstructive pulmonary disease
CPUT	Cape Peninsula University of Technology
CVD	Cardiovascular disease
DNA	Deoxyribonucleic acid
DSHEA	Dietary Supplement Health and Education Act
EC	Epicatechin
ECG	Epicatechingallate
E. coli	*Escherichia coli*
EGC	Epigallocatechin
EGCG	Epigallocatechingallate
FAO	Food and Agriculture Organization
FDA	Food and Drug Administration
FRAP	Ferric reducing ability of plasma
g	Gram
HBM	Health Belief Model
HDL	High-density lipoprotein
H. pylori	*Helicobacter pylori*
ISCO	International Standards Classification of Occupations
KAB	Knowledge Attitude Behaviour
KAP	Knowledge Attitude Practice
kg	Kilogram

kJ	Kilojoule
L	Litre
LDL	Low-density lipoprotein
m^2	Square metre
mg	Milligram
mL	Millilitre
ORAC	Oxygen radical absorbance capacity
PSA	Prostate-specific antigen
ROS	Reactive oxygen species
SAFBDG	South African food-based dietary guideline
SCT	Social Cognitive Theory
SA	South Africa
TAC	Total antioxidant capacity
TRA	Theory of Reasoned Action
WHO	World Health Organization
w/w	Weight per weight
UK	United Kingdom
US	United States
USA	United States of America
USDA	United States Department of Agriculture

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CHAPTER ONE
INTRODUCTION

1.1 Statement of the research problem

The prevalence of chronic diseases pertaining to lifestyle is rapidly escalating in South Africa (SA) (Tollman *et al*., 2008: 893) and dietary behaviour is believed to be a major contributory factor (Mbanya *et al*., 2010: 2258). Phytochemicals are health-promoting bioactive compounds found in plants and plant-based foods. The consumption of plants and plant-based foods, which include fruit, vegetables, whole grains and beverages such as tea, plays a significant role in the amelioration of chronic diseases of lifestyle (CDL) due to the presence of these compounds (Tsao & Deng, 2004: 86; Louwrens *et al*., 2009: 196; Vincent *et al*., 2010: 20). The objective of increasing the consumption of fruit, vegetables, whole grains and tea is to reduce the incidence of CDL; however, the majority of South Africans do not achieve the recommended daily intake of fruit and vegetables (Schneider *et al*., 2007: 718), consume refined grains more often than whole grains (Vorster & Nell, 2001: S17), and consume less (Nel & Steyn, 2002: 92) than the recommended daily intake (Elhatton, 2002: 21) of tea. Enhancing the phytochemical intake of South Africans to assist in alleviating CDL may therefore have to be supported in other ways.

1.2 Background to the research problem

The widely endorsed recommendation for fruit and vegetable intake is an average of 400 grams (g) per day. Nevertheless, data from SA's food balance sheets indicates that fruit and vegetable consumption is exceedingly low (Schneider *et al*., 2007: 718). Data also indicates that South Africans consume refined grains more often than whole grains (Vorster & Nell, 2001: S17) and consume less tea (Nel & Steyn, 2002: 92) than the advised four to six cups of tea daily (Elhatton, 2002: 21). Phytochemicals obtained through the consumption of plant foods such as fruits, vegetables, whole grains and tea may reduce the risk of numerous chronic diseases (Tsao & Deng, 2004: 86; Louwrens *et al*., 2009: 196; Vincent *et al*., 2010: 20), but it is envisaged that the phytochemical intake of South Africans is low due to their inadequate intake of foods rich in phytochemicals.

Dietary phytochemical provision can be enhanced through several strategies, namely the consumption of a variety of particular plant foods (Battino & Mezzetti, 2006: 1099), and the use of dietary supplements and functional foods and/or food biotechnology. The consumption

of a diverse and healthy diet is however recommended above the use of dietary supplements (Liu, 2013: 390S). For example, it was determined in clinical trials that when supplements are taken in isolation, some individual antioxidants did not appear to have consistent preventative effects when compared to those of food (Liu, 2013: 389S). The isolated pure bioactive compound loses its efficacy and does not perform the same way as it would in whole foods (Liu, 2003: 518S). Plant foods, such as fruit, vegetables, whole grains and tea, contain various bioactive phytochemical compounds that biologically act in numerous ways, for example as antioxidants, and as a result provide desirable health benefits to reduce the risk of chronic diseases (Liu, 2003: 517S; Louwrens *et al*., 2009: 196).

Numerous barriers have been found to exist between the general population and a healthy diet. Less healthy foods are commonly consumed due to their pleasurable taste and convenience. Humans are creatures of habit and are often reluctant to change long-standing food preferences, even when the habitual diet poses a risk for the development of chronic diseases (Temple & Steyn, 2011: 505). However, research concerning eating behaviour indicates that adults are capable of changing their ingrained eating habits, even those developed as a child. This is often driven when an urgent need to do so arises, such as when health is at risk due to obesity and diabetes, or coronary heart disease (CHD) (Chapman & Ogden, 2010: 447). The primary constraints to eating fruit and vegetables amongst South Africans are affordability, availability and taste preferences (Schneider *et al*., 2007: 722). The major strategy to increase the consumption of plant foods, particularly fruit and vegetables, for enhanced phytochemical intake may therefore have to be supported in other ways. Research is therefore required to determine the likelihood of consumers to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake (i.e. herbs added as ingredients to dishes, herbal tea incorporated as an ingredient in soup), as well as the likelihood of consumers to purchase commercially manufactured category prepared dishes for enhanced levels of phytochemicals in the dish (i.e. a pasta dish that incorporates powdered dried fruit peel as one of its ingredients, or substituting herbal tea in place of water when baking bread).

1.3 Research questions

i. Would consumers in the professional sector in the City of Cape Town be likely to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake?

ii. Would consumers in the professional sector in the City of Cape Town be likely to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake?

iii. Which dietary source adjustment category/categories added to proficient home-cooked category prepared dishes would consumers in the professional sector in the City of Cape Town be likely to consume?

iv. Which food vehicle category/categories of proficient home-cooked category prepared dishes would consumers in the professional sector in the City of Cape Town be likely to consume?

v. Which dietary source adjustment category/categories added to commercially manufactured category prepared dishes would consumers in the professional sector in the City of Cape Town be likely to purchase and consume?

vi. Which food vehicle category/categories of commercially manufactured category prepared dishes would consumers in the professional sector in the City of Cape Town be likely to purchase and consume?

vii. Which consumers in the professional sector in the City of Cape Town would be likely to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake?

1.4 Objectives of the research

i. To determine whether consumers in the professional sector in the City of Cape Town would be likely to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake, and if so, which dietary source adjustment category/categories would they be likely to consume, and in which dishes as the food vehicle category/categories.

ii. To determine whether consumers in the professional sector in the City of Cape Town would be likely to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake and, if so, which dietary source adjustment category/categories they would be likely to purchase and consume, and in which dishes as the food vehicle category/categories.

iii. To determine which consumers in the professional sector in the City of Cape Town would be likely to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake.

CHAPTER TWO
LITERATURE REVIEW

South Africa is facing the problem of chronic lifestyle diseases, specifically cardiovascular disease (CVD), type-2 diabetes mellitus, and cancers (Puoane *et al*., 2012/2013: 116). These diseases are associated with urbanisation and are accompanied by changes in lifestyle (MacIntyre *et al*., 2002: 239), combined with adopting a Western diet (Bourne *et al*., 2002: 157). Western dietary food choices and patterns are typically dominated by the consumption of red and processed meats, high-fat dairy products, eggs, refined grains, high-sugar drinks, sweets, and desserts, with intakes of fruit, vegetables, whole grains, legumes, poultry and fish found to be low (Tyrovolas & Panagiotakos, 2010: 128).

Diets consisting of a variety of fruit, vegetables, whole grains and tea are rich in phytochemicals that may contribute to improved health through chronic disease risk reduction. The bioactive compounds or phytochemicals found in plant foods are linked to a reduced risk in CDL. The potential protective mechanisms of a phytochemical-rich diet include the lowering oxidative stress, inflammation and cardiovascular precursors, the preservation of vascular function and a contribution towards a reduced incidence of obesity (Vincent *et al*., 2010: 20), to name a few. Most South Africans, however, do not succeed in achieving the recommended daily intake of fruit and vegetables (Schneider *et al*., 2007: 718), consume refined grains more often than whole grains (Vorster & Nell, 2001: S17) and consume less tea (Nel & Steyn, 2002: 92) than the advised four to six cups daily (Elhatton, 2002: 21), thereby increasing the risk of these diseases. Strategies to enhance phytochemical intake may therefore have to be explored through other means. Research clearly shows that prolonged unhealthy nutrition increases the risk of non-communicable diseases. Various commercial strategies, by incorporating phytochemical-rich dietary sources into commonly consumed dishes for enhanced phytochemical intake have been investigated to combat CDL. Methods to increase dietary phytochemical intake at home have also been explored.

2.1 Chronic diseases of lifestyle of concern in South Africa

Overnutrition-related CDL, for example cancer, CVD, hypertension and type-2 diabetes mellitus, are prevalent amongst all the population groups in SA (Maunder *et al*., 2001: S9), posing a public health challenge. Sub-Saharan Africa is undergoing the highest rate of urbanisation in the world, with more than a third of the population currently residing in urban areas. This rapid urbanisation has been suggested as a major determinant in the escalating burden of CDL (Mbanya *et al*., 2010: 2258). The global prevalence of CDL is also increasing

rapidly, with CVD, cancer, type-2 diabetes, and chronic obstructive pulmonary disease (COPD) the leading cause of death. In SA, 37% of mortality is attributed to CDL, namely ischaemic heart disease, stroke, diabetes mellitus, and COPD (Puoane *et al*., 2012/2013: 116). The World Health Organization (WHO) predicts that, within several years, non-communicable diseases may become the primary cause of morbidity and mortality globally (World Health Organization, 2013). The role of the diet in the aetiology of numerous non-communicable diseases has been broadly demonstrated (Kearney *et al*., 2005: 982).

Increased fruit and vegetable consumption is associated with a decreased risk of CHD, stroke, high blood pressure and obesity (Schneider *et al*., 2007: 717). The positive role of fruit and vegetables is due to the combined action of their included components, rather than their individual constituents working in isolation (Liu, 2013: 390S). A diet rich in fruit and vegetables delivers fibre and reduced fat and sugar, which in turn assists in weight reduction. Diets encompassing a wide range of fruits and vegetables, legumes, whole grains and other plant foods provide an assortment of phytochemicals (Vincent *et al*., 2010: 20). Oxidative stress is linked to the development of CVD (Vassalle *et al*., 2012: 1463), cancer (Kryston *et al*., 2011: 193) and diabetes mellitus (Rochette *et al*., 2014: 2714). Phytochemicals have been found to reduce the risk of these chronic diseases (Vincent *et al*., 2010: 20) as many of the phytochemical compounds act as antioxidants. The risk of cancer and other non-communicable diseases may be reduced through mitigating oxidative stress triggered by reactive oxygen species (ROS), which are not only generated by normal metabolic activity, but also by lifestyle factors such as poor diet and smoking (Rao & Rao, 2007: 208). Antioxidants neutralise free radicals and, as a result, reduce oxidative damage to the cells and structures of the body (Kearney *et al*., 2005: 982). Fruit, vegetable and whole grain intake is linked to the reduction of lifestyle diseases, as these foods contain bioactive phytochemicals (Ruel *et al*., 2014: 517), while the consumption of tea is recommended for protection against oxidative stress-induced diseases due to its high content of antioxidant phytochemicals (Tang *et al*., 2009: 282).

2.1.1 Obesity

Obesity is described by the WHO as a body weight status with a body mass index (BMI) equal to or larger than 30 kilogram (kg) per square metre (m^2) (World Health Organization, 1995). Obesity is regarded as a health condition of underlying chronic oxidative stress and low-grade inflammation (Vincent *et al*., 2010: 20), and has been identified by the International Statistical Classification of Diseases as a disease in its own right (Joubert *et al*., 2004: 684). Obesity occurs when energy intake exceeds energy expenditure (Elbelt *et al*., 2010: 766) and

is characterised by the excessive deposit of adipose tissue, mainly around the waist, resulting in an elevated risk of developing several metabolic disorders (Gustafson, 2010: 332). These metabolic disorders include insulin resistance, chronic inflammation (Schofield & Sutherland, 2012: 972), dyslipidaemia (De Luca & Olefsky, 2009: 98), endothelial dysfunction (Mauricio *et al*., 2013: 5718), gall bladder disease (Méndez-Sánchez *et al*., 2004: S59), hypertension, and certain cancers (Vucenik & Stains, 2012: 37). The main cause of insulin resistance is obesity, which may result in impaired glucose tolerance and, ultimately, diabetes mellitus (Schofield & Sutherland, 2012: 972). Numerous South Africans suffer from health implications due to less healthy diets and obesity (Van Heerden & Schönfeldt, 2004: 533).

A 2001 report by the WHO on nutrition, diet and the prevention of chronic diseases ranked obesity as the main preventable risk factor on the public health agenda for the development of non-communicable diseases (World Health Organization, 2003). Excess body fat has been listed by the WHO as one of ten main risk factors for high mortality in developed and developing countries that increase the burden of disease (World Health Organization, 2002), with SA particularly affected. The rate of obesity is increasing amongst all ages and economic levels. More than 70% of women and 45% of men are overweight or obese in SA (Mongal-Singh, 2012: S13). The increasing prevalence of obesity in SA is problematic due to the accompanying risk for the development of CVD, diabetes, hypertension, dyslipidaemia, and certain cancers (Steyn *et al*., 2006: 5).

When compared to persons of a normal body weight, obese individuals consume less fruit, vegetables and other nutrient-rich foods (Neuhouser *et al*., 2001: 2187). Dietary patterns low in fruit and vegetables, whole grains and legumes are linked to weight gain, an increased waist circumference and inflammation (Vincent *et al*., 2010: 20); therefore the role of the diet in the aetiology and prevention of several obesity-related chronic diseases is crucial (Dembinska-Kiec *et al*., 2008: ES109). Culture may be a contributory factor for poor dietary habits, as social gatherings in some cultures encourage over consumption due to the provision of plentiful food at such gatherings. The obesity epidemic amongst black South Africans is said to be due to more freedom of movement and increased exposure to the global market economy. The result is a transition from consuming traditional foods that are low in fat and high in dietary fibre to favouring the consumption of meat and dairy products with high levels of saturated fats, as well as refined foods (Bourne *et al*., 2002: 159; MacIntyre *et al*., 2002: 253; Kruger *et al*., 2005: 493). Interventions through improving dietary intakes have the potential to decrease the incidence of obesity (Cecchini *et al*., 2010: 1775) and, in addition, hypertension, CHD, diabetes, stroke and some types of cancer (Puoane *et al*., 2002: 1038).

2.1.2 Diabetes mellitus

Diabetes mellitus is characterised by elevated blood glucose levels as a result of defects in insulin secretion, insulin action, or both, resulting in abnormalities in the metabolism of carbohydrates, protein and fats (Banerjee & Maulik, 2002: 12). Lifestyle factors, for example a Western diet, and physical inactivity, along with obesity, negatively influence the development and progression of the conditions that lead to the development of type-2 diabetes mellitus and its resulting complications. Modifications of lifestyle factors are therefore imperative to lower the incidence of type-2 diabetes mellitus and its subsequent complications (Hu & Tuomilehto, 2007: 161).

Type-2 diabetes mellitus is a significant non-communicable disease in sub-Saharan Africa (Mbanya *et al*., 2010: 2254) and is prevalent amongst individuals of working age, between the ages of 40 and 60 years (Shaw *et al*., 2010: 10), with the incidence increasing with age (Mbanya *et al*., 2010: 2257). Cardiovascular disease accounts for a large percentage of total mortality in persons with type-2 diabetes. Individuals with type-2 diabetes have an increased risk of developing CVD between two to four times than those who do not have diabetes (Hu & Tuomilehto, 2007: 161).

Nutrition plays a vital role in controlling blood glucose levels and the resulting complications of the disease, such as CVD (Banerjee & Maulik, 2002: 12). The common attributes of the Western diet have been found to be consistent contributing factors for the increased incidence of diabetes (Kengne *et al*., 2005: 3596). Elevated oxidative stress may accompany diabetes, indicating a possible benefit from higher antioxidant consumption (McKevith *et al*., 2003: 258). Increased consumption of fruit, vegetables and whole grains is linked to a reduced risk of type-2 diabetes (Dembinska-Kiec *et al*., 2008: ES109), possibly due to the phytochemical compounds naturally present in these foods displaying antioxidative and anti-inflammatory effects (Salas-Salvadó *et al*., 2011: B39). Research continuously supports regular physical activity, adherence to a healthy diet and the avoidance of excessive weight gain as effective ways to decrease CVD risk in type-2 diabetic patients (Hu & Tuomilehto 2007: 168).

2.1.3 Cardiovascular disease

Heart disease significantly increases morbidity and the mortality burden from CDL in SA (Love & Sayed, 2001: S58). CVD is a multifaceted disease characterised by raised serum lipids (cholesterol and triglycerides), elevated plasma fibrinogen and coagulation factors,

increased platelet activation and alterations in glucose metabolism (Rahman & Lowe, 2006: 736S). Risk factors of CVD include hypercholesterolaemia, smoking, alcohol use and low intakes of fruit and vegetables (Prasad *et al*., 2010: 116).

In SA, 12.5% of men and 17.9% of women are hypertensive (South Africa. Department of Health, 2003: 18). Hypertension is characterised by a systolic blood pressure of 140 mm Hg or higher or a diastolic blood pressure of 90 mm Hg or higher, or both (World Health Organization, 2013), and is the most common risk factor for CVD (Van der Sande, 2003: 33). Differences exist in the prevalence of hypertension in persons of black and white ethnic origin in SA (Van der Sande, 2003: 33), with the highest prevalence amongst white men. A high prevalence was also found amongst coloured and white women and Indian men, with the lowest prevalence found in black men (Steyn *et al*., 2006: 285).

The bioactive compounds present in fruit and vegetables that are recognised as beneficial in preventing CVD include dietary fibre (Mellen *et al*., 2008: 283), vitamin C (McRae, 2008: 48), the carotenoids (Sesso *et al*., 2003: 2336) and the flavonoids (Ishige *et al*., 2001: 433). The Mediterranean diet mainly comprises a daily consumption of dairy products, fruits and vegetables, olive oil and non-refined grains, a weekly consumption of fish and legumes, potatoes, poultry, olives and tree nuts, and the consumption of red meat once a month. Adherence to the Mediterranean diet has been associated with positive effects on mortality and primary and secondary prevention of chronic diseases, in particular CVD and cancer, in addition to type-2 diabetes and obesity (Kastorini *et al*., 2010: 536). The findings from large-cohort studies in Europe have associated the Mediterranean diet with decreased mortality, and clinical studies have found some of the components of the Mediterranean diet to be beneficial in reducing blood pressure and lipid profiles and improving endothelial function. These findings in particular substantiate the potential beneficial effects of the Mediterranean diet on cardiovascular risk (Estruch *et al*., 2006: 1). Despite these findings, South Africans tend to typically follow the Western diet (Puoane *et al*., 2002: 1045), which does not reflect the protective aspects of the Mediterranean diet.

2.1.4 Cancer

Cancers have been found to account for 7.6 million deaths globally in the year 2008 (World Health Organization, 2010). In SA breast cancer is the most commonly diagnosed cancer amongst women (Jemal *et al*., 2012: 4374), while prostate cancer is the most commonly diagnosed cancer amongst men (Jemal *et al*., 2012: 4377). It is recognised that 80 to 90% of cancers are as a result of external factors. Dietary habits have been found to play a

considerable role in up to 35% of all cancers in humans (Irigaray *et al*., 2007: 640; Baena Ruiz & Salinas Hernández, 2014: 202).

Cancer is a complex disease characterised by abnormal gene expression that occurs through a number of mechanisms, including deoxyribonucleic acid (DNA) alteration and abnormal gene translation. When the DNA of normal cells is exposed to damaging substances (carcinogens), the cells may undergo genetic changes resulting in malignant transformations, a process known as carcinogenesis (Ames & Gold, 1998: 205). Carcinogens include chemical agents, viruses and ionising and ultraviolet radiations. Reactive oxygen species (superoxide, hydrogen peroxide, hydroxyl radical) are also found to be major causes of DNA damage, together with protein and lipid damage (Khan *et al*., 2014: 98).

Phytochemicals in fruits, vegetables, spices, herbs and tea play protective roles against numerous chronic diseases including cancer. Cancer is associated with oxidative stress as a result of the presence of high levels of free radicals and other ROS (Kryston *et al*., 2011: 193). Antioxidants exert their effect by neutralising these highly reactive radicals. Polyphenols and carotenoids have been found to be the most important antioxidant phytochemicals (McKay & Blumberg, 2002: 1; Tsao & Deng, 2004: 86).

Lifestyle-related factors are risk factors for the development of cancer and are not considered to be cancer-causing. Overweight, obesity and a sedentary lifestyle are risk factors for the development of cancer. An excessive body weight or obesity in isolation cannot cause cancer; it is, however, an indirect contributor to the development of certain cancers through a gradual accumulation of environmental chemical carcinogens in the adipose tissue (Steyn *et al*., 2006: 5). Since obesity has been linked to numerous types of cancers it may be plausible that an imbalance of food intake and dietary factors contributing to an ‘abnormal’ diet may be implicated in carcinogenesis (Irigaray *et al*., 2007: 642). The Mediterranean diet, which includes an abundance of plant foods, low intakes of red meat and a moderate consumption of wine, is associated with a reduced risk of cancer (Giacosa *et al*., 2013: 91).

2.2 Phytochemicals and protection against the development of chronic diseases of lifestyle

The major dietary constituents typically consist of carbohydrates, proteins and lipids, and the minor constituents constitute vitamins, minerals and the health-beneficial secondary metabolites or phytochemicals. Phytochemicals can be classed as major or minor

constituents, depending on their occurrence in plants. Phytochemicals can furthermore be divided into several groups, *viz*. alkaloids, carotenoids, organosulphur compounds, polyphenols and nitrogen-containing compounds (Grusak, 2002: 508). The polyphenols are one of the most investigated compounds (Lampe & Chang, 2007: 347) due to their high presence in the human diet, the recognition of their antioxidant capacity and their potential role in the prevention of diseases linked with oxidative stress (Manach *et al*., 2004: 727).

It should be noted that not all fruit and vegetables have the same make-up and antioxidant capacity (Ninfali *et al*., 2005: 257). It therefore is suggested that an assortment of plant foods be consumed (Liu, 2007: 214) and that it is necessary to recognise which foods have the highest nutritional quality and antioxidant capacity and to introduce them into the diet frequently (Denev *et al*., 2013: 23).

2.2.1 Polyphenols

Polyphenols provide taste and colour to plants. The polyphenols can be grouped broadly into phenols, flavonoids and non-flavonoids, such as stilbenes (resveratrol), saponins, curcumin and tannins (Andriantsitohaina *et al*., 2012: 1532). The polyphenols can be divided further into various classes, *viz*. flavonoids (flavonols, flavones, flavanols, flavanones, isoflavones and pro-anthocyanidins), phenolic acids (hydroxybenzoic acids and hydroxycinnamic acids), stilbenes and lignans (Gharras, 2009: 2512). Flavonoids are the largest group of polyphenolic compounds (Middleton *et al*., 2000: 673) that are synthesised in plants *via* phenylalanine (Yao *et al*., 2004: 113). The flavonoids and other plant phenolics, such as the phenolic acids, stilbenes, tannins and lignans, are commonly found in the leaves, flowering tissues and woody parts of plants, such as the stem and bark (Gharras, 2009: 2513).

2.2.1.1 Food sources

The main sources of polyphenols in the Western diet are tea, fruit and vegetables (Tabak *et al*., 2001: 61). Fruit and beverages such as tea and red wine comprise the major sources of polyphenols in the human diet. The phenolic compounds contribute to the colour of red wine, as well as its astringency and bitterness. Their presence in wine is derived from the fruit and vine stems, or through yeast metabolism of the grapes (Gharras, 2009: 2512). Fruit such as apples, pears, grapes, cherries and several berries contain up to 200 to 300 milligrams (mg) polyphenols per 100 g fresh weight. Typically, a cup of tea, coffee or a glass of red wine contains approximately 100 mg polyphenols. Dry legumes, chocolate and cereals also contribute to the total polyphenol intake (Scalbert *et al*., 2005a: 287). Some polyphenols,

such as quercetin, are found in all plants (fruit, vegetables, cereals, legumous plants, fruit juices, tea, wine, etc.), while others are found only in specific foods (i.e. flavanones in citrus fruits, isoflavones in soya, phloridzin in apples) (Manach *et al*., 2004: 731).

There are two classes of phenolic acids, namely derivatives of benzoic acid and derivatives of cinnamic acid (Robbins, 2003: 2866). The hydroxybenzoic acid content of plants is typically very low, except in onions, black radish and some red fruits. Hydroxybenzoic acids are found only in a few plants eaten by humans and therefore have not been found to be of significant nutritional interest and have not been studied extensively (Clifford, 1999: 362). The hydroxycinnamic acids are more common than the hydroxybenzoic acids and are seldom found in their free form, other than in processed foods that have been frozen, sterilised or fermented. Fruit with the highest content of hydroxybenzoic acids include apples, blueberries, cherries, kiwis and plums (Manach *et al*., 2004: 728).

The flavonol subfamily is the most abundant amongst the flavonoids, with the most widespread flavonols in this chemical group being quercetin, kaempferol and myricetin (Yao *et al*., 2004: 115). The flavonols are found largely in apples, cherries, berries, broccoli, onion, kale, red wine and tea (Rimm *et al*., 1996: 384). The flavanone subgroup is found mainly in citrus fruit, although chickpeas, cumin, liquorice and peppermint are also good sources. The flavone subgroup is frequently found in grains and herbs, while the isoflavone subgroup is almost exclusively present in soy foods (Yao *et al*., 2004: 115), although they also are present in black beans and green split peas. The flavan subgroup is found in fruit and green and black tea (Peterson & Dwyer, 1998: 1999). The anthocyanin subgroup produces the blue and red colour of plums, grapes, eggplant, cherries, red cabbage and radishes (Peterson & Dwyer, 1998: 2000).

Amongst the non-flavonoid polyphenols, stilbenes occur only in small concentrations in the human diet. Therefore, any protective effect from this compound on human health is unlikely (Gharras, 2009: 2515). Stilbenes are found in grapes, wine, peanuts and soy (Fraga *et al*., 2010: 435). The richest dietary source of lignans is linseeds. Fruit, some vegetables, cereals and grains also contain trace amounts of lignans. Thompson *et al*. (1991: 43) used the technique of *in vitro* fermentation of foods by human colonic microflora to determine the richest sources of lignans and found oilseeds (linseeds) to be the richest source, followed by algae, whole legumes (lentils), cereals (triticale and wheat), vegetables (garlic, asparagus, carrots) and fruit (pears, prunes). The primary biological action of lignans in the human diet is the provision of specific active metabolites produced by the microflora when provided as colonic substrate (Manach *et al*., 2004: 735).

2.2.1.2 Health benefits

Research strongly supports the relationship between polyphenols and the prevention of CVD and cancer, and proposes a role in the prevention of neurodegenerative diseases and diabetes mellitus (Scalbert *et al*., 2005b: 215S). Flavonoids and other polyphenolic compounds have gained public attention because the flavonoids found in tea, fruit and vegetables reduce the risk of CVD (Nijveldt *et al*., 2001: 418). Grapes are a major dietary sources of anthocyanins, providing the black, red and purple colours that are not present in white grapes (Yang *et al*., 2009: 332), as well as resveratrol, which is abundant in grape skins, seeds and in red wine (Yang *et al*., 2009: 333). The 'French paradox' indicates the possible health benefits of the Mediterranean diet, consisting of high intakes of fresh fruit and vegetables as well as red wine, all of which are sources of flavonoids (Sano *et al*., 2004: 669). The regular consumption of red wine linked to a reduced risk of CHD may in part explain the 'French paradox' (Cook & Samman, 1996: 73). Similarly, the 'Far East paradox' proposes that tea flavonoids play a role in the low incidence of CHD in countries such as China and Japan, where a lot of green tea is consumed (Ishikawa *et al*., 1997: 261), despite the high rate of smoking in these countries (Sano *et al*., 2004: 669). Tea consumption has also been associated with cancer prevention (Yao *et al*., 2004: 117), with the polyphenols present in green tea that have been shown to possess chemopreventative effects against tumour development (Yao *et al*., 2004: 119). Chemoprevention is the administration of an individual drug or dietary supplement for the prevention of the development of pre-malignant lesions or their growth to form cancer, as well as the recurrence of cancer (Morse & Stoner, 2005: 445). Green tea may also protect against cancer by causing cell cycle arrest and inducing apoptosis, while black tea can produce an inhibitory effect on tumour promotion (Yao *et al*., 2004: 119).

As antioxidants, polyphenols may protect cells from oxidative damage, thereby limiting the risk of a number of degenerative diseases linked to oxidative stress. *In vivo* research has shown polyphenol consumption to be protective against DNA damage (Scalbert *et al*., 2005a: 290). Experimental research carried out on rats found the intake of wine polyphenols to be protective against oxidative damage of the colonic mucosa (Sengottuvelan & Nalini, 2006: 145). Furthermore, the consumption of red wine by humans has been found to produce a marked decrease in the levels of oxidised plasma low-density lipoprotein (LDL)-cholesterol (Estruch *et al*., 2011: 46).

Associations between the consumption of flavonoids and the incidence of various cancers have been investigated in seven prospective cohort studies and four case-controlled studies.

Significant associations were found only for lung and colorectal cancer (Arts & Hollman, 2005: 319S). Reduced intakes of flavonols and flavones have been found to be associated with lung cancer risk (Knekt *et al*., 1997: 223). For catechins, an inverse association was found with rectal cancer, but not with colon cancer, amongst postmenopausal women in the United States of America (USA). Flavonoid intake has not been found to affect the development of any epithelial cancer as cancer of the breast, prostate, stomach and urinary tract (Arts & Hollman, 2005: 319S).

2.2.1.3 Risk of excessive consumption

Adverse effects of polyphenol consumption on CVD have been reported in humans. Increased polyphenol consumption may increase the risk of CVD through an effect on homocysteinaemia, an independent risk factor of CVD (Olthof *et al*., 2001: 532). Skibola and Smith (2000: 380) indicate that exposure to elevated flavonoid levels, whether through the diet or supplementation, may overwhelm the system and lead to the development of ROS and eventually DNA damage. Toxicity has been found on consumption of quantities ranging from 1 to 1.5 g/day of flavonoid drugs. It is important to remember, however, that a varied diet is unlikely to provide flavonoids in toxic quantities, as plant foods contain an assortment of flavonoids in varying quantities (Cook & Samman, 1996: 73). Plant foods high in tannins have been found to cause acute toxicity in animals (Clifford & Scalbert, 2000: 1118).

2.2.1.4 Effect of food processing

Methods of culinary preparation may affect the polyphenol content of foods. The peeling of fruit and vegetables results in losses of polyphenols, as these compounds commonly are present in greater levels in the skin and outer tissue layers (Manach *et al*., 2004: 731). Cooking may furthermore influence the loss of some polyphenols. The boiling of tomatoes and onions for 15 minutes has been found to reduce the quercetin content between 75 and 80%, while microwave cooking resulted in a 65% loss of quercetin and frying in a 30% loss. Steam cooking of vegetables therefore is preferred, as it avoids leaching of the phenolic compounds into the cooking water (Crozier *et al*., 1997: 590). Lombard *et al*. (2005: 578) assessed the quercetin content in onions after heat-treatment during household preparation and found that baking or sautéing increased the quercetin content by 7 to 25% compared to raw onion, while boiling only decreased the total quercetin concentration by 18%. Levels of flavonols in onions were not affected during refrigeration, frying and oven roasting in a study carried out by Rodrigues *et al*. (2009: 1331). Boiling onions for 30 minutes caused losses of quercetin glycosides through leaching into the boiling water,

while boiling for 60 minutes resulted in more severe effects, with the degradation of quercetin (Rodrigues *et al*., 2009: 1331).

Industrial processing also affects the polyphenol content. Dehulling of legumes and decortication and bolting may reduce the content of some polyphenols, while the grinding of plant tissue may cause oxidative degradation in polyphenols (Manach *et al*., 2004: 731). During the milling of whole grains, the germ and bran are removed, resulting in losses of phenolic acids and fibre (Slavin, 2000: 301S).

Fruit juice production frequently incorporates clarification or stabilisation aimed at removing specific flavonoids that cause the discolouration and cloudiness of the juice. Conversely, maceration operations allow for the dispersion of polyphenols in fruit juice, as occurs during the vinification of red wine, and results in wine with a polyphenol content of up to ten times greater than that of white wine and grape juice (Manach *et al*., 2004: 731). Furthermore, a study conducted by Leong and Oey (2012: 1582) found that heat application increased the anthocyanin content in plums, cherries and peaches, resulting in fruit with a higher anthocyanin content than their fresh counterparts. The application of heat causes the release of phytochemicals from chromoplasts, resulting in an increased concentration (Leong & Oey, 2012: 1582).

2.2.2 Allium compounds

Allium is the largest and most significant genus of the *Alliaceae* plant family and includes roughly 500 species (Sengupta *et al*., 2004: 237; Lanzotti, 2006: 4). *Allium* vegetables are rich in organosulphur compounds in addition to flavonols (Hsing *et al*., 2002: 1648). *Allium* vegetables such as garlic and onion are traditionally known for their antibacterial and antifungicidal properties (Dorant *et al*., 1996: 12).

2.2.2.1 Food sources

The most widely used food sources of the *Allium* genus are onions (*Allium cepa*), garlic (*Allium sativum*), leeks (*Allium porrum*), chives (*Allium schoenoprasum*) and shallots (*Allium ascalonicum*) (Sengupta *et al*., 2004: 237). The *Allium* compounds contain sulphur in the form of diallyl sulphide and allyl methyl trisulphide. Garlic also contains the amino acid allin which is enzymatically converted to allicin when the clove is crushed or cut. Garlic additionally contains the phenolic compound allixin (Simon, 2002: 94).

2.2.2.2 Health benefits

The results from a study carried out by Boivin *et al*. (2009: 375) identified various commonly consumed vegetables containing anti-proliferative activities towards cancer cells of the stomach, kidneys, prostate, breasts, brain, pancreas and lungs. All members of the *Allium* family tested in the study were potent inhibitors of tumour cell proliferation, with the extract from garlic found to be the strongest inhibitor. Leek and immature (green) and mature (yellow) onions were also highly inhibitory against most cells, although green onion was less active against tumour cells from the kidney. Increased intakes of *Allium* compounds have been associated with a reduced risk of several types of cancers in epidemiological studies (Sengupta *et al*., 2004: 237).

Some components of the *Allium* vegetables have been found to suppress certain stages of carcinogenesis. The organosulphur compounds present in *Allium* vegetables are said to be responsible for its anti-carcinogenic properties (Sengupta *et al*., 2004: 237). The volatile organosulphur compounds, named thiosulfinates, are responsible for the pungent taste in onion and garlic and give rise to disulphides and trisulphides, which exhibit pharmacological actions. However, these compounds are unstable and, for this reason, focus has been shifted to the more stable compounds present, specifically the sapogenins, saponins and flavonoids (Lanzotti, 2006: 20).

Research is mounting to support the hypothesis that diets high in *Allium* compounds are protective against stomach cancer (Yuan *et al*., 2004: 169; Shukla & Kalra, 2007:167; Zhou *et al*., 2011: 80). The antibacterial actions of allicin in the reduction of the bacterial conversion of nitrate and nitrite in the stomach may limit the development of nitrosamines that may be carcinogenic. A potential mechanism of action is the anti-nitrosating and nitrite scavenging action of the sulphur compounds. It has also been proven that garlic has the potential to kill *Helicobacter pylori (H. pylori) in vitro*. Since *H. pylori* infection increases the risk of stomach cancer, the antibacterial activity of garlic may protect against the formation of stomach cancer (Ernst, 1997: 82).

2.2.2.3 Risk of excessive consumption

Excessive intakes of concentrated garlic preparations may result in adverse effects on human health that include anaemia development, reduced weight and toxicity to the liver, heart and kidney, in addition to causing chromosomal breaks (Banerjee *et al*., 2003: 99). Doses of 4 mL/kg raw garlic juice or 100 mg/kg garlic oil were found to be lethal to rats

(Banerjee *et al*., 2003: 103). A study revealed that elevated doses of 500 mg/kg orally administered to rats resulted in lung and liver tissue damage (Ali *et al*., 2000: 67).

2.2.2.4 Effect of food processing

Thiosulfinates are volatile sulphur compounds, typically found in *Allium* plants, and are responsible for their distinctive pungent aroma and taste. These compounds are highly unstable and, as a result, focus has shifted to the polar compounds present that are more stable during processing and storage (Lanzotti, 2006: 4). Regarding the more stable compounds, a study was conducted by Takenaka *et al*. (2004: 405) to determine the effect of processing on the antioxidants in onion soups prepared using different cooking methods. Most of the flavonoids were retained after sautéing the onions. However, high amounts of the flavonoids were lost after frying the onions. A plausible cause for the reduced flavonoid levels in the soup prepared using fried onions is that flavonoids were removed with the surface oil during cooking due to the higher quantity of oil used during frying. To investigate the above, a further study was conducted using the same recipe with fried onions, but which assessed the losses in flavonoids. The results indicated that the flavonoids in the fried onions were partially dispersed in the oil and discarded, with additional losses caused by degradation and aggregation as a result of the thermal heating (Takenaka *et al*., 2004: 406). Rodrigues *et al*. (2009: 1331) studied the effect of cooking on the flavonol and anthocyanin levels in onion. The results of the study found that chopping, refrigerated storage, oven roasting, frying and moderate microwave cooking did not greatly affect the levels of flavonols. Intense microwave cooking, however, resulted in flavonol losses of between 16 and 18% for quercetin. Boiling onions for 30 minutes resulted in losses of quercetin due to dispersion into the cooking water. Extreme frying resulted in anthocyanin degradation and consequently colour loss.

2.2.3 Carotenoids

The most abundant pigments in nature are the carotenoids, which deliver yellow, orange and red colours to various plants (Avital & Jablonka, 2000: 151). Their role as provitamins and their ability to act as antioxidants have received major interest in them as compounds (Liu, 2007: 209). Amongst the large carotenoid family, alpha-carotene, beta-carotene, beta-crytoxanthin, lutein and lycopene contribute greatly to the total carotenoids found in fruits and vegetables (Leong & Oey, 2012: 1582).

2.2.3.1 Food sources

The two major dietary sources of vitamin A are readily absorbed retinyl palmitate in foods of animal origin, and provitamin A carotenoids that are poorly bioavailable in plants (Thurnham & Northrop-Clewes, 1999: 449). The main precursors of vitamin A are alpha-carotene, beta-carotene and beta-cryptoxanthin, which cannot be produced within the body and must be supplemented through the diet (Leong & Oey, 2012: 1582). Deeply pigmented fruit and vegetables are major dietary sources of carotenoids, with yellow-orange fruit and vegetables providing the majority of alpha-carotene and beta-carotene. Orange fruits provide most of the alpha-cryptoxanthin, with dark green vegetables providing lutein, and tomatoes or tomato-based products providing lycopene (Rao & Rao, 2007: 208).

2.2.3.2 Health benefits

Epidemiological research has established an association between increased dietary intake and tissue concentrations of carotenoids and a reduced risk of chronic diseases (Agarwal & Rao, 2000: 189; Johnson, 2002: 47). Epidemiological research also suggests that vitamin A and carotenoids can contribute to reducing the prevalence of heart disease (Ito e*t al*., 2006: 154). While there are discrepancies in the findings from human studies, experimental studies continue to reveal the effectiveness of these compounds in mitigating and defending against many forms of CVD (Ito e*t al*., 2006: 154; Buijsse *et al*., 2008: 334). Beta-carotene and lycopene have been shown to reduce the risk of CVD and some cancers, whereas lutein and zeaxanthin have been found to protect against disorders related to the eyes (Rao & Rao, 2007: 209).

Several studies have demonstrated a decreased risk of cancer linked to an increased intake and level of serum lycopene (Kucuk *et al*., 2001: 861; Giovannucci *et al*., 2002: 391; Rao & Rao, 2004: 127; Rao *et al*., 2006: 99). Lycopene has received major interest due to its role in reducing prostate cancer risk (Cooper, 2004: 222S). Lycopene has been found to considerably reduce the levels of oxidised LDL, as well as lower serum cholesterol levels, thereby reducing CVD risk (Agarwal *et al*., 2001: 9). The awareness of lycopene as a powerful antioxidant and its preventative role in oxidative stress-mediated diseases has resulted in researchers investigating its role in other human diseases (Engelhard *et al*., 2006: 100.e1).

Beta-carotene has received major attention not only due to its role in human health as a vitamin A precursor, but also because of the association between dietary beta-carotene intake and chronic disease prevention (Garcia *et al*., 2010: 24), most notably cancer

(Cooper, 2004: 222S). Many carotenoids contain an extended system of conjugated double bonds, resulting in strong antioxidative activity (Sies & Stahl, 1995: 1318S). The antioxidant properties of carotenoids are thought to be their main health benefit. Carotenoids may mediate their effects though immune response, cell growth regulation, gap junction communication and modulating gene expression (Rao & Rao, 2007: 209).

2.2.3.3 Risk of excessive consumption

Hypercarotenaemia or high serum concentrations of carotene may result when individuals take dietary supplements containing 20 mg or more of beta-carotene for extended periods. Hypercarotenaemia has also been observed in individuals who consume large quantities of foods rich in beta-carotene. Symptoms include yellow palms and soles. However, these symptoms disappear with reduced intake (Mann & Truswell, 2012: 212). In an alpha-tocopherol beta-carotene study supplementation of beta-carotene at pharmacological levels increased the incidence of lung cancer in smokers (Alpha-Tocopherol Beta Carotene Cancer Prevention Study Group, 1994: 1029). Mortality from CVD was also increased in a group of smokers, former smokers and asbestos-exposed individuals in a beta-carotene and retinol efficiency trial (Omenn *et al*., 1996: 1150). According to Rao and Rao (2007: 210) the findings of the above studies suggest that beta-carotene is beneficial to health when consumed at normal dietary intake levels, but may cause adverse effects when consumed in large quantities.

2.2.3.4 Effect of food processing

Major losses of carotenoids do not occur as a result of leaching into water-soluble mediums during processing and storage, as they are lipid soluble. They are, however, susceptible to oxidation (Rickman *et al*., 2007: 1187). Lycopene has been demonstrated to be stable during thermal processing and storage, and absorbed more effectively from processed tomato-based products than raw tomatoes (Agarwal *et al*., 2001: 9). This is due to the greater absorption of cis-isomers of lycopene in processed tomato-based products (Rao & Rao, 2007: 211).

A positive effect has been established during heat processing on beta-carotene, as the antioxidant levels increase instantly after heating by 34.3%. It has been proven conclusively that, while epoxy carotenoids are fairly sensitive to heat, lutein and hydrocarbons such as neurosporene, alpha- and beta-carotene, lycopene, phytofluene and phytoene can withstand processing (Kaur & Kapoor, 2001: 713).

2.3 South African dietary intake of phytochemicals and their food sources

Knowledge of the dietary total antioxidant capacity (TAC) may be helpful in supporting health and preventing disease (Rautenbach & Venter, 2010: 753), as antioxidant nutrition is the exogenous source of antioxidant defences in the body (Sen *et al*., 2010: 93). This indicates that the dietary intake of antioxidant phytochemicals may need to be enhanced to support the dietary TAC (Kearney *et al*., 2005: 982). An exploratory study calculated the mean daily dietary TAC per person in SA from secondary dietary intake data and compared it to the suggested mean daily dietary TAC per person pertaining to the recommended intake of fruit and vegetables, legumes, whole grains and beverages. The mean South African daily dietary TAC per person was found to be almost 50% less than the calculated suggested TAC per person per day (Louwrens *et al*., 2009: 199).

2.3.1 Fruit and vegetables

National and international health promotion agencies recommend a minimum of five portions, equalling 400 g of fruit and vegetables daily, but these recommendations are not being met globally (Love & Sayed, 2001: S29). The 5-A-Day for Better Health Programme was initiated jointly in the USA by the National Cancer Institute and the Produce for Better Health Foundation in 1991 to modify the dietary behaviour of American adults. The aim of the programme is to encourage individuals to consume a minimum of five servings of fruit and vegetables every day. Several countries have subsequently adapted these recommendations and started similar campaigns (Ungar *et al*., 2013: 200). The United Kingdom's (UK) Food Standards Agency recommends '5-A-Day' and 'Eat a wide variety of fruit and vegetables and aim for at least five portions a day' (Capacci & Mazzocchi, 2011: 90). The Danish Veterinary and Food Administration, which includes the Danish Cancer Society, recommend '6-A-Day', consisting of three fruit and three vegetable servings, equating to 600 g daily (The International Fruit and Vegetable Alliance, 2013). While recommendations by the Greek Ministry of Health are '9-A-Day', consisting of three fruit and six vegetable servings (Supreme Scientific Health Council, Ministry of Health and Welfare of Greece, 1999: 522), the USA announced it should be '7-A-Day' for most adults, specifically four servings of vegetables and three of fruit (Lang, 2005: 732). The recommendation of the 5-A-Day for Better Health Trust in SA is consistent with the South African food-based dietary guidelines for individuals older than two years of age to consume plenty of fruits and vegetables every day (About 5-A-Day, 2000: 5). The South Africa Comparative Risk Assessment was re-analysed to determine the mean fruit and vegetable consumption in g/day for adults older than 15 years of age (Schneider *et al*., 2007: 717). Per capita fruit and

vegetable consumption was found to be just under three servings (325 g per day in males and 226 g per day in females) (Naude, 2013: S49), which is considerably lower than the recommended intake of fruit and vegetables per day.

2.3.2 Whole grains

The major whole grains include wheat, rice and corn, and the minor grains include oats, barley, sorghum and millet (Slavin *et al*., 1999: 459S). Whole grains contain unique phytochemicals that complement those of fruit and vegetables when consumed synergistically (Liu, 2007: 207). Evidence is lacking to determine the exact number of daily servings of whole grain foods that are necessary for optimum health. However, recommendations by the American Dietetic Association suggest a minimum of three servings of whole-grain foods daily (Adams & Engstrom, 2000: 340S). Food products made from refined grains are mostly produced and consumed (Smith *et al*., 2003: 455). The dietary guideline in SA is to eat starchy foods in the form of minimally processed or whole grains (Vorster, 2013: S28). However, urban lifestyles in SA are characterised by changes in dietary habits that include an increase in the consumption of refined grains and a reduction in fibre intake (Vorster, 2013: S34). South Africans consume an average intake of less than 20 g dietary fibre daily (Steyn, 2006: 33).

Cereals are economical dietary sources of energy and consequently form the staple food for numerous populations in Africa (Galati *et al*., 2014: 317). Maize, bread and rice are consumed by the majority of South Africans. An increase in the consumption of unrefined grains and cereals should be encouraged for improved nutritional status (Vorster & Nell, 2001: S24). Whole grains are high in dietary fibre and low in fat, whereas refined grains have had most of the bran and some of the germ removed, resulting in losses of dietary fibre, minerals, vitamins, lignans, phytoestrogens, phenolic flavonoid compounds and phytic acid (Slavin *et al*., 1999: 459S).

2.3.3 Herbal tea and tea

Rooibos herbal tea (*Aspalathus linearis*) is indigenous to SA and is becoming increasingly popular due to its health benefits. South African consumers who drink rooibos herbal tea are said to drink approximately six cups per day, with one 150 mL cup said to contain 1.5 mg quercetin, one of the many flavonoids found in this beverage (Joubert & Ferreira, 1996: 37). The production of rooibos herbal tea includes the shredding of the plant, which is then fermented at an ambient temperature and finally sun dried. The resulting oxidation of the

phenolic compounds present leads to a tea with a mildly sweet flavour and that is red-brown in colour (Joubert *et al*., 2008: 387; Joubert *et al*., 2009: 702). Green, or unfermented rooibos herbal tea, has a higher phenolic content due to the limited oxidative changes that take place through predominant rapid sun drying (Joubert *et al*., 2008: 387). Most of the tea processed globally can be classed as non-fermented/aerated green tea, semi-fermented (oolong) tea and fermented black tea, although processing has diversified, resulting in speciality teas, namely white tea, flavoured teas, organic teas, decaffeinated teas, herbal teas, scented teas and various other blended teas (Karori *et al*., 2007: 2287).

Tea is the most commonly consumed beverage worldwide after water, with an average *per capita* of 120 mL per day, and it contributes significantly to the dietary intake of flavonoids (Hogenkamp *et al*., 2008: 430). Black tea is frequently consumed in Western countries and typically contains 200 mg of flavonoids per cup (Gardner *et al*., 2007: 3). Data on the consumption of black tea derived from Euromonitor International, which used sales data from 2009, revealed the consumption (kg/year) data for black tea per capita to be highest in Ireland (2.1576), UK (1.8137), Turkey (1.6631), and Russia (1.0668). The lowest per capita consumption of black tea was observed in South Korea (0.0007), Brazil (0.001), and China (0.0011), as the Chinese population drink 30 times more green tea (0.036 kg per inhabitant) than black tea (Beresniak *et al*., 2012: 3).

The results of a number of food consumption surveys conducted in SA were summarised by Nel and Steyn (2002: 93). In their report they indicated that the mean intake per person per day of the beverage tea, which contributed to the intake of phytochemicals (Louwrens *et al*., 2009: 196), was only 441.4 g per person (Nel & Steyn, 2002: 92). This tea consumption, expressed as 2½ servings (441.4 g) per person per day, was less than the advised serving of four to six cups daily (Elhatton, 2002: 21), with one cup as a serving of 190 g (Langenhoven *et al*., 1992: 148). Tea consumption in SA therefore may not be considered adequate, as the intake is approximately half that of the minimum intake suggested by Elhatton (2002: 21).

2.3.4 Spices and herbs

Spices, as defined by the United States (US) Food and Drug Administration (FDA), are aromatic plants in whole, broken or ground form. In contrast, herbs used in cooking typically comprise plant leaves and stems (US Food and Drug Administration, 2009). Spices may consist of the aromatic seeds (cumin), bark (cinnamon), buds (cloves), berries (peppercorns), roots (ginger) and even the stigma of the flower (saffron) (Tapsell *et al*.,

2006: S5). Numerous spices and their oils have been found to possess antimicrobial properties (Oiye & Muroki, 2002: 39) and act as antioxidants (Oiye & Muroki, 2002: 43). Spices and herbs have been found to possess high levels of antioxidants, although they are only used in small quantities in food (Carlsen *et al*., 2010: 18).

Aromatic herbs contain an abundance of phenolic compounds concentrated in only a few grams. Their addition to dishes can provide increased phenolic content and antioxidant capacity in the human diet (Zheng & Wang, 2001: 5165). A study conducted by Ninfali *et al*. (2005: 264) set out to determine the antioxidant capacity of aromatic herbs relevant to nutrition. The study found sage, marjoram, rosemary and garden thyme to possess powerful oxygen radical absorbance capacity (ORAC). These aromatic herbs are rich in rosmarinic acid, a powerful antioxidant (Zheng & Wang, 2001: 5165). Therefore, a diet in which herbs and spices are used to flavour food can promote health and protect against chronic diseases through the various phytochemicals they provide (Craig, 1997: S203).

A report by Nel and Steyn (2002: C26) summarised secondary data obtained from 24-hour recall dietary assessments of different South African adult populations and found that only one percent of the adult sample used herbs and spices on the application days of the 24-hour recall. The mean use per person for these users was calculated to be 3.5 g per day. This suggests that herb and spice use is not a common daily practice in many South African households. Global usage of herbs and spices has increased with grocery stores providing a wider variety of herbs and chefs adding plentiful herbs to dishes (Tapsell, 2008: 137). The use of herbs amongst consumers in SA may consequently have increased since the publication by Nel and Steyn (2001: C26) and calls for current data to be collected on the herb use and consumption of South Africans.

2.4 Strategies to enhance dietary phytochemical intake and/or food source intakes

Research indicates that phytochemicals should be obtained from a balanced diet encompassing a wide variety of fruit, vegetables, whole grains, and other plant foods, and not in the form of dietary supplements (Liu, 2013: 384S). When studied in clinical trials, the antioxidants in supplements do not appear to provide consistent preventative effects when compared to those in food. The isolated pure compound does not behave in the same way as it would in food and loses its bioactivity (Liu, 2004: 3483S). Dietary supplements will also only provide some components in a concentrated form, and not an assortment of phytochemicals that food would naturally provide (Liu, 2013: 389S). Natural phytochemicals at low levels provide protective effects, but may not be safe when higher doses are

consumed, even in a pure dietary supplement form, and may increase the risk for toxicity (Liu, 2003: 519S). Strategies to enhance dietary phytochemical intake are discussed below.

2.4.1 Household strategies

One way for consumers to optimise their phytochemical intake is to consume greater intakes of an assortment of fruit, vegetables (Battino & Mezzetti, 2006: 1099) and whole grains (Battino & Mezzetti, 2006: 1099; Liu, 2007: 217) on a daily basis. Practical recommendations for enhanced vegetable and fruit intake include adding vegetables to pasta and rice dishes, incorporating vegetables such as onions, peppers, tomatoes and mushrooms in egg dishes, adding fresh fruit such as bananas, apples, grapes and berries to breakfast cereals, baking fruit of the season for dessert, making fruit kebabs, eating raw chopped fruit and vegetables as a snack, and drinking fruit and vegetable juices (Love & Sayed, 2001: S30). The 5-A-Day campaign suggests including one 200 mL serving of fresh fruit/vegetable juice or 100% pure unsweetened fruit/vegetable juice as a method to achieve one serving of fruit and vegetables a day (About 5-A-Day, 2000: 5). There is a growing concern regarding the excessive intake of fruit juice and the impact on human health, which would support limiting daily fruit juice intake. In a large cohort of women, an increased consumption of fruit juice (more than 3 cups of apple juice per month compared to those who consumed less than 1 cup of apple juice per month) was associated with type-2 diabetes, while whole fruit was not (Bazzano *et al*., 2008: 1311). Although Schulze *et al*. (2004: 927) did not find an association between fruit juice consumption and type-2 diabetes; they did find a positive association with weight gain. Although fruit juice can provide some vitamins and minerals, they are typically high in sugar and should therefore be consumed in moderation (Malik *et al*., 2010: 1361). Whole grains contain an assortment of unique bioactive phytochemicals (Liu, 2007: 217). Adding whole grains such as barley, oats, brown rice and quinoa to casseroles, soups or stews is a simple and convenient way to increase whole-grain consumption (Adams & Engstrom, 2000: 342S).

It is essential to recognise the vegetables with the highest antioxidant capacity and to frequently incorporate them into the diet. It is equally essential to know how much antioxidant capacity is lost by cooking vegetables (Ninfali *et al*., 2005: 257). A study by Ninfali *et al*. (2005: 264) assessed the losses of phenolics and antioxidant capacity in vegetables that require cooking. The findings indicated that steamed vegetables retained nearly 80% of the phenolic and the ORAC of raw vegetables, while boiled vegetables retained only 30% of antioxidants, with losses of flavour also occurring. It therefore is recommended to steam vegetables at the lowest temperature for the shortest time to retain the phenolic content and

vitamins of the vegetable (Ninfali *et al*., 2005: 264). Considering the above recommended cooking method, the cooking water is a potentially rich source of dietary antioxidants and should be incorporated into soups and gravies for optimum antioxidant intake (Wachtel-Galor *et al*., 2008: 709). When measuring the TAC in vegetables processed under different conditions, Hunter and Fletcher (2002: 405) found that frozen vegetables have similar antioxidant levels to their counterparts when bought fresh. This is an important consideration for those who lack the time and culinary skill in the kitchen.

2.4.2 Prospective commercial strategies

The food industry often removes phenols, flavonoids, isoflavones, terpenes and glucosinolates from plant-based foods, as these compounds are typically bitter, acrid or astringent and their adverse flavour often makes them less appealing to the consumer (Sun-Waterhouse & Wadhwa, 2012: 607). The removal of these compounds is conducted through selective breeding and de-bittering processes. This poses a problem in functional food development, because enhancing the content of bitter phytochemicals may be undesirable amongst consumers. Methods to incorporate phytonutrients into a selection of foods to enhance sensory appeal are continuously being investigated by the food industry (Drewnowski & Gomez-Carneros, 2000: 1424).

Various technologies have been developed to overcome barriers to increased fruit and vegetable consumption. These technologies have overcome barriers of convenience (pre-cut, pre-packaged) and taste (addition to other foods, fruit juice mixtures) (Cooper, 2004: 223S). Fruit bars, for example, can overcome barriers to increased fruit consumption. Fruit bars have a high nutritional value and antioxidant activity and are a convenient way to obtain concentrated nutrients preserved in the fruit (Orrego *et al*., 2014: 84). Newer technologies include the enrichment of fruit and vegetables *via* biotechnology or traditional plant breeding, the availability of dehydrated vegetables, the fortification of foods or use of antioxidant mixtures or individual phytochemicals in dietary supplements. The latter alternative tends to be more controversial due to insufficient studies proving the benefit from isolated phytochemicals (Cooper, 2004: 223S).

2.4.2.1 Plant biotechnology

The association between high dietary intakes of fruit and vegetables rich in phytochemicals and the reduced risk of chronic diseases has presented new opportunities to develop food crops with uniformly high levels of naturally occurring antioxidants (Tsao *et al*., 2006: 781).

The concentration of phytochemicals can vary substantially amongst different plants, with the levels being fairly low or non-existent in some plants; therefore methods are being developed to enhance the quantity of phytochemicals in certain crops (Grusak, 2002: 508). Enhanced levels of antioxidant phytochemicals in fruit and vegetables can be accomplished through traditional breeding or through genetic engineering (Henning *et al*., 2014: 61). Conventional breeding is a long term initiative and only few programmes have led to the commercial production of fruit and vegetables enriched with phytochemicals (Tsao *et al*., 2006: 782). Biotechnology can enhance the quality, reliability and productivity of plant crops which, in turn, will be beneficial to farmers, consumers and the environment (Levinson & Thomas, 2013: 58). Biotechnology uses biological systems, living organisms or components of organisms to create or modify plants or processes. Modern biotechnology can transfer a desirable genetic trait from any plant into the genetic make-up of another plant (Hsieh & Ofori, 2007: 69). The use of breeding and/or biotechnology to enhance the antioxidant content of fruit is an important undertaking, as it can provide for higher antioxidant consumption amongst individuals, especially those who consume little or no fruit (Battino & Mezzetti, 2006: 1099).

2.4.2.2 Food trials

A number of food trials have been undertaken as research efforts to enhance dietary phytochemical intake. Various plant and animal food sources, in addition to beverages, have been used as food vehicles incorporating various phytochemical-rich additions applied in these investigations. These efforts provide many possible applications the food industry could consider for use and/or further development work.

2.4.2.2.1 Baked goods and flour

Bread is a staple food worldwide and is typically produced using wheat flour, yeast and salt. Nowadays, a growing number of consumers prefer to eat more nutritious foods for the prevention of non-communicable diseases (Fan *et al*., 2006: 1158). Consequently, the food industry and researchers are involved in optimising bread-making technology to improve the quality, taste and nutritional value of breads. Amongst the ingredients that can be incorporated into bread formulations are herbs and spices for enhanced flavour, colour and aroma, as well as to act as preservatives and antioxidants (Balestra *et al*., 2011: 700). A study conducted by Balestra *et al*. (2011: 701) investigated the effects of adding ginger powder to bread for enhanced antioxidant content. The results indicated that incorporating

three percent ginger powder was acceptable on a sensory level and doubled the antioxidant content in comparison to the control (refer Table 2.1).

Table 2.1: Trials in which foods have been enhanced with functional ingredients for enhanced phytochemical content

Title of the trial	Food vehicle	Enhanced functional property	Type and quantity of raw material used as functional ingredient	Outcome	Reference
Evaluation of antioxidant, rheological and sensorial properties of wheat flour dough and bread containing ginger powder	Bread	Antioxidants	Ginger powder added to bread formulation at 0, 3, 4.5 and 6%	Good rheological characteristics, highest sensory acceptability and double anti-oxidant content found at 3% addition.	Balestra *et al*., 2011: 701
Comparison study of the effect of green tea extract on the quality of bread by instrumental analysis and sensory evaluation	Bread	Catechins	Green tea extract incorporated into bread at levels of 1.5 and 5.9 g/kg flour	Sensory analysis found uncompromised sensory quality of green tea extract-fortified bread. 84% of total tea catechins remained after baking.	Wang *et al.,* 2007: 470
Quality and antioxidant property of green tea sponge cake	Sponge cake	Catechins and dietary fibre	Green tea powder incorporated into sponge cake at 0%, 10%, 20% and 30%	Sensory analysis found 30% addition to be slightly bitter. Green tea cake contained a greater variety of catechins and possessed good antioxidant activity.	Lu *et al*., 2010: 1090
Dietary fibre and phenolic compounds from apple skins	Muffins	Dietary fibre and phenolic compounds	Apple skin powder was incorporated into muffins at six levels (0%, 4%, 8%, 16%, 24% and 32% w/w[a])	Increased dietary fibre, total phenolic content and total antioxidant capacity.	Rupasinghe *et al*., 2008: 1217
Raspberry pomace as a potential fibre source for cookies enrichment	Biscuits	Dietary fibre	Crumbled and non-crumbled raspberry pomace at levels of 25 and 50%	Increased dietary fibre content rich in cellulose and lignin, highest in the 50% non-crumbled raspberry pomace sample. No negative organoleptic characteristics.	Górecka *et al*., 2010: 451
Effects of incorporation of integral raw materials and dietary fibre on the selected	Biscuits	Phenolic compounds and dietary fibre	Inulin (10.5%) combined with either soy flour (24.5%) or amaranth (24.5%) or carob (24.5%) or apple fibre (16.5%) or	Increased total dietary fibre in all samples. Increased phenolic content in all samples	Vitali *et al*., 2009: 1462

Table 2.1 (continued)

Title of the trial	Food vehicle	Enhanced functional property	Type and quantity of raw material used as functional ingredient	Outcome	Reference
nutritional and functional properties of biscuits			oat fibre (16.5%)	except oat fibre. Antioxidant activity determined physiologically (gastrointestinal digestion) and chemically and was highest in samples with carob, soy and apple fibre.	
Physicochemical properties of hull-less barley fibre-rich fractions varying in particle size and their potential as functional ingredients in two-layer flat bread	Two-layer flat bread	Dietary fibre	20% barley fibre-rich fractions	Increased phenolic compounds, vitamins and minerals, as well as increased total fibre.	Izydorczyk *et al*., 2008: 561
Dietary fibre enhancement in cassava based composite flours through fortification	Cassava flour	Dietary fibre	Legumes (green gram, black gram, chickpea and horse gram flour), cereals (rice, whole wheat, refined wheat and finger millet flour), bran sources (rice bran and wheat bran) and other additions (banana peel flour and popped rice flour) in three proportions, *viz.* 90:10, 80:20 and 70:30	Considerable enhancement of dietary fibre observed through fortification with green gram and black gram flours, whole wheat flour and rice bran/wheat flour.	Jisha & Padmaja, 2008: 26
Effect of polyphenolic ingredients on physical characteristics of cheese	Cheese	Phenolic compounds	Nine different phenolic compounds (catechins, epigallocatechin gallate, tannic acid, homovanillic acid, hesperidin, flavones, grape extract, green tea extract and dehydrated cranberry powder) added at a total concentration of 0.5 mg/mL	Cheese curds containing polyphenolic compounds at a concentration of 0.65 mg/mL showed a decrease in curd moisture content with gel strength not affected. A rough and granular texture resulted with the addition of crude polyphenolic compounds.	Han *et al*., 2011: 494
Orange fibre as potential functional ingredient for dry-cured sausages	Dry-cured sausages	Dietary fibre and phenolic compounds	Orange fibre at five concentrations (0.5; 10; 15 and 20 g^{a}/kg^{a})	Added fibre and polyphenol, decreased nitrite levels.	Fernández-López *et al*., 2007: 1

Table 2.1 (continued)

Title of the trial	Food vehicle	Enhanced functional property	Type and quantity of raw material used as functional ingredient	Outcome	Reference
Mango peel powder: a potential source of antioxidant and dietary fibre in macaroni preparations	Macaroni	Dietary fibre, phenolic compounds, carotenoids and increased antioxidant activity	Mango peel incorporated into macaroni at three levels (2.5, 5.0 and 7.5%)	Sensory analysis found mango peel to be acceptable at 5% addition rate. Increased dietary fibre, polyphenol and carotenoid content and increased antioxidant activity.	Ajila *et al*., 2010: 219
Edible Japanese seaweed, wakame (*Undaria pinnatifida*) as an ingredient in pasta: chemical, functional and structural evaluation	Semolina pasta	Phenolic compounds	Wakame in the ratio of semolina pasta to wakame at 100:0; 95:5; 90:10; 80:20 and 70:30	Sensory analysis found wakame to be acceptable at a 20% addition rate. Uncooked seaweed pasta exhibited higher total antioxidant content.	Prabhasankar *et al*., 2009: 501
Enrichment of tomato paste with 6% tomato peel increases lycopene and beta-carotene bioavailability in men	Tomato paste	Carotenoids: lycopene and beta-carotene	Tomato paste enriched with 6% tomato peel	Increased lycopene content by 100% and increased absorption of carotenoids by human intestinal cells.	Reboul *et al*., 2005: 790
Increasing espresso coffee brew antioxidant capacity using phenolic extract recovered from hazelnut skin waste	Espresso coffee	Phenolic compounds	Seven groups of rats received 1 mL[a] of 1:2 diluted espresso mixed with food Group 1: control. Group 2: espresso coffee. Groups 3 to 5: phenolic extract espresso coffees fortified with hazelnut skin phenolic extract (180, 270 and 360 mg[a] respectively). Groups 6 to 7: phenolic extract espresso coffee fortified with post-brewing hazelnut skin phenolic extract (120 and 180 mg respectively)	Antioxidant potential of rat plasma showed increased *in vitro* and *in vivo* antiradical activity with added hazelnut skin phenolic extract. Hazelnut skin phenolic extract was more antioxidant active than phenolic fraction naturally present in espresso coffee.	Contini *et al*., 2012: 137

Table 2.1 (continued)

Title of the trial	Food vehicle	Enhanced functional property	Type and quantity of raw material used as functional ingredient	Outcome	Reference
Functional milk beverage fortified with phenolic compounds extracted from olive vegetation water, and fermented with functional lactic acid bacteria	Milk beverages	Phenolic compounds	Phenolic compounds extracted from olive vegetable water and fermented with γ-amino butyric acid added at a concentration of 100 and 200 mg/L[a] respectively	Fortified beverage showed the same phenolic composition as phenol extract from olive vegetable water but with a different ratio. Sensory analysis showed both addition rates to be acceptable.	Servili *et al*., 2011: 45
Bergamot: a source of natural antioxidants for functionalised fruit juices	Apple and apricot fruit juices	Ascorbic acid and phenolic compounds	Apricot and apple juices each fortified with bergamot at 10 and 20% concentrations respectively	Enhanced antioxidant and preserved ascorbic acid contents.	Pernice *et al*., 2009: 545
Extraction and utilisation of barley beta-glucan for the preparation of functional beverage	Beverage	Dietary fibre	Beta-glucan was incorporated at 0, 0.2, 0.4, 0.6, 0.8 and 1.0% levels	Sensory analysis showed an addition of up to 0.8% did not affect sensory parameters.	Din *et al*., 2009: 737

[a] Abbreviations: mL = millilitre; mg = milligram; w/w = weight per weight; g = gram; kg = kilogram; L = litre

Tea polyphenols have been utilised in a wide range of food and beverage applications (Wang *et al*., 2007: 470), with green tea a popular choice due to the awareness amongst consumers of its health benefits. The antioxidants present in green tea, namely catechins, can provide health benefits and delay oxidation during processing. Due to the enjoyment and high consumption of baked products, they act as food vehicles for bioactive compounds and dietary fibre. The antioxidants in green tea, when added to food, can provide beneficial health benefits and prevent oxidation during processing (Lu *et al*., 2010: 1091). A study conducted by Wang *et al*. (2007: 470) (refer Table 2.1) examined the changes in crumb appearance, texture properties and the taste profile of bread containing tea antioxidants. The study found that, when green tea extract was added to bread dough, the catechins were relatively stable in bread making, with 84% of the total tea catechins remaining after baking, as well as during the shelf life of the bread. The sensory evaluation results showed that the sensory appeal was not compromised on addition of green tea extract. Another study undertaken by Lu *et al*. (2010: 1091) (refer Table 2.1) investigated the sensory quality and antioxidant provision of incorporating green tea powder into sponge cake. The sponge cake incorporating green tea powder contained an assortment of catechins and possessed good antioxidant activity without compromising its sensory appeal.

An experiment was conducted in which apple peel, an excellent source of dietary fibre and phenolics, was incorporated into muffins. The effect of baking on the dietary fibre, phenolic content and the TAC of muffins when incorporating dried apple peel was evaluated in the experiment. The experiment yielded muffins with higher dietary fibre content, total phenolic content and TAC than the control (Rupasinghe *et al*., 2008: 1217) (refer Table 2.1).

The potential for biscuits to be fortified with raspberry pomace was investigated for enhanced dietary fibre content through the partial replacement of the flour in the recipe with 25 and 50% raspberry pomace respectively. The trial yielded a biscuit with increased total dietary fibre, rich in cellulose and lignin in all fortified samples, with the highest total dietary fibre observed in the sample fortified with 50% non-crumbled raspberry pomace. Consumer evaluation of the developed biscuits did not reveal any negative organoleptic characteristics (Górecka *et al*., 2010: 451) (refer Table 2.1). A standard wheat flour-based biscuit recipe formulation was supplemented with inulin in combination with one of five selected raw materials, namely soy flour, carob, amaranth, apple fibre and oat fibre. The outcome of this investigation presented an increase in the total phenolic content in all the samples except the sample supplemented with oat fibre. The increase in the total dietary fibre content ranged from 30.9% (sample supplemented with amaranth) to 130.6% (sample supplemented with oat fibre). The highest increases in the polyphenol content and antioxidant activity were found in the samples supplemented with carob, soy flour and apple fibre (Vitali *et al*., 2009: 1462) (refer Table 2.1).

Izydorczyk *et al*. (2008: 566) assessed the effectiveness of incorporating barley fibre-rich fractions as a high dietary fibre ingredient in two-layer flat bread. The study found that substituting 20% wheat flour with barley-rich fractions contributed those phytochemicals naturally present in the grain tissue, namely phenolics, in addition to vitamins and minerals. The addition of 20% barley fibre-rich fractions substantially increased the amount of total and soluble beta-glucan in the flat breads (refer Table 2.1). A further study (Jisha & Padmaja, 2008: 26) investigated the likelihood of increasing the dietary fibre levels through composite mixes of cassava flour fortified with legumes (black gram, green gram, horse gram and chickpea) and cereal (refined wheat, rice, finger millet and whole wheat) flours, bran sources and other additions (rice bran, popped rice flour, banana peel flour and wheat bran). Considerable enhancement of dietary fibre was observed through blending cassava flour with black or green gram flours, whole wheat flour and rice bran/wheat flour (refer Table 2.1).

2.4.2.2.2 Animal source foods

The effects of selected nutritional and functional properties of animal-derived food products, such as dry-cured sausages and cheese, on the incorporation of certain raw materials that are sources of dietary phytochemicals have also been investigated (refer Table 2.1). A study by Han *et al*. (2011: 494) investigated the effects of polyphenolic ingredients on the physical attributes of a novel cheese. Single phenolic compounds along with natural crude compounds were incorporated as functional ingredients during the cheese manufacturing process. The curd moisture was reduced on polyphenolic compounds incorporated at a level of 0.65 mg/mL, while the gel strength was unaffected. A rough and granular texture developed in the cheese when crude polyphenolic compounds were incorporated. Another study conducted by Fernández-López *et al*. (2007: 1) assessed orange fibre as a likely functional ingredient for dry-cured sausages by using by-products of oranges from the fruit juice industry. The addition of orange fibre into the sausages resulted in a major reduction in the residual nitrite level. This protective effect from oxidation, due to the reduced residual nitrite level, may inhibit the formation of nitrosamines and nitrosamides. Hesperidin, a phenolic compound in orange fibre, was assayed in the sausages with added orange fibre. Sausages with 20 g/kg orange fibre provided the highest hesperidin level.

2.4.2.2.3 Pasta

The effects of incorporating various raw materials, often by-products of food processing that are natural sources of dietary fibre, as well as phytochemicals such as phenolics and carotenoids, into regularly consumed food products for enhanced phytochemical content was also studied in a number of trials (refer Table 2.1). A study undertaken by Ajila *et al*. (2010: 219) used mango peel, the by-product of mango processing, at three different concentrations for incorporation into macaroni. The incorporation of mango peel at up to five percent yielded an acceptable product and provided a good source of phytochemicals, namely carotenoids, polyphenols and dietary fibre, and also exhibited improved antioxidant activity (Ajila *et al*., 2010: 219). Another study was conducted in which semolina pasta was fortified with wakame (*Undaria pinnatifida*) seaweed at various levels, and the sensory, cooking, nutritional and biofunctional quality of the pasta was evaluated. Wakame is a variety of brown seaweed that naturally contains carotenoids, fatty acids, phytosterols and various antioxidants. The study found that Wakame can be incorporated up to a 20% level in semolina pasta while remaining acceptable on a sensory level. The phenolic content was greater in the seaweed-containing pasta *vs* the control, while the uncooked seaweed pasta provided a higher total antioxidant content when compared to the cooked pasta. The total

antioxidant activity decreased beyond ten percent in the case of the cooked pasta. Cooking may have resulted in the bioactive components leaching into the water. In general, the increase in antioxidant activity that was found in the seaweed-containing pasta could be the results of the radical scavenging activities of the seaweed itself (Prabhasankar *et al*., 2009: 501).

2.4.2.2.4 Vegetable source foods

An experiment was conducted to evaluate the effectiveness of tomato paste enriched with tomato peel, a by-product of tomato processing, for increased carotenoid content. The inclusion increased the lycopene content by 100% without any adverse sensory changes (Reboul *et al*., 2005: 792). In an absorption study carried out on intestinal cells, the experimental tomato paste showed an increased absorption of carotenoids when compared to traditional tomato paste (Reboul *et al*., 2005: 793) (refer Table 2.1).

2.4.2.2.5 Beverages

The enrichment of various beverages using natural sources of dietary phytochemicals for added functionality have also been explored (refer Table 2.1). Hazelnut phenolics possess potent antioxidant properties beneficial to human health for diseased risk reduction, particularly CVD (Hackman *et al*., 2008: 195; Wang *et al*., 2011: 14). A study (Contini *et al*., 2012: 137) was undertaken that aimed at increasing the antioxidant capacity of a novel coffee-based beverage. The antioxidative effects of the espresso brew were examined *in vitro* and *in vivo*. Both post-brewing and pre-brewing phenolic-enriched espresso coffees were analysed for total phenols and screened for their *in vitro* antiradical ability, as well as the *in vivo* biological effect on the antioxidant potential of plasma in rats. The results showed post-brewing and pre-brewing hazelnut skin phenolic extract in espresso coffee allowed for the enhancement of the antioxidant activity of the brew, both *in vitro* and *in vivo*. The *in vivo* studies suggested that the hazelnut skin phenolic extract supported a higher antioxidant activity in rats with respect to the phenolics naturally present in coffee (Contini *et al*., 2012: 140). Servili *et al*. (2011: 45) conducted a study using phenolic compounds extracted from olive vegetation water and fermented with functional lactic acid bacteria for the fortification of milk beverages. The fortified beverages did not present any adverse sensory changes and both the functional milk beverages of different added ratios displayed the same phenolic composition as the phenol extract from the olive vegetable water, but with a different ratio between 3,4-dihydroxyphenylethanol and 3,4-dihydroxyphenylethanol-elenolic acid dialdehyde. A study (Pernice *et al*., 2009: 545) was also conducted to explore the use of

bergamot orange (*Citrus bergamia* Risso), a natural hybrid fruit derived from orange and lemon, for the enrichment and fortification of antioxidants in apple and apricot juice respectively. The addition of bergamot juice to apple and apricot juices preserved the content of ascorbic acid from thermal degradation and contributed enhanced antioxidant activity. Din *et al*. (2009: 737) explored the effects of the addition of beta-glucan extracted from barley in the preparation of a functional beverage. The addition of beta-glucan improved the sensory characteristics of the beverage in terms of acidity and viscosity, while sensory evaluation tests revealed the beverage containing 0.2% and 0.4% beta-glucan showed similar responses to that of the control. The incorporation of beta-glucan up to 0.8% did not affect the sensory parameters of flavour, colour and acceptability.

2.5 Specific foods and their health benefits for use to enhance dietary phytochemical intake

Epidemiological studies have revealed a reduced prevalence of CDL in individuals who consume fruit, vegetables, whole grains and other plant foods (Liu, 2013: 384S). The diverse phytonutrient and nutrient antioxidants naturally present in these foods are able to control oxidative reactions in the body, thereby decreasing the risk of major chronic degenerative diseases (Sen *et al*., 2010: 91). The myriad of compounds in tea, herbs, red wine, fruit, vegetables and whole grains and their beneficial health properties are discussed below.

2.5.1 Herbal tea and tea

The global consumption of tea is second to that of water. Tea is a commonly consumed beverage around the world; therefore, the health benefits of drinking tea can have a significant impact of human health. Black tea is the most commonly consumed tea around the world. Green tea is more popular in China, Japan and other Asian countries, but its popularity is increasing in Western populations (Hodgson & Croft, 2010: 496).

2.5.1.1 Rooibos herbal tea

Rooibos herbal tea is native to the Cederberg Mountains in the Western Cape. The stems and needle-like leaves of the plant are both bruised and fermented after sun-drying (McKay & Blumberg, 2007: 2). Green, or unfermented rooibos herbal tea, compared to the fermented or traditional rooibos herbal tea, is rapidly sun-dried, resulting in tea with a higher phenolic content (Joubert *et al*., 2008: 387, Joubert *et al*., 2009: 702). Rooibos herbal tea contains no caffeine, has a low tannin content compared to green or black teas (Iswaldi *et al*., 2011: 3643)

and is currently the only known natural source of aspalathin and nothofagin, which are unique phenolic metabolites with powerful antioxidant properties (Joubert, 1996: 403).

The phenolic metabolites in rooibos herbal tea act as potent antioxidants and play a key role in its therapeutic value. A study undertaken by Marnewick *et al*. (2011: 46) investigated the effect of rooibos herbal tea on biochemical and oxidative stress parameters in adults at risk for CVD. The results revealed the total plasma polyphenol levels to increase significantly after daily ingestion of the tea (six cups per day) for six weeks, while the serum LDL-cholesterol and triacylglycerol levels decreased significantly. Further human studies have established that aspalathin is absorbed and bioavailable in the human body with aspalathin metabolites present in the urine after ingestion of rooibos herbal tea (Courts & Williamson, 2009: 1104; Stalmach *et al*., 2009: 7104), with none present in the plasma (Stalmach *et al*., 2009: 7104). The absence of plasma metabolites suggests their low bioavailability, rapid turnover rate and removal from the circulatory system (Stalmach *et al*., 2009: 7110). Villaño *et al*. (2010: 679) assessed the effect of drinking 500 mL fermented and unfermented rooibos herbal tea on the TAC, lipid triacylglycerols, cholesterol and glycaemia plasma levels in humans. The study found, that after acute consumption of both of the teas, plasma antioxidant levels increased significantly, while the plasma triacylglycerols, cholesterol and uric acid levels remained unchanged. The results further indicated that unfermented rooibos herbal tea displayed a 28% higher *in vitro* antioxidant capacity compared to that of fermented rooibos (Villaño *et al*., 2010: 683).

2.5.1.2 Green and black tea

Green tea is produced from the dehydration of *Camellia sinensis* leaves. The heating process applied inactivates the enzyme polyphenol oxidase. The tea is then rolled, during which the leaves are twisted and cut. The final form of green tea is dependent on the variety being produced. The main flavonoids present in green tea include the flavanols (catechins). Catechins are a sub-group of flavonoids that comprise epicatechin (EC), epicatechingallate (ECG), epigallocatechin (EGC) and epigallocatechingallate (EGCG) (Hodgson & Croft, 2010: 497). Black tea is produced through the plucking, withering, maceration (rolling) and drying of the tea leaves. The most abundant polyphenols present in black tea are also the catechins, namely EC, ECG, EGC and EGCG (Łuczaj & Skrzydlewska, 2005: 911). Green tea leaves consequently contain more catechins, whereas black tea leaves, which undergo oxidation during production, contain more complex thearubigins and theaflavins (Rietveld & Wiseman, 2003: 3285S; Gardner *et al*., 2007: 4). Green and black tea have been found to possess a higher antioxidant activity against peroxyl radicals using the ORAC assay than

some vegetables, namely kale, garlic, spinach and Brussels sprouts (Cao *et al*., 1996: 3426). Using the Ferric Reducing Ability of Plasma (FRAP) assay, Langley-Evans (2000: 181) found the TAC of black tea to be lower than that of green tea.

The health benefits of green and black tea are thought to be predominantly related to the flavonoids consumed (Hodgson & Croft, 2010: 496). Plasma flavonoid levels are increased by 25% after drinking three cups of tea daily for two weeks (2 g dry tea per cup) (Hollman *et al*., 1997: 719). Isolated flavonoids found in tea have consistently been found to impair atherosclerosis development in animal models, and data indicates tea and tea flavonoids can improve endothelial function and enhance nitric oxide status (Hodgson & Croft, 2010: 495). Studies on humans have demonstrated that black tea flavonoids improve endothelial function (Schreuder *et al*., 2014: 145) and coronary circulation (Hodgson & Croft, 2010: 495), reducing the risk of CVD.

Population studies have demonstrated that an increase in green and black tea consumption is associated with a decreased risk of CVD, consistent with that of animal studies (Hodgson & Croft, 2010: 500). Peters *et al*. (2001: 495) conducted a meta-analysis of tea consumption in relation to CVD and found myocardial infarction risk to decrease by 11% with an increase in tea consumption of three cups daily. The meta-analysis considered ten cohort and seven case-control studies. Another meta-analysis revealed that the consumption of three cups per day of either green or black tea was linked to a reduced risk of ischaemic stroke (Arab *et al*., 2009: 1786). Tea flavonoids have additionally been found to lower LDL-cholesterol by 11.1% (Hodgson *et al*., 2006: 14). Green tea has been shown to have a positive effect on cardiovascular function through the inhibition of LDL-cholesterol oxidation due to the presence of EC and EGCG antioxidant activity (Cabrera *et al*., 2006: 88). The hypocholesterolaemic and antioxidant activity of tea may contribute to the protection against heart disease (Yang *et al*., 2009: 150).

Due to increasing research related to the health benefits of green tea, the US Food and Drug Administration intends to consider the enforcement of the qualified health claim pertaining to green tea and a reduced risk of breast or prostate cancer. Green tea products may be marketed in the USA using the following qualified health claim "*Green tea may reduce the risk of breast or prostate cancer although the FDA has concluded that there is very little scientific evidence for this claim*" (US Food and Drug Administration, 2012). A case control study encompassing 1 009 patients with breast cancer and 1 009 healthy control patients found the risk of breast cancer to significantly decrease with increased green tea consumption. A significant relationship was also found for increasing quantity, duration, and

frequency of green tea consumption (Zhang *et al*., 2007: 1074). Kurahashi *et al*. (2008: 71) examined 404 Japanese men newly diagnosed with prostate cancer at various stages in diagnosis (114 advanced, 271 localised, and 19 undetermined). The consumption of green tea was associated with a decreased risk of advanced prostate cancer for men drinking more than five cups per day. Epidemiological research suggests that green tea consumption may protect against the development of several types of cancers (Cabrera *et al*., 2006: 94). In a case control study in China, the frequent consumption of green tea was linked to a reduced prevalence of oesophageal cancer in women (Wang *et al*., 2007: 171). Green tea and its polyphenolic compounds have been shown to possess anti-mutagenic and anti-carcinogenic activity. In addition to having chemopreventative properties, green tea may also enhance the activity of chemotherapeutic agents (Cabrera *et al*., 2006: 94).

2.5.2 Herbs

Culinary herbs have been used to flavour food for many years. The flavour of herbs is typically due to the aromatic compounds present in their essential oils and oleoresins (Craig, 1999: S419). There are no clear distinctions between culinary herbs and spices in the scientific literature, with some plants considered to be both (Kaefer & Milner, 2008: 348). To date, numerous compounds have been recognised as potential modifiers of cancer, several of which are active ingredients in herbs (Singh *et al*., 2014: 66). Experimental studies on herbs have primarily been conducted on animals, thereby limiting researchers to determine the clinical effectiveness in humans. Despite these limitations, research indicates that the bioactive components found in herbs may act in isolation to lower cancer risk through their antioxidant, antimicrobial and anti-tumorigenic properties (Singh *et al*., 2014: 71).

Many herbs are the subject of on-going scientific investigations pertaining to their antioxidant properties and health. Epidemiological evidence suggests a correlation between increased dietary intake of antioxidants and a lower incidence of morbidity and mortality (Kaefer & Milner, 2008: 353). A wide variety of phenolic compounds and flavonoids present in herbs and spices are responsible for their potent antioxidant, anti-mutagenic, and anti-carcinogenic activities (Prasad *et al*., 2004: 521). The phenolic compounds and flavonoids such as quercetin, which are present in herbs, are recognised for their ability to scavenge ROS (Tapsell, 2008: 134). In addition to flavonoids, numerous herbs contain the cancer chemoprotective compounds phytosterols, triterpenes, saponins and carotenoids (Craig, 1999: S494). Herbs which have been found to possess anti-cancer activity and can be used for cancer-chemoprevention include ginger, liquorice, flax, turmeric, celery and parsley (Singh *et al*., 2014: 66). A study by Zheng and Wang (2001: 5165) evaluated the antioxidant

activity in the hydrophilic fractions of 39 fresh herbs and found oregano, marjoram and dill to possess the highest antioxidant capacity. Wu *et al*. (2004: 4027) measured the antioxidant capacity of hydrophilic and lipophilic fractions of 16 dried spices and found that the lipophilic ORAC fractions of clove, ginger, black pepper and turmeric to be higher than the hydrophilic ORAC fractions. This indicates the essential oils in these spices contain a substantial amount of antioxidants (Wu *et al*., 2004: 4031).

The antiviral and antimicrobial properties of plants are being examined for their ability to inhibit pathogens, as several bacterial infections are now recognised as a prominent cause of cancer in humans. A preliminary screening of 35 different herbs and spices demonstrated potent antimicrobial activities against *Bacillus subtilis*, *Escherichia coli* and *Saccharomyces cerevisiae* (Lampe, 2003: 581S). The antimicrobial activities of thyme and oregano are said to be due to their essential oils, which contain the terpenes carvacrol and thymol (Oiye & Muroki, 2002: 42).

Over the years, free radicals, through initiating oxidative reactions, have been shown to contribute to CVD development and progression. The high antioxidant capacity of herbs has the potential to inhibit the oxidation of LDL-cholesterol (Aggarwal & Aggarwal, 2011: 2; Sharma *et al*., 2013: 27). Similar to fruit and vegetables, herbs contain numerous classes of antioxidants in varying amounts and can significantly contribute to the total dietary antioxidant intake. It has been found that the total phenolic content of culinary use herbs ranges from 0.23 mg to 2.85 mg gallic acid/g fresh weight (Zheng & Wang, 2001: 5165), which is relatively high in comparison to the content of most other foods (Dragland *et al*., 2003: 1289). Herbs may also possess possible hypocholesterolaemic activity. Individuals with elevated blood cholesterol experience a profound reduction in LDL-cholesterol and triacylglycerol concentrations after the consumption of powdered fenugreek seeds without any change in high-density lipoprotein (HDL)-cholesterol levels (Sharma *et al*., 1991: 145).

2.5.3 Red wine

The phenolic profile of wine is different to that of fresh grapes due to changes that occur during processing. Red wine contains numerous polyphenolic compounds, many of which are found in the skin and seeds of the grape (Liu & White, 2012: 5). Red wine is produced by fermentation of the grape juice in the presence of grape solids (Cordova *et al*., 2005: 431). Red wine is therefore considered to have greater antioxidant content than white wine as a result of the presence of the skin and seeds of the grape (Bertelli & Das, 2009: 468). During the production of white wine the skin and seeds are removed immediately from the must,

which is left to ferment (Fernández-Mar *et al*., 2012: 797). A bottle of red wine contains 1.8 g/L of polyphenols, whereas a bottle of white wine contains 0.2 to 0.3 g/L of polyphenols (Bertelli & Das, 2009: 468). Red wine has an excellent antioxidant capacity due to its high levels of phenolic compounds (tannins and anthocyanins), which are able to scavenge free radicals (Kaur & Kapoor, 2001: 709).

Red wine plays a significant role in the diet, which can be explained partly through the "French Paradox" (Kaur & Kapoor, 2001: 708). In many countries an increased saturated fat intake is correlated with greater CHD mortality (Renaud & De Lorgeril, 1992: 1523). However, the situation in France is different in that wine drinkers have a significantly lower CHD mortality despite high intakes of saturated fat (Renaud & De Lorgeril, 1992: 1523; Hertog, 1996: 394; Erdman *et al*., 2007: 725S). It is suggested that the protection against cardiovascular disorders may be due in part to the high consumption of red wine (Renaud & De Lorgeril, 1992: 1523; Erdman *et al*., 2007: 725S), which counteracts the negative effects of the saturated fats (Renaud & De Lorgeril, 1992: 1523).

Atherosclerosis is a multifactorial disease and is the primary cause of myocardial infarction, peripheral vascular disease and stroke (Olin & Sealove, 2010: 678). The development of arteriosclerosis is linked to the oxidation of the LDL-cholesterol particles (Samson *et al*., 2012: 1). Polyphenols, present in red wine, reduce the oxidation of LDL *in vitro* and *in vivo* through the scavenging of reactive oxygen and nitrogen species, chelating metal ions and the preservation of paraoxonase activity (Cordova *et al*., 2005: 429). In addition, the polyphenols present in red wine counteract the potential pro-antioxidant effect of the ethanol present (Cordova *et al*., 2005: 431).

Resveratrol is part of the stilbene family belonging to the phenolic compounds, and is found in grape seeds and skin (not in the flesh) (Fernández-Mar *et al*., 2012: 799). Resveratrol inhibits cell apoptosis, thereby providing protection from certain diseases such as myocardial ischaemic reperfusion injury, atherosclerosis and ventricular arrhythmias (Das & Das, 2007: 133). Platelet adhesion is a major risk factor for the development of atherosclerosis, and resveratrol has been found to prevent platelet aggregation *in vitro* (Bertelli & Das, 2009: 468) and *in vivo* (Wang *et al*., 2002: 77). Jang *et al*. (1997: 218) demonstrated the ability of resveratrol to act at all stages of carcinogenesis contributing to the inhibition of cancer initiation, promotion and progression. Resveratrol could slow tumour growth through the suppression of enzymatic activity and the initiation of cell cycle arrest and apoptosis. Overall, *in vivo* studies clearly show potential for resveratrol in cancer treatment;

although studies on red wine consumption and cancer development in humans are still in their initial stage (Fernández-Mar *et al*., 2012: 801).

It is suggested that the alcohol in red wine could play a role in preventing or delaying atherosclerosis (Cordova *et al*., 2005: 428). The exact mechanisms are not yet fully explained, but a number of pathways have been postulated. Moderate ethanol consumption in isolation can elevate plasma HDL-cholesterol concentrations and reduce platelet adhesion, thereby reducing the risk for blood clot formation (Cordova *et al*., 2005: 431).

2.5.4 Specific fruit

The culinary definition of fruit is part of the plant that contains the seeds and pulpy surrounding tissue (Vainio & Weiderpass, 2006: 111). Fruit contains a variety of potential cardio-protective compounds, including fibre, antioxidants, vitamins and minerals (Chong *et al*., 2010: S28), in addition to various phytochemicals (Liu, 2003: 517S), which may, individually or in combination, be protective against CVD and certain cancers (Chong *et al*., 2010: S38). The WHO recognises that there is evidence of decreased risk of CHD, stroke, high blood pressure and obesity with increased fruit consumption (Schneider *et al*., 2007: 717).

2.5.4.1 Apples

Apples contain various nutrients, including vitamin C, in addition to soluble fibre (Weichselbaum *et al*., 2010: 93) and several phytochemicals, but mainly the phenolic flavonoids and phenolic acids (Gallus *et al*., 2005: 1842). Apples are a major flavonoid source in the Western diet (Biedrzycka & Amarowicz, 2008: 235). The phenolic compounds in apples are not bound to other compounds and may be absorbed more easily into the bloodstream than the phenolic compounds present in other dietary items (Boyer & Liu, 2004: 5). In comparison to other fruit, apples have the second highest level of antioxidant activity after that of cranberries, and the highest level of free phenolics (Gallus *et al*., 2005: 1842).

Apple peels are good sources of procyanidins, catechins, ECs, chlorogenic acid, phloridzin and quercetin conjugates (Escarpa & González, 1998: 335). The compounds found in apple flesh include the catechins, procyanidins, ECs and phloridzin; however, they occur in lower concentrations than in the peel (Escarpa & González, 1998: 336). Apple peel therefore may have higher antioxidant activity and higher bioactivity than the flesh because the apple peel contains more antioxidant compounds, which are abundantly present in the peel (Lee *et al*.,

2003: 6516). As apple peels contain more antioxidant compounds, especially quercetin, apple peels may have higher antioxidant activity and higher bioactivity than the apple flesh (Eberhardt *et al*., 2000: 903). Apple peels contain anywhere from two to six times (depending on the variety) more phenolic compounds than in the flesh, and two to three times more flavonoids in the peels when compared to the flesh (Wolfe *et al*., 2003: 609). Apples with the peels were therefore better able to inhibit cancer cell proliferation when compared to apples without the peels in research undertaken in this respect (Eberhardt *et al*., 2000: 903). A study conducted by Leontowicz *et al*. (2003: 5780) found that when rats were fed apple peels they exhibited a greater inhibition of lipid peroxidation and greater plasma antioxidant capacity when compared to rats fed apple flesh.

Epidemiological research has revealed a reduced risk of CVD associated with apple consumption (Boyer & Lui, 2004: 5). The Women's Health Study in the USA examined the association between flavonoids in apples and CVD (Sesso *et al*., 2003: 1401). Women ingesting two to six apples per week showed a 13 to 22% decrease in CVD risk (Sesso *et al*., 2003: 1402). In the Nurses' Health Study and the Health Professionals' Follow-up Study involving more than 77 000 women and 47 000 men, fruit and vegetable consumption was associated with a 21% reduced risk in lung cancer risk in women, but not in men. Few of the individual fruit and vegetables examined had a significant effect on lung cancer risk in women; however apples were one of the fruits associated with a decreased risk in lung cancer. Women who consumed at least one serving per day of apples and pears had a reduced risk of lung cancer (Feskanich *et al*., 2000: 1812). Apple intake may also be linked to a decreased risk for diabetes (Boyer & Liu, 2004: 5).

2.5.4.2 Berries

Berries are consumed in their fresh, frozen and dried form, and are also used in processed food products such as yoghurt, jam and beverages (Seeram, 2006: 615). Berries provide beneficial health effects as a result of their high levels of polyphenols, vitamins, minerals and fibre (Stoner & Seeram, 2010: 228). They are characterised by their high level and wide variety of bioactive phenolic compounds, which include the phenolic acids, tannins, anthocyanins and various other flavonoids (Seeram, 2008a: 627; Szajdek & Borowska, 2008: 147). The anthocyanins are a subgroup of flavonoids that possess powerful antioxidant abilities and are abundant in berries with red, blue or purple pigments (Lopes-da-Silva *et al*., 2007: 374). A combination of berry extracts has been found to exhibit substantially higher antioxidant and antibacterial activity when compared to that of the individual berries (Zafra-Stone *et al*., 2007: 675).

Flavonoids are primarily responsible for the beneficial properties in fruit. The main pharmacologic activities of berries are largely of cardiovascular nature, including cardiotonic, anti-arrhythmic, hypotensive and hypolipidaemic effects (Quittier-Deleu *et al*., 2003: 577). Erlund *et al*. (2008: 323) found berry consumption over eight weeks to positively affect middle-aged subjects with cardiovascular risk factors. Findings from the study included a substantial reduction in systolic blood pressure. Platelet function also decreased from 11% to 1.4%, while the plasma polyphenol and vitamin C levels increased. In addition, serum HDL-cholesterol concentration significantly increased, while total cholesterol and triacylglycerol remained the same (Erlund *et al*., 2008: 328).

Epidemiological data is varied regarding the anti-carcinogenic properties of berries (Seeram, 2008b: 630), with limited clinical research undertaken in this regard (Huntley, 2009: 299). The anti-cancer effects of berries, to an extent, is as a result of the phenolic compounds present that have the ability to counteract, reduce and repair damage caused by oxidative stress and inflammation (Seeram, 2008b: 630). Berry polyphenolics extend beyond functioning as antioxidants and have been shown to influence cell signalling. Animal *in vitro* studies have demonstrated berry phenolics to possess anti-inflammatory properties, to induce the carcinogenic detoxification (phase II) enzymes and to modulate cell signalling in cancer cell proliferation, apoptosis and tumour angiogenesis (Seeram, 2008b: 630). Proanthocyanidins or condensed tannins present in blueberries have been found to be responsible for counteracting urinary tract infections due to *E*. *coli* (Kaur & Kapoor, 2001: 707).

Raspberry phytochemicals beneficially modulate enzyme activity, cellular pathways and gene expression, as well as reduce LDL-cholesterol formation and oxidation through their antioxidant activity. Raspberry phytochemicals have thus demonstrated anti-atherosclerotic and anti-inflammatory activities that may protect against CVD development (Meyer *et al*., 1998: 71). Raspberry phytochemicals have also been shown to reduce cancer cell growth *in vitro* (Nile & Park, 2014: 134).

2.5.4.3 Citrus fruit

Citrus fruit belong to the *Rutaceae* family, which encompasses tangerine, grapefruit, lime, lemon and orange (Okwu, 2008: 451; Khan *et al*., 2014: 88). The consumption of citrus fruit has been widely investigated for its possible role in the prevention of CVD and cancer. These beneficial health effects are mainly attributed to the flavanones, the typical polyphenols of the citrus fruit species (Khan *et al*., 2014: 85). Numerous therapeutic properties have been

ascribed to citrus fruit, namely anti-cancer, anti-tumour, anti-viral and anti-inflammatory activities, in addition to their ability to suppress platelet aggregation (Okwu, 2008: 451). Citrus fruit protect cell membranes and DNA from oxidative damage through their high vitamin C content (Watson & Preedy, 2010: 547). The vitamin C in citrus fruit may further help reduce cancer risk through reducing the formation of nitrosamines as a result of its nitrite-scavenging ability (Radcliffe *et al*., 2003: 369).

While pink grapefruit contain high levels of beta-carotene, other citrus fruit, namely tangerines and oranges, contain high levels of other carotenoids, namely zeaxanthin, lutein and cryptoxanthin. These carotenoids have been linked to a reduced risk of age-related macular degeneration, the main cause of blindness in persons older than 65 years of age (Seddon *et al*., 1994: 1413). A significant inverse relationship exists between the incidence of age-related macular degeneration and the ingestion of citrus fruits rich in provitamin A (Bruno & Mediros, 2000: 79). Pink grapefruit also contains a high level of lycopene, the red pigment that renders significant anti-tumour activity (Okwu, 2008: 459).

2.5.5 Fruit juice

Fruit juices are excellent sources of vitamins, minerals, trace elements and soluble fibre (the latter only present in juices containing pulp). A range of phytochemicals (e.g. polyphenols, especially flavonoids) may also be present, depending of the fruit juice variety (Plesko *et al*., 2000: 201; Ruxton *et al*., 2006: 250). A study conducted by Mulero *et al*. (2012: 372) found a significant difference in oxidised LDL-cholesterol, C-reactive protein and homocysteine in volunteers with metabolic syndrome who consumed 300 mL of a citrus-based juice daily over six months. Ruxton *et al*. (2006: 253) summarised 11 studies pertaining to the health benefits of fruit juice consumption and found the polyphenols and other antioxidant compounds present in fruit juices to provide cancer-protective effects through decreasing oxidative and other damage to DNA. However, clinical data is lacking to demonstrate that fruit juice consumption may lower cancer risk.

Cranberry juice has been found to effectively inhibit bacterial adherence, a plausible link to its role in the effective treatment and prevention of urinary tract infections (Burger *et al*., 2000: 295). A study investigated the effects of drinking cranberry juice on antioxidant status and biomarkers relating to heart disease and cancer in 20 healthy young adult female volunteers. The volunteers consumed 750 mL/day of either a placebo drink or cranberry juice over the course of two weeks. Plasma total phenolics, triglycerides and both HDL- and LDL-cholesterol levels showed no change. The findings of this short-term study indicated that the

consumption of cranberry juice did not affect blood or cellular antioxidant status or several biomarkers of lipid status, and had no influence on basal or induced oxidative DNA damage (Duthie *et al*., 2006: 113).

Pomegranate juice is rich in polyphenolic compounds. The peel of the pomegranate contains punicalagin, the largest of the tannin compounds, which accounts for a great proportion of its antioxidant capacity (Tzulker *et al*., 2007: 9559). The flesh (arils) also contains a number of antioxidant compounds, including anthocyanins, ellagic acid and other flavonoids (Mousavinejad *et al*., 2009: 1274). Several studies have reported that pomegranate juice displays the highest TAC when compared to other fruit juices (Seeram, 2008b: 630; Carlsen *et al*., 2010: 11; Ryan & Prescott, 2010: 1191). Pomegranate juice has been shown to assist cardiovascular health by decreasing systolic blood pressure, thus positively affecting the progression of atherosclerosis and the potential development of CHD (Stowe, 2011: 115). According to Seeram *et al*. (2005: 360), punicalagin and other polyphenols present in pomegranate juice exhibit anti-proliferative apoptotic and antioxidant effects *in vitro*.

A concern when recommending the consumption of fruit juice is its impact on dental health due to its acidity, which favours bacterial growth and acid erosion in the oral cavity (Wootton-Beard & Ryan, 2011: 3142). Considering the guidelines of the 5-A-Day for Better Health campaign it is advised that only one serving of the daily fruit intake should be consumed as a serving of fruit juice (About 5-A-Day, 2000: 5). South African food-based dietary guidelines recommend to “use foods and drinks containing sugar sparingly, and not between meals” (Temple & Steyn, 2013: S100). As fruit juices are typically high in carbohydrates (as fructose), it is advised they be consumed in moderation. The intake of fruit juice should not exceed 125 to 250 mL (one to two servings) per day (Temple & Steyn, 2013: S103). Although increased fruit and vegetable intake is encouraged, the daily fruit consumption should not soley be in the form of fruit juice. As mentioned, there is growing concern about excessive fruit juice consumption and the effect on human health.

2.5.6 Specific vegetables

Epidemiological research has revealed that populations who frequently consume a variety of vegetables have a lower prevalence of CDL (Sen *et al*., 2010: 91). Vegetables are natural sources of nutrients with antioxidant properties, such as provitamin A (carotenoids) and vitamin C (Weisburger, 1999: 944). The phytochemicals present in vegetables may offer

greater protection against oxidative stress induced by free radicals than is currently believed and, as a result, may reduce the risk of a wide range of chronic diseases (Liu, 2003: 517S).

2.5.6.1 Onions

The onion, *Allium cepa*, is used for its flavour and aroma (Ali *et al*., 2000: 55) and a commonly as an ingredient in composite dishes (O'Brien *et al*., 2003: 718). The two flavonoid groups found in onions are the anthocyanins, imparting a red/purple colour and the flavonols, largely quercetin, responsible for the yellow and brown skins (Downes *et al*., 2009: 80). Onions possess antioxidant, anti-inflammatory and antibacterial properties (Shobana & Naidu, 2000: 107). Research on the components of onion and onion extract has found them to play a positive role towards CVD, pertaining to hypolipidaemic and anti-platelet activity (Griffiths *et al*., 2002: 610). Galeone *et al*. (2006: 1028) found moderate onion consumption (between one and seven 80 g portions weekly) to be protective against colorectal, laryngeal, and ovarian cancers. The inverse relation was more evident for higher frequency of use (as seven or more portions weekly). Ali *et al*. (2000: 55) suggested that the biological efficacy is preserved in raw onion and destroyed by heat, which impacts on its effectiveness in CVD, as onion is typically consumed in cooked dishes.

2.5.6.2 Garlic

Garlic generally contains three times more organosulphur compounds than onions (Benkeblia, 2004: 263). Garlic is also more effective than onion in suppressing platelet adhesion and is more effective when ingested raw *vs* cooked or boiled (Ali *et al*., 1999: 43). Epidemiological research has revealed an inverse association between garlic intake and the progression of CVD (Rahman & Lowe, 2006: 736S). Garlic has been demonstrated to lower risk parameters concerned with CVD, namely cholesterol reduction, platelet aggregation inhibition, blood pressure reduction and increased antioxidant status (Rahman & Lowe, 2006: 736S). Short-term supplementation of garlic in human subjects has shown an increased resistance to LDL-oxidation. This may be a powerful mechanism responsible for the beneficial effects of garlic in the protection of the heart and blood vessels (Lau, 2001: 985S). The protective effects of garlic are related to the presence of the organosulphur compounds, allyl derivatives, which have been demonstrated to inhibit carcinogenesis in the stomach, oesophagus, colon, mammary gland and lung (Omar & Al-Wabel, 2010: 51).

Garlic also has antibacterial properties as a result of the interaction of the sulphur compounds, such as allicin, with the sulphur (thiol) groups of microbial enzymes, resulting in

reduced microbial growth (Jonkers *et al*., 1999: 837; Bakri & Douglas, 2005: 645). When garlic is sliced or crushed, the enzyme allinase is activated which acts on alliin to produce allicin (Lau, 2001: 985S). Garlic powder is a result of dehydrating and pulverising garlic cloves. Its composition and allinase activity can be identical to fresh garlic. However, the temperature should not exceed 60ºC during the dehydration process to prevent the inactivation of *allinase* (Banerjee *et al*., 2003: 101).

2.5.6.3 Cruciferous vegetables

Many frequently consumed cruciferous vegetables are derived from the *Brassica* genus and include broccoli, cabbage, cauliflower, Brussels sprouts, collard greens, watercress, kale and bok choy (Higdon *et al*., 2007: 225). Increased consumption of cruciferous vegetables has been linked to a reduced risk of intestinal, bowel (Williamson, 1996: 6; Moreno *et al*., 2006: 1508) and thyroid cancer (Williamson, 1996: 6) in addition to cancer of the lungs (Moreno *et al*., 2006: 1508). Cruciferous vegetables contain numerous nutrients and phytochemicals that possess cancer chemopreventative properties, including folate, dietary fibre, carotenoids, glucosinolates and other sulphur-containing compounds and chlorophyll (Stan *et al*., 2008: 339). Amongst the phytochemicals in cruciferous vegetables, glucosinolates and S-methylcystine sulfoxide are the major constituents. More than 120 glucosinolates and the precursors of isothiocyanates have been identified (Hirai *et al*., 2007: 6478). Experimental data has demonstrated the chemopreventative agents derived from the *Cruciferae* family to affect carcinogenesis during the initiation and promotion stages of cancer development (Moreno *et al*., 2006: 1509). The antioxidant activity of cruciferous vegetables in the body is a result of both the bioactive compounds and influence on the endogenous antioxidant enzymes such as catalase, superoxide dismutase and peroxidase. The bioactive molecules from cruciferous vegetables are known to induce phase II enzymes, which aid in the metabolism of xenobiotics to prevent potent carcinogenesis (Manchali *et al*., 2012: 98).

The characteristic that differentiates crucifers from other plant foods is their distinctive family of secondary metabolites, termed glucosinolates, that provide bioactive isothiocyanates upon hydrolysis (Herr & Büchler, 2010: 378). The glucosinolates and sulphur-containing compounds such as sulforaphane found in cruciferous vegetables are responsible for their pungent aroma and bitter taste (Drewnowski & Gomez-Carneros, 2000: 1424). Glucosinolates have been demonstrated in experimental and patient case studies to protect against gastric cancer (Ahmad *et al*., 2010: 652; Higdon *et al*., 2007: 224). Gastric cancer risk is increased with *H. pylori* bacterial infection (Ohata *et al*., 2004: 138). Purified

sulforaphane was shown to kill multiple strains of antibiotic-resistant strains of *H. pylori* in tissue culture (Fahey *et al*., 2002: 7610). A clinical trial (Yanaka *et al*., 2009: 355) involving 48 patients found profound reduction in *H. pylori* infection after broccoli sprouts where consumed. The test group consumed 70 g broccoli sprouts daily (correlating to approximately 420 millimole or 183 mg glucoraphanin), while the control or placebo group received the same quantity of alfalfa sprouts but without providing glucoraphanin/sulforaphane. Individuals from the test group had fewer markers for *H. pylori* in the breath and faeces tests compared to the placebo group after eight weeks. After discontinuing the intake of the broccoli in the patients' diet, the parameters returned to their initial values before the clinical trial. This showed that the tested quantity of broccoli sprouts did not result in the permanent eradication of *H. pylori* (Yanaka *et al*., 2009: 357).

Broccoli contains the polyphenolic compounds glucosinolates, in addition to other antioxidants. The cancer-protective effects of broccoli consumption may be attributed to the bioactive compounds that prompt a number of physiological actions, such as acting as direct or indirect antioxidants, regulating enzymes and controlling the cell cycle and cell apoptosis (Moreno *et al*., 2006: 1510). Michaud *et al*. (1999: 605) examined fruit and vegetable consumption and bladder cancer risk in men aged 40 to 75 years in the Health Professionals Follow-up Study. The consumption of individual cruciferous vegetables, which included cabbage, cauliflower, Brussels sprouts, kale, sauerkraut and broccoli, but not coleslaw, was inversely associated to the risk of bladder cancer, with the inverse association only significant for broccoli and cabbage consumption. A 51% reduced risk of bladder cancer was found amongst individuals consuming a high intake (> 5.0 servings/week) in comparison to individuals with a low intake (≤ 1.0 serving/week) of cruciferous vegetables (Michaud *et al*., 1999: 608). While some case control studies have found that individuals who have been diagnosed with lung cancer consumed fewer cruciferous vegetables than individuals in cancer-free control groups (Verhoeven *et al*., 1996: 733), the findings from prospective cohort studies have presented varied results pertaining to the effect of cruciferous vegetable intake on lung cancer (Higdon *et al*., 2007: 225).

A negligible amount of fat (less than 1.0%) in cruciferous vegetables makes them an important constituent of a low fat and heart friendly diet (Manchali *et al*., 2012: 95). A 12-year follow-up study conducted on middle-aged women indicated that a higher consumption of cruciferous vegetables, namely broccoli, cabbage, cauliflower and Brussels sprouts was linked to a reduced incidence of obesity (He *et al*., 2004: 1569).

2.5.6.4 Tomatoes

Tomatoes contain phytochemicals such as the carotenoids and polyphenols. The bioactive components present in tomatoes, which include the above antioxidants, in addition to vitamins C and E, may be responsible for inhibiting cholesterol synthesis, reducing inflammation and improving immune function (Canene-Adams *et al*., 2005: 1226). Tomato-based products (pasta, juice, and puree and tomato sauce) are particularly rich sources of lycopene (Rodriguez-Amaya, 1999: 74S). Lycopene is the main carotenoid in tomatoes and is commonly assumed to be responsible for the beneficial health effects associated with increased tomato intake (Canene-Adams *et al*., 2005: 1226). Lycopene has the ability to effectively scavenge singlet oxygen and ROS (Cantrell *et al*., 2003: 47). The antioxidant properties of lycopene are potentially beneficial in disease prevention for both CVD and prostate cancer (Canene-Adams *et al*., 2005: 1229).

Lycopene has been found to play a role in the protection against CVD. A clinical trial by Shen *et al*. (2007: 6475) treated 24 subjects with either fresh tomato or tomato juice (both delivering 40 mg lycopene per day) for six weeks. The study found that triglyceride levels and LDL-cholesterol were decreased, and HDL-cholesterol increased in subjects who consumed fresh tomato and tomato juice. Similar findings were achieved in another study (Bohn *et al*. 2013: 919) where 18 healthy men and women consumed a soy-tomato beverage daily (22 mg lycopene per day) for eight weeks. The consumption of the beverage significantly reduced the susceptibility of the LDL blood plasma fraction to oxidative damage. In addition, HDL-cholesterol levels significantly increased, and the ratio of total cholesterol/HDL cholesterol significantly decreased over the course of the study (Bohn *et al*. 2013: 919). Another study compared men aged 50 years from Lithuanian and Swedish populations which likewise found reduced levels of lycopene to be linked to an increased risk and mortality from CHD (Kritenson *et al*., 1997: 629). Significant reductions have been found following lycopene consumption in the levels of oxidised LDL-cholesterol, which is believed to be a risk factor for CVD (Ried & Fakler, 2011: 299), as well as to reduce inflammation and improve immune function (Canene-Adams *et al*., 2005: 1229), which is essential to reduce the inflammatory background associated with atherosclerotic plaque formation and vascular inflammation in CHD (Koenig *et al*., 1999: 237).

The suggested mechanisms of action of lycopene in the prevention of prostate cancer include the inhibition of cell proliferation, anti-androgen and anti-growth factor effects (Nelsom *et al*., 2003: 366; Wang *et al*., 2003: 2367). A small clinical trial conducted by Chen *et al*. (2001: 1872) studied 32 patients with prostate cancer after consuming tomato-

based pasta dishes for the three weeks (30 mg of lycopene per day). Although there was no control group, the consumption of these dishes reduced the serum prostate-specific antigen levels from 10.9 to 8.7 microgram/L. Leukocyte oxidative DNA damage was reduced after the regular lycopene intake when compared to before the lycopene intervention. Furthermore, oxidative DNA damage in the prostate tissue was also reduced in these men. According to Etminan *et al*. (2004: 340), the beneficial role of tomatoes in preventing prostate cancer development is dependent on the type and quality of the tomato products, in addition to the quantity consumed. Cooked *vs* raw tomato consumption appears to further play a role, with high intakes of cooked tomato having a slightly stronger preventative effect than raw intakes. This may be due to the higher concentration of lycopene present, as well as the increased bioavailability of lycopene in cooked tomato (Etminan *et al*., 2004: 344). Studies have shown that the absorption of lycopene increases with processing, heat and the addition of fat (Pool-Zobel *et al*., 1997: 1847; Kucuk *et al*., 2001: 861; Wang *et al*., 2003: 2367).

The US FDA has established four qualified health claims for tomatoes, lycopene and cancer with only the qualified health claim for tomatoes, lycopene and prostate cancer holding scientific ground. The qualified health claim for prostate cancer was "*Very limited and preliminary scientific research suggests that eating one-half to one cup of tomatoes and/or tomato sauce a week may reduce the risk of prostate cancer*" (US Food and Drug Administration, 2005). The qualified health claim for gastric cancer was "*Four studies did not show that tomato intake reduces the risk of gastric cancer although three studies suggest that tomato intake may reduce this risk. Based on these studies, the FDA determined that the ability of tomatoes to reduce the risk of gastric cancer is questionable*". The qualified claim for ovarian cancer was "*One study suggests that consumption of tomato sauce two times per week may reduce the risk of ovarian cancer; while this same study shows that consumption of tomatoes or tomato juice had no effect on ovarian cancer risk. The FDA determined the ability of tomato sauce to reduce the risk of ovarian cancer as questionable*". The qualified health claim for pancreatic cancer was "*One study suggests that consuming tomatoes does not reduce the risk of pancreatic cancer, but one weaker, more limited study suggests that consuming tomatoes may reduce the risk. Based on these studies the FDA determined that the ability of tomatoes to reduce the risk of pancreatic cancer is questionable*" (US Food and Drug Administration, 2005).

2.5.7 Whole grains

Most South Africans consume large quantities of bread, along with rice and maize. However, available literature suggests that all South Africans will greatly benefit from

consuming more unrefined cereals and grains, which will improve their nutritional status (Vorster & Nell, 2001: S24). A wide variety of cereals and grains and their products are available in SA, namely breads, porridges, pastas, breakfast cereals, as well as wheat, sorghum and rye (Vorster & Nell, 2001: S23). Whole grains include wheat, oats, corn, barley and rye, and are made up of the germ, the endosperm and the bran of the grain (Slavin *et al*., 2001: 780). Most of the compounds that promote health in whole grains are found in the germ and bran, which are removed in the production of refined-grain products (Gil *et al*., 2011: 2316).

Whole grains contain many phytochemicals, including phenolics (phenolic acids, alkylresorcinols, and flavonoids), and carotenoids, along with dietary fibre, and beta-glucan (Okarter & Liu, 2010: 199). Whole grains also contain vitamin E, which protects against the oxidation of polyunsaturated fatty acids in cell membranes (Slavin, 2003: 132). Vitamin E also impairs the formation of nitrosamines, particularly at low pH (Slavin, 2000: 302S). The trace mineral selenium is another compound found in whole grains that functions as a cofactor for glutathione peroxidase, an enzyme that protects tissues against damage caused by oxidation (Slavin, 2000: 303S).

Research has shown that the consumption of whole grains aids in the reduction of CVD, ischaemic stroke, type-2 diabetes, metabolic syndrome and gastrointestinal cancers (Jones, 2006: 108). A meta-analysis of seven cohort studies indicated that consuming an average of 2.5 servings per day of whole grains was associated with a 21% reduced risk of CVD events (Gaskins *et al*., 2010: 1669). Amongst women diagnosed with type-2 diabetes, a protective association was observed between whole grain consumption, particulary bran, and mortality from all causes and CVD-specific mortality (He *et al*., 2010: 2162). Furthermore, the consumption of dietary fibre from cereals and fruit was inversely associated with the risk of CHD in several cohort studies (Pereira *et al*., 2004: 370).

Diets rich in high-glycaemic index foods may increase insulin-resistance and obesity in susceptible individuals with type-2 diabetes. In contrast, some whole-grain foods can aid in reducing insulin resistance and improving glucose intolerance (Smith *et al*., 2003: 461). A study of overweight hyperinsulinaemic adults free from diabetes and other chronic conditions found the consumption of an assortment of whole grains to be effective in reducing insulin resistance (Pereira *et al*., 2002: 848). Plasma glucose levels and insulinaemia are improved on whole grain consumption, as it reduces tissue insulin resistance (Slavin, 2004: 99). Available data further indicate that the components present in whole-grain cereals are responsible for the reduced risk, as the fibre from fruit and vegetables does not exhibit the

same protective effects (Montonen *et al*., 2003: 622). Grains such as oats, rye and barley have been found to be more effective in improving insulin sensitivity than wheat. This is due to the soluble beta-glucans they contain in contrast to wheat, which predominantly contains insoluble dietary fibre (Smith *et al*., 2003: 461).

The consumption of whole-grain cereals has been found to reduce the risk of certain types of gastrointestinal cancers (Gil *et al*., 2011: 2319). A review of 40 studies on gastrointestinal cancer established reduced risk for cancer, from 43% to 21% in individuals with high intakes of whole-grain cereals (Slavin, 2004: 99). Numerous biological actions are thought to be responsible for the role of cereals in gastrointestinal cancer risk reduction. The fibre and resistant starches present in cereals and their products ferment in the colon and aid in a reduced transit time, thereby improving intestinal health (Gil *et al*., 2011: 2320). A greater faecal bulk and reduced transit time allow the intestinal epithelium to have less contact with faecal mutagens. Secondary bile acids are presumed to encourage cell proliferation, allowing for an increased opportunity of mutagens to develop and increased duplication of denatured cells (Fardet, 2010: 67). Insoluble fibre may act directly, by adsorbing or diluting carcinogens (through increased faecal bulk by water absorption), or indirectly by decreasing colon pH (through short chain fatty acid production and increasing butyrate production) (Bartsch & Nair, 2006: 499).

Sorghum contains several phytochemicals, namely tannins, phenolic acids, anthocyanins, phytosterols and policosanols (Awika & Rooney, 2004: 1199). Cho *et al*. (2000: A249) observed that, when sorghum was incorporated into the diets of rats at 30%, HDL-cholesterol increased, without altering the total cholesterol levels. Sorghum has additionally demonstrated anti-carcinogenic attributes *in vitro* (Yang *et al*., 2009: 1797). Grimmer *et al*. (1992: 251) established anti-mutagenicity related to sorghum polyphenol extracts. Van Rensburg (1981: 243) associated sorghum consumption with a reduced incidence of oesophageal cancer in several regions of the world, such as Africa, Russia, India, China and Iran. Such regions have a number of specific mineral and vitamin deficiencies in their diets. The author proposed that these nutrient deficiencies could be responsible for a high incidence in oesophageal cancer and that sorghum consumption promoted resistance to the risk. Sorghum brans have been found to have a higher TAC (measured by the ORAC analysis) than blueberries and other common fruit, namely strawberries, plums, grapes, watermelon and orange (Awika & Rooney, 2004: 1211) and therefore may provide comparable health benefits to those attributed to fruit and vegetables through antioxidant provision (Awika & Rooney, 2004: 1216).

2.6 Dietary change as strategy to enhance phytochemical intake

The act of eating is a complex process that comprises numerous choices, with environmental, psychological, behavioural and biological variables said to play a role (Baranowski *et al*., 2003: 24S), along with social and cultural factors. The culture in which an individual is brought up in also influences the types of foods consumed, with social interactions having a profound effect on the way in which food is regarded (Shepherd, 1999: 807). These fundamentals are commonly mediated by an individual's beliefs and attitudes. Similarly, various economic, social or demographic factors may influence the beliefs and attitudes held by an individual (Shepherd, 1999: 808).

Habitual dietary intake may impact chronic disease risk, and comprehending when and understanding how and why dietary change occurs over time are imperative when constructing intervention strategies. Food choices change from infancy through to adulthood and are likely to evolve through exposure to new situations and life transitions. Nutritional education has focused on increasing the public's awareness related to nutrition in an effort to modify behaviour; however, adherence to a healthy diet is not guaranteed (Lake *et al*., 2004: 255). Food choices are restricted by convenience due to demanding lifestyles. Cost is also a factor that greatly affects food choice. Factors affecting food preferences include genetic determinants and environmental effects. Genetic determinants include inborn desires for sweet and salty flavours, while environmental effects are learned preferences that are as the result of cultural and socio-economic influences (Grodner *et al*., 2013: 21). There is a lack of focus on health-related and non-health-related issues affecting food choice. Steptoe and Pollard (1995: 267) developed a questionnaire to determine aspects related to diet and health. The questionnaire was administered to a sample of 358 adults between the ages of 18 and 87 years. Factors found to affect food choice were sensory appeal, convenience, price, familiarity, ethical concern, mood, health, weight control and natural composition, pointing to both health-related and non-health-related factors.

The evolution of the human diet has been driven by necessity, economics and more recently, by taste, cost and convenience (Herber & Bowerman, 2001: 3078S). Numerous barriers have been found to exist amongst individuals and a healthy diet, with unhealthy foods commonly owing their enjoyment to their pleasurable taste and convenience. Humans are often controlled by routine and are typically hesitant to change long-standing dietary preferences, even when the habitual diet poses a risk of chronic disease (Temple & Steyn, 2011: 505). This said, research concerning eating behaviour indicates adults are capable of changing their strongly ingrained eating habits when an urgent need to do so arises

(Chapman & Ogden, 2010: 447). A report by the WHO/Food and Agriculture Organization (FAO) Expert Consultation on diet, nutrition and the prevention of chronic diseases demonstrated the importance of the adult phase as a critical time for chronic disease prevention (Darnton-Hill *et al*., 2004: 108). However, obesity during the teen years is associated with many adverse health consequences (Danaei *et al*., 2005: 1784; Dietz & Robinson, 2005: 2100). The consequences of childhood and adolescent obesity include type-2 diabetes and increased incidence of the metabolic syndrome in the youth and adulthood, and obesity in adulthood. These health distresses are associated with CVD, as well as with several cancers in adults, likely through insulin resistance and production of inflammatory cytokines (Biro & Wien, 2010: 1499S). This indicates the younger years as important as the adult phase for chronic disease prevention (Gore *et al*., 2011: 2093).

2.6.1 Motivation for, and adherence to dietary change

Dietary change involves limiting or avoiding the intake of specific foods, beverages or constituents of foods or beverages (e.g. fat or salt), in addition to increasing the consumption of some foods (e.g. fruit and vegetables). Methods to assist individuals to permanently change dietary habits typically involve social learning theory and behaviour modification strategies (Kumanyika *et al*., 2000: 48).

Intrinsic and extrinsic motives could explain the reasons for dietary change. Intrinsically motivated behaviours provide internal rewards, while extrinsic motives are performed to receive external rewards or punishment (Deci & Ryan, 1985: 49). Patterson *et al*. (1996: 1394) found the positive relation between the perceived pressure to eat a healthy diet and healthy eating practices to be associated with extrinsic motives (Satia *et al*., 2001: 954). Satia *et al*. (2001: 957) measured the motives for adopting new dietary patterns amongst adults and found intrinsic and extrinsic motivation scales to be valid and reliable for use as assessment tools. Overall, the desire for improved self-esteem was more critical to females, with low-fat diets an important accompanying factor. A further finding was that older individuals and males were more inspired to alter their diets for personal health reasons. Extrinsic motivation was found to be higher in males compared to females, and was found to be linked to less healthy dietary habits (Satia *et al*., 2001: 958).

Although motivated individuals can greatly increase their fruit and vegetable intake, interventions to increase fruit and vegetable intake can reach numerous individuals, but have minor effects (Kumanyika *et al*., 2000: 52). A multifocal, two year worksite intervention reported differences in the effect of fruit and vegetable intake by worker job classification.

The intervention, which focused on decreasing dietary fat and increasing dietary fibre and fruit and vegetable intake, made healthier foods readily available and facilitated health education programmes to assist behavioural change. The intervention was successful in enhancing fruit and vegetable consumption to five servings daily, assessed through questionnaires. Increased dietary fibre intake was achieved amongst workers in the skilled and unskilled labour categories but not in the office worker, professional and managerial worker categories (Mhurchu *et al*., 2010: 62).

Evidence pertaining to dietary change is not conclusive, as some studies state dietary change is lacking, while other studies report a degree of success in the implementation and maintenance of long-term dietary change in decreasing daily fat and increasing daily fruit, vegetable and fibre consumption (Lanza *et al*., 2001: 387; Howard *et al*., 2006: 655; Pierce *et al*., 2007: 289). Chapman and Ogden (2010: 447) aimed to determine the occurrence of dietary change in a community sample and found that minor dietary change occurred in most (99%) of the participants. The results further established that an increase in fruit and vegetable intake as well as that of water were the most prevalent changes that occurred (Chapman & Ogden, 2010: 449).

2.6.2 Diet-related behaviour-change theories and models

Changes in the variables that support behaviour interventions may trigger behavioural change. These variables, commonly derived from theories or models, are used to understand behaviour (Baranowski *et al*., 2003: 23S). There are numerous models describing food choice factors and their interrelations (Wądołowska *et al*., 2008: 123), which are explained here.

2.6.2.1 Transtheoretical Model

A number of behaviour-change theories have been explored by researchers in the development of diet-related behavioural interventions. One of these is the Transtheoretical Model, often termed the Stages of Change Model, which explains a five stage sequential process by which people may change their eating behaviour (Nothwehr *et al*., 2006: 1035). The theory uses various states of behaviour to determine an individual's likelihood to change. During the past decade, nutrition research has used this model as a guide to determine dietary intervention outcomes. The research has mainly focused on promoting limiting fat intake and increasing fruit and vegetable consumption (Molaison, 2002: 252). The Transtheoretical Model of Change proposes that changes in behaviour consists of five

stages, namely (i) Pre-contemplation: Not intending to make changes in behaviour in the foreseeable future; (ii) Contemplation: Considering changing behaviour; (iii) Preparation: Committing to changing behaviour in the next 30 days; (iv) Action: Successfully changing behaviour; and (v) Maintenance: Behaviour change that is sustained over six months (Contento, 2010: 109). The Transtheoretical Model will be used in this study as further consideration of the likelihood of the respondents to make certain proposed dietary adjustments (e.g. increased daily fruit, vegetable and whole grain intakes) to enhance their phytochemical intake. The Stages of Change Model has attracted extensive attention as a basis for developing change intervention strategies. The appeal of the Stages of Change Model is that rather than conceptualising behavioural action and inaction, the behaviour is understood as a process of movement through a sequence of five stages (Malotte *et al*., 2000: 358).

2.6.2.2 Knowledge Attitude Practice Model

The Knowledge Attitude Practice (KAP) model suggests that an individual's behaviour or practice (P) is dependent on their knowledge (K) and attitudes (A). This model is commonly used in health behaviour research (Hausmann-Muela *et al*., 2003: 3). The underlying assumption of this model is that by changing knowledge, behaviour is automatically changed. The KAP model can be regarded as over-simplistic as it does not consider the numerous factors that influence behaviour, such as cultural, social and environmental influences (Rennie, 1995: 77), as well as motivation (Ingle, 2003: 1). This model, however, has been successful in cases where the target group has limited knowledge. In addition, it may be even more difficult to counteract misconception, which has been available for a considerable period of time (Rennie, 1995: 78). The provision of information is said to be insufficient for behavioural change to occur. The individulal must be ready to change their behaviour, and the changes must be perceived to be attainable by the individual (Anon, 1998: 2).

2.6.2.3 Knowledge Attitude Behaviour Model

Knowledge is a logical prerequisite for health-related behaviour. Different types of knowledge may influence the decision-making process during consumption. The Knowledge Attitude Behaviour (KAB) model, also called the Theory of Enlightened Self-Interest, assumes a person is rational and proposes that behaviour change is a gradual process (Baranowski *et al*., 2003: 25S). As knowledge accumulates, changes in attitude commence and, over time, these changes result in behavioural change. There has been some apprehension that many individuals in varying circumstances do not display what would be considered as 'rational' behaviour. The acquisition of information, such as provided

through school curricula, has been the most frequent process for encouraging dietary change using the KAB model. While the principal resource in this model appears to be improved knowledge that progresses into change in attitudes, behaviours or both, the course by which behavioural change takes place has not been detailed in the KAB model. The KAB model, in isolation, appears to be unsatisfactory for understanding or encouraging dietary behavioural change (Pirouznia, 2000: 89).

2.6.2.4 Health Belief Model

The Health Belief Model (HBM) suggests the motivation to change dietary behaviour is based on the level of a perceived risk of a particular illness, also referred to as the readiness to act (Baranowski *et al*., 2003: 27S). The main principals of the HBM are (i) perceived susceptibility (the perceived risk for contracting a health ailment or illness), (ii) perceived severity (the perception of the result of contracting the illness), (iii) perceived advantage (an individual's perception of the positive aspects that may occur due to the behaviour change, particularly regarding decreasing the risk of the disease), (iv) perceived obstacles (an individual's perception of the negative aspects and complications applying the beneficial behaviours), (v) environmental aspects (e.g. family history of illness), (vi) bodily events (e.g. symptom severity), or media publicity that may prompt perceptions of vulnerability and, in newer versions of the HBM, self-efficacy (an individual's belief or assurance that he or she can implement the required behaviour). A disadvantage of the HBM is linked to children and adolescents, as they are inclined to view themselves as untouchable and will live forever, therefore the notions of the HBM may not be very valuable to them (Baranowski *et al*., 2003: 27S).

2.6.2.5 Social Cognitive Theory

The Social Cognitive Theory (SCT) assists in understanding health-related behaviours and adapting them. Primary concepts of the SCT include skills (the ability to execute the behaviour when needed), self-efficacy (the assurance that one can accomplish the desired behaviour in various situations) and outcome expectancies (the outcomes likely to result from implementing the behaviour). The main environmental factors include modelling (understanding how to behave by observing the behaviour of others and receiving approval or reward for implementing it) and accessibility (whether food is available for consumption or preparation). The underlying basis of the SCT for behaviour change is the ability to control one's own behaviour, i.e. self-control (Hearn *et al*., 1998: 26).

2.6.2.6 Theory of Reasoned Action

Another approach in understanding food choice is one that originates from social and psychological research studying attitude-behaviour relationships. This approach assumes that the individual's beliefs and attitudes influence many of the factors that influence food choice, offering a possible method towards improved understanding of the factors affecting food choice (Montano & Kasprzyk, 2008: 85). Attitudes are measured because they are believed to be informally linked to behaviour. The Theory of Reasoned Action (TRA) explains that behaviour which is within the control of an individual has been applied to a number of issues concerning food choice (Shepherd, 1999: 808). The TRA further proposes that people are only likely to behave a certain way when they are ready. The degree of intention to behave in a specific manner is stronger amongst those who are positive and have more of a subjective outlook. Attitudes and subjective norms result in intention and in turn will cause an individual to act in a certain way within the context of other influences. A shortcoming of the TRA is said to be that some individuals are not always in control of their behaviour (e.g. the availability of healthier foods) (Baranowski *et al*., 2003: 30S).

2.7 Summary and concluding remarks

The burden of CDL such as obesity, diabetes, CVD and cancer is increasing in SA. A reduced prevalence of CDL in individuals who consume fruit, vegetables, tea, red wine and whole grains on a regular basis have widely been accepted. Similar to fruit and vegetables, herbs can significantly contribute to the total dietary antioxidant intake. The diverse phytonutrient and nutrient antioxidants naturally present in these foods are able to control oxidative reactions in the body, thereby decreasing the risk of major chronic degenerative diseases.

Ways to enhance dietary phytochemical intake should be considered in the preparation of food at home. Consuming fruit and vegetables with skin/peel where possible, adding herbs to flavour dishes, using wholegrain pasta and other whole-grain cereals instead of the refined products, and incorporating a variety of plant foods in dishes should be considered for enhanced phytochemical intake. Cooking methods should also be considered, with the steaming of vegetables the most suitable option. In the commercial sector, the development of dishes with enhanced phytochemical content is an ideal way to target those who lead busy lives, as well as those with limited culinary skills in the kitchen. Biotechnology is another method of optimising the dietary intake of phytochemicals through traditional breeding or genetic engineering to yield crops with higher levels of phytochemicals. The increase of

antioxidant levels is critical to support increased antioxidant intake, particularly when the daily intake of fruit and vegetables is low. Phytochemicals are also available in supplementary forms, but evidence is lacking to support that they provide the same health benefits as dietary phytochemicals.

Numerous models have been created to better understand the behaviour behind dietary change. The Transtheoretical Model, also called the Stages of Change Model, uses a five-stage sequential process by which people may change their eating behaviour to obtain understanding of where a person is in the change process, thereby providing an intervention by customising it to meet their current needs. The KAP model assumes that, by changing knowledge, behaviour is automatically changed. It furthermore suggests that an individual's behaviour is dependent on their knowledge and attitudes. The KAB model, however, proposes that behaviour change is gradual and, as knowledge accumulates, changes in attitude commence, which results in behaviour change. The HBM suggests an individual's primary motivation to change is based on his/her perception of the risk of illness. The SCT involves the ability to control one's own behaviour and includes skills, self-efficiency and outcome expectancies. The TRA model explains that behaviour is under the control of the individual and proposes that individuals are only likely to behave a certain way when they are prepared to do so. Although these models differ in a number of ways, they can all be used to better understand the reasoning behind dietary behaviour change.

The motives or reasons for dietary change or for adopting new dietary behaviour seem to be centred on intrinsic and extrinsic factors. Dietary behavioural changes appear to involve minor rather than major change over time, reflecting that some degree of dietary behaviour change success is possible.

The research topic of whether consumers in the professional sector in the City of Cape Town are likely to make dietary adjustments in order to enhance their phytochemical intake and, if so, what changes they would be likely to make, was selected due to the increasing prevalence of lifestyle diseases amongst South African adults. The resulting burden of the high prevalence of lifestyle diseases on the health care system is of great concern in SA. The ongoing research related to the health benefits attributed to dietary phytochemicals in health promotion and disease prevention requires application to South African consumers based on their low consumption of phytochemical-rich foods. Education to motivate dietary change should be promoted and encouraged via all communication channels to assist in reducing the prevalence of lifestyle diseases. Increased awareness and knowledge of the dietary adjustments consumers can make to enhance their phytochemical intake is an important and

practical aspect that should be included in food, nutrition and health awareness, as well as education efforts. The information obtained through the research on the dietary adjustments that consumers are likely to make in order to enhance their phytochemical intake can assist in profiling awareness and education efforts. The information can also assist recipe and food developers and the food industry in their efforts to provide food with enhanced phytochemical content, particularly pertaining to composite foods.

CHAPTER THREE
RESEARCH DESIGN AND METHODOLOGY

3.1 Permission to conduct the study

Permission to conduct this study was granted upon approval of the research proposal by the Faculty of Applied Sciences Research Committee at the Cape Peninsula University of Technology (CPUT), and ethical clearance to conduct this study was granted by the Faculty of Applied Sciences Research Ethics Committee (refer Appendix A). Thereafter a letter was presented to the respective human resources departments of the companies who were willing to co-operate with the survey (refer Appendix B). The letter included the logo of CPUT, the title of the study and a brief introduction to the objective of the study, and was signed by the supervisor of the study and the Head of the Agricultural and Food Science Department. Seven medium-sized companies were approached for participation based on their identified existence and their location. The selected locations were the northern and the southern regions of the City of Cape Town. Three companies declined to participate in the study due to time constraints and limited resources to assist with the administration. One company could not be used in the study due to the majority of the employees not meeting the age inclusion criteria (were too young). Once authorisation from the Human Resources Manager was obtained, the prospective respondents were issued with a consent form (refer Appendix C) to verify their involvement prior to the completion of the questionnaire. The consent form included the title of the study, the objective of the study as well as the research outline, contact information for any queries, the respondent involvement (which was the completion of the questionnaire), and assurance to the participant of their anonymity and the confidentiality of the information they provided in the study (South Africa. Department of Health, 2006: 70). The consent form also indicated that participation was completely voluntary and that the participants would be free to withdraw from the study at any time. Once the potential respondents comprehensively understood the above, written consent was obtained from those prepared to participate in the study.

3.2 Sample and sampling method

A consumer survey was conducted in the City of Cape Town amongst adults representing professional sector occupations who were willing to participate through the distribution of a questionnaire. Income reflects the availability of economic and material resources and therefore directly determines dietary quality through making healthy and nutritious food more affordable and readily accessible (Turrell *et al*., 2003: 191). It therefore was decided to

include the following occupations as defined by the International Standards Classification of Occupations (ISCO) as professionals (listed as major group 2) and technician and associate professionals (listed as major group 3) (Bureau of Statistics, 2009) (refer Appendix D) as sample groups representing the professional sector.

The respondents varied in age (within the adult lifecycle grouping 31 to 65 years) and were not limited by gender, race or ethnicity. A report by the WHO/FAO Expert Consultation on diet, nutrition and the prevention of chronic diseases demonstrated the importance of the adult phase in terms of life course, nutrition and chronic disease expression in addition to being a critical stage in the prevention of numerous chronic diseases. There is strong evidence to suggest that adults, more so men than women, have risk factors leading to the development of chronic diseases (Darnton-Hill *et al*., 2004: 108). The adult lifecycle grouping was selected to represent both young (19 to 50 years) and middle (51 to 70 years) adulthood (Wardlaw, 2003: 515) until the older life stage of 65 years (Wardlaw, 2003: 518). The age group selection considered the dietary reference intakes within these adulthood groupings (31 to 50 years and 51 to 70 years) (Wardlaw, 2003:i) and the implication of age as a risk factor for the development of CVD (men over 45 years and women over 55 years) (Wardlaw, 2003: 181) and type-2 diabetes (usually after age 40) (Wardlaw, 2003: 141), and that age can be used to initiate examinations for the early detection of cancer as recommended by the American Cancer Society (i.e. colonoscopy examinations for middle-age and older adults, prostate-specific antigen (PSA) tests for middle-age and older men, and papanicolaou tests (Pap smears) and regular breast examinations (and mammograms), starting at approximately age 40 for women) (Wardlaw, 2003: 288).

The sample method was convenient purposive sampling, a form of non-probability sampling in which individuals are selected because of the ease of their availability or easy access and having particular characteristics of interest appropriate for the purpose of the research (Zikmund & Babin, 2013: 323). As the selected individuals have particular characteristics, this sampling technique infers sampling bias as the sample cannot be said as truly representative of the general population (Mangal & Mangal, 2013: 297). A minimum sample size of 169 respondents was calculated from a population of 186 456, representing 85 815 persons employed in the ISCO professional group and 100 641 in the technicians and associate professional group according to the ISCO occupation classification for the City of Cape Town (City of Cape Town, 2001). The sample calculation used for this study was as follows:

$$n = \frac{Z^2\, p\, q\, N}{e^2\,(N-1) + z^2\, p\, q}$$

Where: p (probability of success) = 0.05; q (probability of failure) = 0.05; Z (z-value for 95% confidence interval) = 1.96; e (precision) = 0.0755; N (population size) = 186 456.

3.3 Type of study

A cross-sectional study design utilising a survey was followed obtaining quantitative data through the use of a questionnaire as the research tool.

3.4 Research method

The method applied to obtain data for the consumer survey was the distribution of a self-administered questionnaire (refer Appendix E), which required the respondents to complete a questionnaire on their own without the presence of the researcher. The absence of the researcher is beneficial in that it enables respondents to complete the questionnaire in private, devoting as much time as they deem necessary to its completion while in familiar surroundings to avoid any potential threat or pressure. Any questions or problems the respondents may have, however, could not be addressed (Cohen *et al*., 2007: 344). As the developed questionnaire was pilot tested (refer 3.5) questions and problems were not expected to arise in its answering.

3.4.1 Questionnaire design

The consumer survey employed a structured questionnaire. A questionnaire is a research instrument used to question subjects concerning a specific topic, with the result recorded in a logical manner (Hague, 1993: 1). The questions were set out in a logical and sequential manner in order to maintain the respondents' attention and required answering in the order in which they appeared (Hague, 1993: 21).

3.4.2 Format of the questions

The questionnaire contained short-answer questions with no use of bias or negative terms in order to avoid bias and confusion (Babbie & Wagenaar, 1992: 164). Closed-ended questions were asked that required restricted answers from a set of fixed responses. Closed-ended questions are simple to analyse when evaluating data (Collins & O'Rourke, 2009: 66), and are beneficial in that they can generate frequencies of responses for statistical analysis.

This enable comparisons to be made across all groups within the sample (Cohen *et al*., 2007: 321).

The major part of the questionnaire consisted of closed-ended scaled questions in which the respondents' answers were limited to a fixed set of responses and the responses were graded in a continuum. The major types of scaled questions that were asked were behavioural questions used to determine facts instead of opinions (Hague, 1993: 30). The likelihood Likert scale questioned specific options of dietary adjustments that could be made to enhance phytochemical intake when consuming proficient home-cooked category prepared dishes as well as commercially manufactured category prepared dishes. A scale typically consists of a series of statements that express a favourable or unfavourable response toward the concept under study (McDaniel & Gates, 1998: 247) which for this study was the dietary adjustments for enhanced phytochemical intake. Each respondent was given a numerical score to reflect how favourable or unfavourable their opinion was towards each statement. The scores were totalled to represent the respondents overall measure (McDaniel & Gates, 1998: 247), which in this study reflected the respondents likelihood to consume proficient home-cooked category prepared dishes and commercially manufactured category prepared dishes for enhanced phytochemical intake (represented in section 3.4.3). A Likert scale is an example of a summated rating scale in which a person's score is determined by summarising the number of questions answered in a particular way. Each item in a Likert scale is an ordinal measure for the reason that the response alternatives have a fixed order, but there is not necessarily equal spacing between the alternatives (Monette *et al*., 2010: 354). An ordinal variable may be ranked from low to high, but there cannot be a partial rank (Monette *et al*., 2010: 114). The Transtheoretical Model was used as consideration to determine the likelihood of the respondents to make commonly advocated dietary adjustments (i.e. increase the intake of fruit, vegetables, whole grains, and tea) for enhanced phytochemical intake.

3.4.3 Questionnaire outlay

The cover page of the questionnaire included the aim of the study. Section A (as page one of the questionnaire) required the respondents to answer questions to determine their awareness of phytochemicals and intake of phytochemical-rich dietary sources. Section B was related to their likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake, and used the stages of change model to determine the stage of the respondents in their current consumption of phytochemical-rich dietary food sources. Section C included the likelihood to purchase and consume commercially

manufactured category prepared dishes for enhanced phytochemical intake; while section D covered the respondents' demographic, health and lifestyle information (refer Appendix E).

Each respondent was allocated a respondent code for confidentiality and data capturing purposes, which was indicated on the first page of the questionnaire. In the questionnaire possible unfamiliar dishes were explained, such as risotto, pesto, compote, crêpe (section B), pulp and pomace (section C), and potential non-specific terms were defined, namely current and former smoker, dietary supplements and physical activity (section D). The content of the questions in sections B and C respectively was directly related to proficient home-cooked category prepared dishes and commercially manufactured category prepared dishes the respondents would be likely to consume in order to enhance their dietary phytochemical intake.

In the first section of the questionnaire (as section A), pertaining to phytochemical awareness and phytochemical-rich dietary source intake, the respondents were questioned about their awareness of common phytochemicals (carotenoids, polyphenols, flavonoids, etc.) and their perceived dietary importance of phytochemicals. The major groups of phytochemicals, which include polyphenols, flavonoids, carotenoids and *Allium* vegetables (Lako *et al*., 2007: 1728), were focused on in the study. The respondents were also asked to report their daily intake of fruit, vegetables, whole grains and tea (black tea, green tea, rooibos herbal tea and other herbal teas), considering the recommended daily consumption of each as phytochemical-rich dietary sources. The serving sizes of whole grains, vegetables and fruit, as defined by the United States Department of Agriculture (USDA), were provided in the questionnaire to assist the respondents in answering questions regarding their daily intake of these foods so that they could report their intake more truthfully and also homogenously in the questionnaire (refer questions 3, 4 and 5, Appendix E). The USDA states that one serving of grains is equivalent to one slice of bread, half a cup of cooked rice or pasta or one cup of ready-to-eat cereal. The USDA further defines whole-grain foods as whole grain, low fat breads, cereals, crackers and pastas. One serving of vegetables is defined by the USDA as half a cup raw or cooked vegetables or one cup raw leafy green vegetables. One serving of fruit is specified by the USDA as one medium-sized fruit or half a cup cut-up fruit or fruit juice (Sizer & Whitney, 2006: 35). Section A of the questionnaire included six multiple-choice questions.

Section B of the questionnaire related to the household dietary adjustments for enhanced phytochemical intake and how likely the respondents would be to consume home-cooked category prepared dishes, if proficiently prepared. The respondents were required to mark their answers in the Likert scale corresponding to their 'likelihood' to consume each of the

category prepared dishes ranging from ‘extremely unlikely’ (scored 1) to ‘extremely likely’ (scored 5). Recipe books from SA, Australia and the UK were screened for food pairing ideas for food vehicle categories and phytochemical-rich dietary source options for proficient home-cooked category prepared dishes. The incorporation of added rooibos herbal tea to category prepared dishes was selected for flavonoid provision (Joubert & Ferreira, 1996: 37), herbs for flavonoid provision (Yao *et al*., 2004: 115), fruit for flavonoid provision (Yao *et al*., 2004: 115), and vegetables for carotenoid (Palace *et al*., 1999: 749), *Allium* compound (Sengupta *et al*., 2004: 237) and flavonoid (Yao *et al*., 2004: 115) provision, which represented the various dietary source adjustment categories. These dietary source adjustment categories were grouped according to food groupings and included a spread of 48 questions (refer Appendix F for the complete dietary source adjustment categories and food vehicle categories). A mean score of the respondents’ likelihood to consume the dietary source adjustment categories, namely rooibos herbal tea (n = 7 questions), herbs (n = 16 questions), vegetables (n = 13 questions) and fruit (n = 12 questions) and food vehicle categories, namely egg (n = 5 questions), chicken (n = 6 questions), fish (n = 1 question), meat (n = 1 question), potato (n = 3 questions), water (n = 1 question) and other starch (n = 7 questions), was determined and used for the data analysis. In this section the respondents were furthermore asked whether they were involved with the preparation of food at home (n = 1 question) and were questioned about their current consumption of phytochemical-rich dietary sources, namely tea, whole grains and fruit and vegetables, separately and combined, using the stages of change model (n = 5 questions), providing for a total of 54 questions (refer Appendix E).

Section C covered commercial dietary adjustments and asked the respondents how likely they would be to purchase and consume a range of commercially manufactured category prepared dishes for enhanced phytochemical intake. Some options are currently available (n = 9 questions), and others may become available in SA in the future (n = 21 questions). The respondents were also required to mark their answers using the Likert scale. Journal articles summarising food trials (such as presented in Table 2.1) were screened for ideas for food vehicle categories and ingredient additions as added phytochemical-rich dietary source adjustment categories for incorporation in the selection of commercially manufactured category prepared dishes. The incorporation of added rooibos herbal tea was selected for flavonoid provision (Joubert & Ferreira, 1996: 37), herbs for flavonoid provision (Yao *et al*., 2004: 115), fruit for flavonoid (Yao *et al*., 2004: 115) and vegetables for carotenoid (Palace *et al*., 1999: 749), *Allium* compound (Sengupta *et al*., 2004: 237) and flavonoid (Yao *et al*., 2004: 115) provision as well as added fibre for phenolic compound provision (Dykes & Rooney, 2007: 105), which represented the various dietary source adjustment categories. These dietary source adjustment categories were grouped according

to their type and included a spread of 30 questions (refer Appendix G for the complete dietary source adjustment categories and food vehicle categories). A mean score of the respondents' likelihood to consume the phytochemical-rich dietary source adjustment categories, namely tea (n = 5 questions), herbs (n = 3 questions), vegetables (n = 8 questions), fruit (n = 8 questions) and fibre (n = 6 questions) categories, and food vehicle categories, namely grains/bake (n = 15 questions), pizza/pasta (n = 7), dairy (n = 4 questions) and beverages (n = 4 questions), was determined and used for the data analysis.

Demographic (n = 7 questions), health and lifestyle (n = 6 questions) information was included in section D of the questionnaire (refer Appendix E). The latter was included to ascertain characteristics of the respondents pertaining to their health consciousness to enable possible comparisons across groups in the sample. In the demographic section of the questionnaire, the respondents were required to state their current occupation from an attachment to the questionnaire. The attachment included the two major occupation groups representing the professional sector for the purpose of defining the sample population for this research as identified by the ISCO. The health and lifestyle information included in the questionnaire were obtained from the literature from a case-controlled study to determine the potentially modifiable risk factors associated with acute myocardial infarction. The study defined current smokers as "individuals who smoked tobacco in the last 12 months" and included those who had quit within the past year. Former smokers were defined as "those who had quit more than a year ago", while the consumption of alcohol to promote health was defined as "consumption three or more times a week". Physically active was defined as "regular involvement of moderate (walking, cycling or gardening) or strenuous exercise (jogging, football and vigorous swimming) for four hours or more a week" (Yusuf *et al*., 2004: 939). According to Kraft and Goodell (1993: 18), individuals who pursue a wellness-oriented lifestyle are those concerned with nutrition and physical fitness and those who commonly purchase and use health-related products and services. The US Dietary Supplement Health and Education Act (DSHEA) defines a dietary supplement as "a product (other than tobacco) that is intended to supplement the diet and that bears or contains one or more of the following dietary ingredients: a vitamin, a mineral, a herb or other botanical, an amino acid, a dietary substance for use by man to supplement the diet by increasing the total daily intake, or a concentrate, metabolite, constituent, extract or combinations of these ingredients" (Halsted, 2003: 1007S). The definition of a dietary supplement, as supplied by the DSHEA, was used in the questionnaire to assist the respondents in answering whether they take dietary supplements, and further, to ascertain the respondents health consciousness.

3.5 Pilot study

Five lecturers involved in the Consumer Science: Food and Nutrition programme at the CPUT assessed the pilot questionnaire for content validity pertaining to the relevance of the questions, and the components of the questionnaire as to the representativeness of the content domain investigated (Fawcett, 2007: 171). Furthermore, the lecturers assessed the questionnaire for face validity concerning the relevance of the questions and suggested focusing on more widely available and familiar foods, as well as dishes that included meat and fish, as the latter were excluded. They also checked whether the questions were clear and unambiguous (Bruce *et al*., 2008: 173). Their assessment of the questionnaire predominantly focused on the questions of sections B and C. A number of changes were made (replacing food pairing ideas) and their suggestions were considered (defining potential unknown foods/ingredients and terms) within sections B and C of the questionnaire.

A pilot study was conducted upon approval of the study, whereby the questionnaire was distributed to approximately 10% of the planned respondent sample (n = 17). The questionnaire was piloted for its ease of use amongst respondents, (with the information being printed on both sides of the paper) and its face validity to identify whether there were any problems amongst the respondents pertaining to content, wording, layout, length, instructions and coding (McCormack & Hill, 1997: 97). Changes made to the questionnaire included a technical error and the approximate time to complete the questionnaire was added to the front page. It took the respondents an average of 20 minutes to complete the questionnaire.

3.6 Data analysis

The responses provided were standardised into numerical codes in the questionnaire. The descriptive analyses included frequencies and percentages considering the range of the data. The scale responses were also considered for each question included within the dietary source adjustment category grouping and the means (along with the standard errors) calculated across the respondent sample for the proficient home-cooked category prepared dishes (section B of the questionnaire) and the commercially manufactured category prepared dishes (section C of the questionnaire) for each dietary source adjustment and food vehicle category. The dietary source adjustment and food vehicle categories for the proficient home-cooked category prepared dishes are presented in Appendix F and the dietary source adjustment and food vehicle categories for the commercially manufactured category prepared dishes in Appendix G. The mean of the scale values was computed as the central

limit theorem indicates that sample means of all possible samples of a specific sample size ($n \geq 30$) from any shaped population of scaled data will be normally distributed (Burns & Burns, 2008: 187).

The repeated measure analysis of variance (ANOVA) was used (as the variables were from the same respondent sample) to determine significant differences ($p < 0.05$) for the likeliness scale means (with '1' as 'extremely unlikely' and '5' as 'extremely likely') of each of the different household and commercial phytochemical dietary adjustments. This statistic was applied across the different phytochemical provider ingredients or dietary source adjustment categories (addition of fruit, vegetables, rooibos herbal tea, herbs, etc.) and selected food vehicle categories (chicken, fish, egg, potato, other starch, etc.). Where the ANOVA results showed significant differences, the Bonferroni correction for multiple comparisons was applied and pair-wise comparisons were utilised, for identification of the contrasts within the different dietary source adjustment or food vehicle categories. A dummy variable (indicating whether the respondents were involved in the preparation of food at home or not) was used as independent variable and the phytochemical-rich dietary source adjustment categories (fruit, vegetables, rooibos herbal tea, herbs, etc.) and food vehicle categories (chicken, fish, egg, potato, other starch, vegetables, fruit, etc.) were used as dependent variables. ANOVA and the Bonferroni correction for multiple comparisons were also used to identify significant differences between the respondents. Such differences included the respondents' perceived phytochemical dietary importance and dietary source consumption, along with their demographic, health and lifestyle characteristics, in relation to the likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake, constituting fruit, vegetable, rooibos herbal tea and herb inclusions as phytochemical-rich dietary source adjustment categories.

The frequencies of the respondents' consumption of phytochemical-rich dietary sources (fruit, vegetables, whole grains, tea and herbs) in relation to the stages of change model were also assessed using Pearson's chi-squared analysis to determine significant associations/differences ($p < 0.05$) between the data sets for the consumption of each of the phytochemical-rich dietary sources. The data was analysed using SPSS version 20.

CHAPTER FOUR
RESULTS

4.1 Introduction

The study sample included respondents employed on a full-time basis representing the professional sector at various companies in the City of Cape Town. The respondents' demographic characteristics were obtained, along with their health and lifestyle characteristics. The respondents' (i) overall awareness of common phytochemicals, (ii) their perceived dietary importance of phytochemicals, coupled with (iii) their consumption of phytochemical-rich dietary sources, namely fruit, vegetables, whole grains and tea, are presented along with (iv) their phytochemical-rich dietary source consumption in relation to their intention to change their current daily intake of these dietary sources as the first section of the results.

The respondents' likelihood to consume set options of category prepared dishes and food vehicle categories with fruit, vegetable, whole grain, tea and herb additions as the phytochemical-rich dietary source adjustment categories for enhanced phytochemical intake was obtained for both the household and commercial sector are presented next. In the analyses of the respondents' likelihood to consume phytochemical-rich dietary source adjustment and food vehicle categories for enhanced phytochemical intake, the number of prepared dishes (and which) representing the set options for each category are presented in Appendix F for the proficient home-cooked category prepared dishes and in Appendix G for the commercially manufactured category prepared dishes. These Appendices can be consulted to substantiate the table indications.

Also presented here, as the last section of the results, is the respondents' demographic, health and lifestyle characteristics, which influenced their likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake. No analyses were considered pertaining to the likelihood of the respondents to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake in relation to these characteristics, as the bulk of the questions (21 of the 30 questions) referred to food products not currently available in SA.

4.2 Sample size and profile

4.2.1 Sample size

A total of 230 questionnaires were distributed to allow for incomplete questionnaire data and participation withdrawal, of which 184 were captured and used for the results as any respondent number higher than 169 would be statistically suitable as a sample size. The 184 respondents were personnel within various divisions presenting professional sector occupations of the companies that provided study co-operation. The questionnaires of 30 respondents were not returned due to their withdrawal from the study (87% response rate), and 16 questionnaires had to be discarded as they were returned incomplete (the questionnaires were self-administered). In these 16 questionnaires a food pairing option (question) (or two) in Section B, question 8 (comprising 48 food pairings covering the household dietary adjustments) and/or Section C, question 10 (comprising 30 food pairings covering the commercial dietary adjustments) were generally missed. No pattern could be identified across these missed food pairings spread across questions 8 and 10 (n = 78 food pairings/questions). These incomplete questionnaires were discarded to maintain the same sample size of 184 across all the food pairings in questions 8 and 10 since the household and commercial phytochemical dietary adjustment and food vehicle categories formed the focus of the study. Those respondents who withdrew from the study appeared to do so due to time constraints.

4.2.2 Respondent demographic characteristics

The respondents were predominantly female (58.7%), between the ages of 31 and 44 years (67.9%) and of White ethnic origin (72.3%). The highest level of education attained by the majority (61.5%) of the respondents, with marginal differences between the levels, was grade 12 and a diploma (29.4%) or a degree (32.1%). A small percentage (8.7%) of the respondents within the occupation groups representing the professional sector as the sample for this research attained grade 12 (matric) as their highest level of education. A large percentage (42.4%) of the respondents' occupations fell within the category 'other professionals', and included occupations such as business professionals and legal professionals (Bureau of Statistics, 2009). Almost half of the respondents were married or living together with children (48.9%), and were English (48.9%) or Afrikaans (47.3%) speaking. The majority (76.1%) of the respondents were involved in the preparation of food at home. The respondents' demographic characteristics are presented in Table 4.1.

Table 4.1: Demographic characteristics of the respondents

Respondent demographic characteristics (n = 184)		%	n
Gender	Male	41.3	76
	Female	58.7	108
Age (years)	31-44	67.9	125
	45-54	19	35
	55-64	13	24
Ethnicity	White	72.3	133
	Black	3.8	7
	Coloured	22.3	41
	Other	1.6	3
Level of education (highest)	Grade 12 (matric)	8.7	16
	Grade 12 and certificate	11.4	21
	Grade 12 and diploma	29.4	54
	Grade 12 and degree	32.1	59
	Postgraduate (master's/doctorate)	18.5	34
Occupation[a]	Physicists, chemists and related professionals	16.3	30
	Life science and health professionals	1.6	3
	Teaching professionals	1.1	2
	Other professionals	42.4	78
	Technicians and associate professionals	4.4	8
	Life science and health associate professionals	1.1	2
	Teaching associate professionals	0.5	1
	Other associate professionals	32.6	60
Marital status	Married / living together with children	48.9	90
	Married / living together without children	21.7	40
	Single and living with children	9.8	18
	Single and living without children	19.6	36
Home language	English	48.9	90
	Afrikaans	47.3	87
	Xhosa	1.6	3
	Other	2.2	4
Involved in home food preparation	Yes	76.1	140
	No	23.9	44

[a] International Standards Classification of Occupations as professionals and technician and associate professionals as sample groups

4.2.3 Respondent health and lifestyle characteristics

The respondents' health and lifestyle characteristics are presented in Table 4.2. The majority of the respondents were non-smokers (69%), with a few (10.9%) of the respondents being former smokers. Just over half of the respondents consumed alcohol less than three times per week (54.4%), were regular supplement users (50.5%) and regularly engaged in physical activity (59.2%).

Table 4.2: Health and lifestyle characteristics of the respondents

Respondent health and lifestyle characteristics (n = 184)		%	n
Smoking status[a]	Non-smoker	69	127
	Current smoker	20.1	37
	Former smoker	10.9	20
Alcohol consumption[b]	None	28.3	52
	Less than three times per week	54.4	100
	Three or more times per week	17.4	32

Table 4.2 (continued)

Respondent health and lifestyle characteristics (n = 184)		%	n
Dietary supplement usage[c]	Never	19	35
	Seldom	16.9	31
	When remembered	13.6	25
	Fairly regularly	11.4	21
	Regularly	39.1	72
Level of physical activity[d]	Physically active	59.2	109
	Not physically active	40.8	75
Diagnosed with chronic disease	Obesity	7.6	14
	Diabetes mellitus	4.4	8
	Cardiovascular disease	2.2	4
	Cancer (excluding melanoma and skin cancer)	2.2	4
Family history of lifestyle disease	Obesity	7.6	14
	Diabetes mellitus	29.9	55
	Cardiovascular disease	26.6	49
	Cancer (excluding melanoma and skin cancer)	36.4	67

[a] Current smoker included those who smoked any tobacco in the past 12 months and those who had quit within the past year. Former smoker included those who had quit more than a year ago (Yusuf *et al*., 2004:939)
[b] Protective consumption was defined as consumption three or more times a week (Yusuf *et al*., 2004:939)
[c] Dietary supplement was defined as a vitamin, a mineral, a herb or other botanical, an amino acid, a dietary substance for use by man to supplement the diet by increasing the total daily intake, or a concentrate, metabolite, constituent, extract or combinations of these ingredients (Halsted, 2003:1007S)
[d] Physically active was defined as regular involvement in moderate (walking, cycling or gardening) or strenuous exercise (jogging, football and vigorous swimming) for four hours or more a week (Yusuf *et al*., 2004:939)

A small percentage of the respondents had been diagnosed with a lifestyle disease, with the highest percentage diagnosed with obesity (7.6%), followed by diabetes mellitus (4.4%) and CVD and cancer (excluding melanoma and skin cancer) (2.2% or four respondents each). The most prevalent lifestyle disease within the respondents' family history was cancer (36.4%), followed by diabetes mellitus (29.9%), CVD (26.6%) and obesity (7.6%) (refer Table 4.2).

4.3 Respondent phytochemical awareness and dietary source consumption

The respondents' phytochemical awareness and perceived importance of phytochemicals in the diet are presented in Figures 4.1 and 4.2 respectively. The majority (77.7%) of the respondents indicated that they had not heard of phytochemicals before taking part in this study (refer Figure 4.1) and approximately half (55.4%) of the respondents could not indicate the role these compounds play in the human diet (refer Figure 4.2). A third (31%) indicated that phytochemicals were necessary to support health and well-being; some (10.9%) indicated they were necessary to prevent illness and disease; while a few (2.7% or five respondents) indicated that the body can produce them and that they therefore are not very necessary in the human diet (refer Figure 4.2). More than 80% of the respondents indicated that they were not familiar with the *Allium* compounds (87%), the polyphenols (84.8%) or the isoflavones (83.7%). About three-quarters (76%) of the respondents indicated that they were not aware of the carotenoids and just less than two-thirds (62%) were not familiar with the flavonoids (refer Figure 4.1).

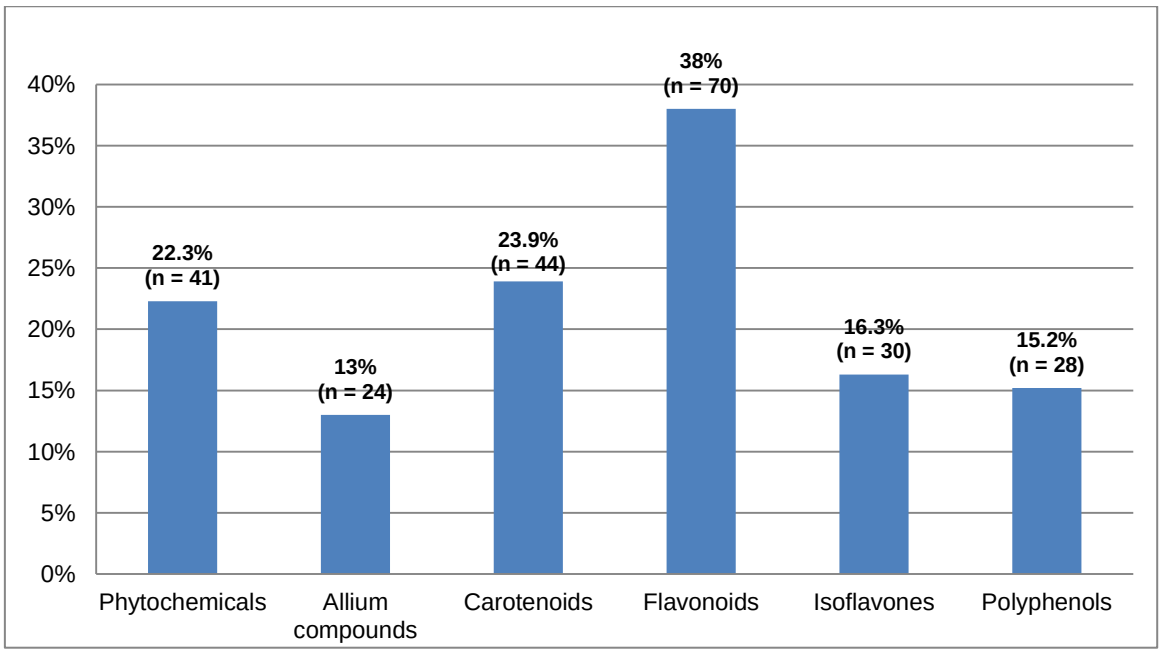

Figure 4.1: Respondent phytochemical awareness (n = 184)

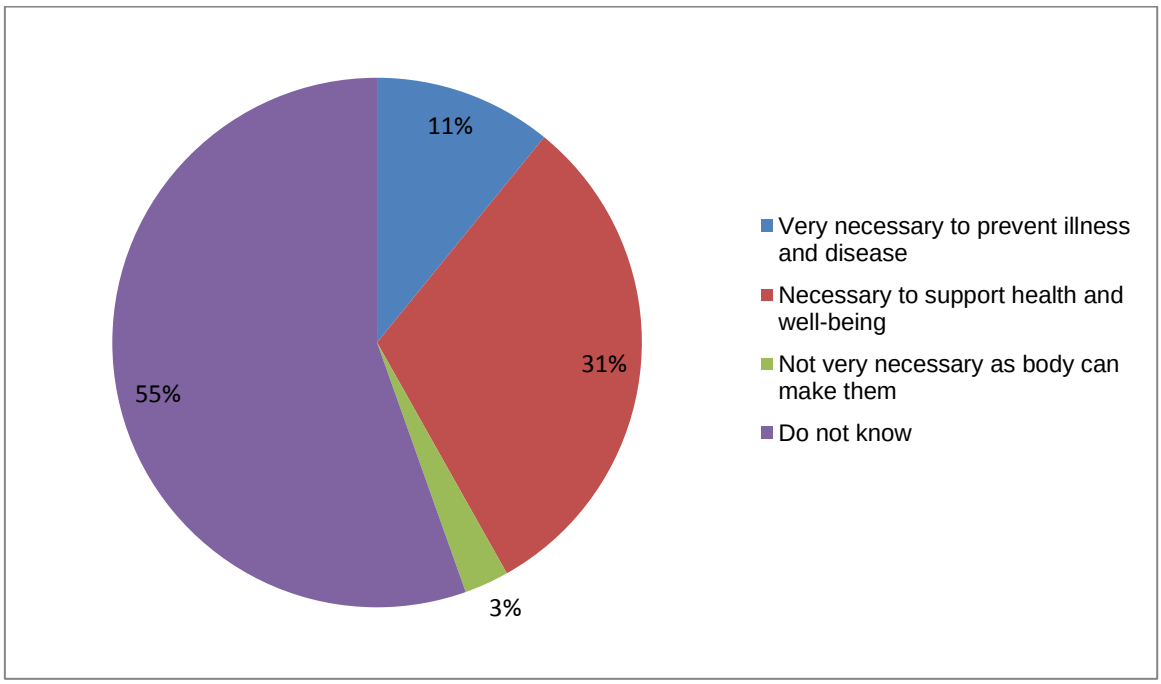

Figure 4.2: Respondent (n = 184) perceived importance of phytochemicals in the diet

The respondents were also questioned about their daily intake of dietary sources of phytochemicals, namely fruit, vegetables, whole grains and tea (refer Table 4.3). Less than half (42.9%) of the respondents indicated that they consumed none to one serving of fruit daily, while half (50%) indicated that they consumed two to four servings daily. When questioned about their vegetable intake approximately a third (31%) of the respondents indicated that they consumed none to one serving of vegetables daily. Most (58.2%) of the

respondents indicated that they consumed two to four servings of vegetables daily, and very few (10.9%) indicated that they consumed three to five servings of vegetables daily. The respondents' whole-grain intake varied quite considerably. Twelve percent of the respondents indicated that they did not consume whole grains. The majority (72.3%) of the respondents indicated that they either consumed one serving (41.9%) or two servings (30.4%) of whole grains daily. About 10% (9.2% or 17 respondents) indicated that they consumed three servings of whole grains daily, and about five percent (6.5% or 12 respondents) indicated that they consumed more than three servings daily. Approximately a quarter of the respondents indicated that they did not consume tea (22.8%) or consumed only one cup daily (26.6%). About a third (36.4%) of the respondents indicated that they consumed two to three cups daily, while only a few (14.1% or 26 respondents) indicated that they consumed more than three cups daily.

Table 4.3: Respondent consumption of phytochemical-rich dietary sources

Respondent consumption of phytochemical-rich dietary sources (n = 184)		**%**	**n**
Daily fruit intake	None to 1 serving	42.9	79
	2 to 4 servings	50	92
	3 to 5 servings	7.1	13
	More than 5 servings	0	0
Daily vegetable intake	None to 1 serving	31	57
	2 to 4 servings	58.2	107
	3 to 5 servings	10.9	20
	More than 5 servings	0	0
Daily whole-grain intake	None	12	22
	1 serving	41.9	77
	2 servings	30.4	56
	3 servings	9.2	17
	More than 3 servings	6.5	12
Daily tea intake	None	22.8	42
	One cup	26.6	49
	2 to 3 cups	36.4	67
	4 to 6 cups	14.1	26
	More than 6 cups	0	0

4.4 Respondent stage of change in relation to phytochemical-rich dietary source consumption

Approximately a quarter of the respondents indicated that they were 'in the process of implementing' increasing their daily fruit intake to two servings daily (25.5%) and their daily vegetable intake to three servings (23.4%). Just more than a third (37.5%) of the respondents indicated that they had 'currently implemented (longer than six months)' their daily fruit intake to consume at least two servings, and just less than a third (29.9%) of the respondents indicated that they had 'currently implemented (longer than six months)' their daily intake of vegetables to consume at least three servings. Just more than a quarter of the respondents indicated that they were 'not intending to change' (29.4%) and 'considering changing in the next 30 days' (28.3%) their current whole-grain intake to three servings a

day. Most (41.9%) of the respondents indicated that they were 'not intending to change' their current daily tea intake, while almost a fifth (21.7%) indicated that they were 'considering changing in the next 30 days' to increase their tea consumption to four to six cups daily. Approximately a quarter of the respondents indicated that they had 'currently implemented (longer than six months)' (26.1%) or were 'in the process of implementing' to increase (21.2%) their daily fruit and vegetable intake to five servings. The respondents' stage of phytochemical-rich dietary source intake is summarised in Table 4.4.

Table 4.4: Respondent stage of change in relation to phytochemical-rich dietary source consumption

Phytochemical-rich dietary source consumption	Stage of change									
	Not intending to change		Considering changing in the next 30 days		Committing to change in the next 30 days		In the process of implementing		Currently implemented (longer than six months)	
	%	n	%	n	%	n	%	n	%	n
Fruit as at least two servings daily	8.7	16	17.4	32	10.9	20	25.5	47	37.5	69
Vegetables as at least three servings daily	11.4	21	21.2	39	14.1	26	23.4	43	29.9	55
Whole grains as at least three servings daily	29.4	54	28.3	52	10.3	19	16.9	31	15.2	28
Tea (black tea, green tea, rooibos or any other herbal tea) as four to six cups daily	41.9	77	21.7	40	9.8	18	14.7	27	12	22
Fruit and vegetables as at least five servings daily	14.7	27	24.5	45	13.6	25	21.2	39	26.1	48

The respondents' stage of change in relation to their phytochemical-rich dietary source intake is summarised in Table 4.5. A significant difference ($p < 0.001$) was found between the respondents' stage of change and their daily fruit intake. Most (63.2%) of the respondents who consumed none to one serving of fruit daily were considering changing in the next 30 days to consume two or more servings daily (35.4%) or were in the process of implementing this (27.8%). On the contrary, most (82.8%) of the respondents who consumed two or more servings of fruit daily were in the process of implementing this (23.8%) or had already done so for longer than six months (59%). A significant difference ($p < 0.001$) was additionally found between the respondents' stage of change and their daily vegetable intake. About a quarter (24.6%) of the respondents who consumed none to one serving of vegetables daily were not intending on changing their current intake and approximately a third (35.1%) were considering changing their daily intake in the next 30 days to at least three servings. Approximately a third of the respondents who consumed two to four servings of vegetables daily were in the process of increasing their intake (28%), or were already consuming at least

three servings of vegetables daily for longer than six months (34.6%). Considering the respondents who consumed three or more servings of vegetables daily, 80% were already doing so and had implemented this for longer than six months.

Table 4.5: Respondent differences in the consumption of phytochemical-rich dietary sources in relation to the intention to change

Daily intake of dietary phytochemical-rich sources[a]	Stage of change											
	Total (n = 184)	Not intending to change		Considering changing in the next 30 days		Committing to change in the next 30 days		In the process of implementing		Currently implemented (longer than six months)		P value
	n	%	n	%	n	%	n	%	n	%	n	
Fruit												
None to 1 serving	79	10.1	8	35.4	28	17.7	14	27.8	22	8.9	7	0.000
2 or more servings	105	7.6	8	3.8	4	5.7	6	23.8	25	59	62	
Vegetables												
None to 1 serving	57	24.6	14	35.1	20	15.8	9	21.1	12	3.5	2	0.000
2 to 4 servings	107	4.7	5	17.8	19	15	16	28	30	34.6	37	
3 servings or more	20	10	2	0	0	5	1	5	1	80	16	
Whole grains												
None to 1 serving	99	35.4	35	34.4	34	12.1	12	15.2	15	3	3	0.000
2 servings	56	28.6	16	28.6	16	10.7	6	19.6	11	12.5	7	
3 servings or more	29	10.3	3	6.9	2	3.4	1	17.2	5	62.1	18	
Tea												
None to 1 cup	91	48.4	44	27.5	25	9.9	9	9.9	9	4.4	4	0.000
2 to 3 cups	67	41.8	28	19.4	13	10.4	7	16.4	11	11.9	8	
More than 3 cups	26	19.2	5	7.7	2	7.7	2	26.9	7	38.5	10	

[a] Response options combined due to low respondent representation

A significant difference ($p < 0.001$) was additionally found between the respondents' stage of change and their daily whole-grain intake. Almost equal proportions of respondents who consumed none to one serving of whole grains daily were not intending on changing their current intake (35.4%) and considering changing in the next 30 days (34.4%) to three or more servings daily. A similar pattern was found amongst the respondents who consumed two servings of whole grains daily, with approximately a quarter of the respondents not intending on changing (28.6%) and considering changing

in the next 30 days (28.6%). In contrast, nearly two thirds (62.1%) of the respondents who consumed three servings or more of whole grains daily had already implemented this for longer than six months. A significant difference ($p < 0.001$) was furthermore found between the respondents' stage of change and their current daily tea intake. Most of the respondents who consumed none to one cup of tea daily (48.4%) and most of the respondents who consumed two to three cups daily (41.8%) were not willing to change their current tea intake. About a quarter (27.5%) of the respondents who consumed none to one cup of tea daily and almost a fifth (19.4%) of the respondents who consumed two to three cups of tea daily were considering changing in the next 30 days to between four and six cups daily. Amongst those respondents who consumed more than three cups of tea daily, on the other hand, about a quarter (26.9%) were in the process of implementing drinking more than three cups, while more than a third (38.5%) had already done so for longer than six months (refer Table 4.5).

4.5 Respondent likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

The respondents' likelihood to consume proficient home-cooked category prepared dishes with rooibos herbal tea, fruit, vegetable and herb additions for enhanced phytochemical intake is summarised in Table 4.6. Less than half of the respondents indicated that they would be likely to consume fruit as the food vehicle category for rooibos herbal tea addition, as only 38% indicated that they would be likely to consume prunes stewed in rooibos herbal tea, 36.4% that they would be likely to consume plum compote prepared with rooibos herbal tea, and 43.5% that they would be likely to consume pears poached in rooibos herbal tea. Starch as food vehicle category for the addition of rooibos herbal tea was a more likely option. Here more respondents indicated that they would be likely to consume bread baked with rooibos herbal tea than the other rooibos herbal tea dietary source adjustment options. Just more than half (53.3%) of the respondents indicated that they would be likely to consume this, while less than half (44%) indicated that they would be likely to consume risotto prepared with rooibos herbal tea. Less than half (40.8%) of the respondents also indicated that they would be likely to consume vegetable soup prepared with rooibos herbal tea, and only approximately a third (34.8%) that they would be likely to consume tomato soup prepared with rooibos herbal tea as the dietary source adjustment category and vegetables as the food vehicle category (refer Table 4.6).

Table 4.6: Respondent likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

Phytochemical-rich dietary source adjustment category	Food vehicle category	Category prepared dish	Respondent consumption likeliness (n = 184)									
			Extremely unlikely		Very unlikely		Unsure		Very likely		Extremely likely	
			%	n	%	n	%	n	%	n	%	n
Rooibos herbal tea	Fruit	Prunes stewed in rooibos herbal tea	20.7	38	20.7	38	20.7	38	26.6	49	11.4	21
		Plum compote[a] prepared with rooibos herbal tea	19	35	16.3	30	28.3	52	23.9	44	12.5	23
		Pear poached in rooibos herbal tea	15.2	28	20.7	38	20.7	38	28.3	52	15.2	28
	Other starch	Risotto[b] prepared with rooibos herbal tea	14.7	27	16.3	30	25	46	29.9	55	14.1	26
		Bread baked with rooibos herbal tea	9.8	18	13	24	23.9	44	37	68	16.3	30
	Vegetables	Vegetable soup prepared with rooibos herbal tea	14.1	26	23.4	43	21.7	40	32.1	59	8.7	16
		Tomato soup prepared with rooibos herbal tea	19.6	36	23.9	44	21.7	40	27.7	51	7.1	13
Fruit: Berries	Salad and dessert	Green leafy salad with strawberries	5.4	10	9.2	17	12.5	23	30.4	56	42.4	78
		Crêpe[c] with mixed berries	5.4	10	8.2	15	9.2	17	33.2	61	44	81
		Mixed berry compote	7.1	13	13.6	25	13	24	35.3	65	31	57
Pome	Miscellaneous	Pear poached in red grape juice	12.5	23	15.8	29	17.9	33	34.8	64	19	35
		Rocket and pear salad	8.2	15	13	24	22.8	42	29.4	54	26.6	49
		Chicken breast salad with apple pieces	4.4	8	7.1	13	10.3	19	39.7	73	38.6	71
		Chicken and apple casserole	9.2	17	12	22	12.5	23	39.7	73	26.6	49
Pome	Miscellaneous	Raw apple with skin	0	0	4.4	8	4.9	9	32.1	59	58.7	108

Table 4.6 (continued)

Phytochemical-rich dietary source adjustment category	Food vehicle category	Category prepared dish	Respondent consumption likeliness (n = 184)									
			Extremely unlikely		Very unlikely		Unsure		Very likely		Extremely likely	
			%	n	%	n	%	n	%	n	%	n
Citrus	Animal source	Kingklip fish baked with naartjie (citrus fruit)	10.3	19	12	22	20.7	38	34.8	64	22.3	41
	Vegetables	Carrots roasted in orange juice	7.6	14	8.7	16	17.4	32	35.9	66	30.4	56
		Butternut and orange soup	7.6	14	14.7	27	15.8	29	33.7	62	28.3	52
Dried fruit		Carrot salad with raisins	9.2	17	13.6	25	10.9	20	34.8	64	31.5	58
Vegetable: Broccoli	Soup and bakes	Broccoli soup	13	24	13.6	25	13	24	39.1	72	21.2	39
		Pasta and broccoli bake	7.6	14	6	11	8.7	16	35.9	66	41.9	77
		Chicken and broccoli bake	7.6	14	3.8	7	5.4	10	37.5	69	45.7	84
Butternut	Soup and egg	Roasted butternut soup	4.9	9	3.3	6	5.4	10	46.2	85	40.2	74
		Roasted butternut quiche	7.6	14	7.6	14	12	22	37.5	69	35.3	65
Onion	Soup and egg	Onion soup	10.9	20	19	35	16.9	31	37	68	16.3	30
		Onion quiche	12.5	23	12.5	23	19	35	37	68	19	35
Spinach	Miscellaneous	Spinach quiche	11.4	21	8.2	15	6	11	35.3	65	39.1	72
		Chicken breast stuffed with spinach	6	11	4.9	9	7.6	14	34.8	64	46.7	86
		Pancakes filled with cooked spinach	8.7	16	16.3	30	10.9	20	33.2	61	31	57
Tomato	Miscellaneous	Tomato soup	14.7	27	13.6	25	8.7	16	43.5	80	19.6	36
		Meatballs cooked in tomato	5.4	10	7.6	14	6	11	31	57	50	92
		Spaghetti with tomato pesto[d]	0	0	9.8	18	6.5	12	40.2	74	43.5	80
Herbs: Mint	Miscellaneous	Split pea and mint soup	10.9	20	20.1	37	16.9	31	36.4	67	15.8	29
		Potato salad with mint	4.4	8	14.7	27	20.1	37	37.5	69	23.4	43

Table 4.6 (continued)

Phytochemical-rich dietary source adjustment category	Food vehicle category	Category prepared dish	Respondent consumption likeliness (n = 184)									
			Extremely unlikely		Very unlikely		Unsure		Very likely		Extremely likely	
			%	n	%	n	%	n	%	n	%	n
Herbs (continued)	Miscellaneous (continued)	Water infused with mint	3.8	7	12	22	12	22	40.2	74	32.1	59
Parsley	Miscellaneous	Boiled baby potatoes with parsley	0	0	4.4	8	4.4	8	45.7	84	45.7	84
		Scrambled egg with parsley	3.8	7	5.4	10	3.3	6	42.9	79	44.6	82
		Carrot salad with raisins and parsley	9.8	18	14.1	26	16.9	31	34.8	64	24.5	45
		Chicken soup with parsley	0	0	7.6	14	3.8	7	49.5	91	39.1	72
Basil	Miscellaneous	Spanspek balls with basil	10.3	19	14.1	26	21.2	39	31.5	58	22.8	42
		Sliced tomato with basil	8.2	15	10.9	20	9.2	17	40.2	74	31.5	58
		Tomato and basil soup	12	22	14.1	26	10.3	19	41.3	76	22.3	41
Mixed herbs	Miscellaneous	Omelette with mixed herbs	3.3	6	3.8	7	6.5	12	45.1	83	41.3	76
		Bread baked with mixed herbs	0	0	8.2	15	13.6	25	52.2	96	26.1	48
		Rice with mixed herbs	0	0	7.1	13	9.8	18	54.9	101	28.3	52
Rosemary	Miscellaneous	Roasted potatoes with rosemary	0	0	5.4	10	7.6	14	40.2	74	46.7	86
		Butternut soup with rosemary	7.6	14	10.9	20	16.9	31	44	81	20.7	38
		Roast chicken with rosemary stuffing	4.9	9	3.8	7	7.6	14	35.3	65	48.4	89

[a] Plum compote means plums cooked in syrup
[b] Risotto means rice cooked to a creamy and sticky consistency
[c] Crêpe means a very thin pancake
[d] Tomato pesto means a paste of crushed sundried tomatoes, pine nuts and olive oil

The respondents indicated that they would be likely to consume the available options of berries as a phytochemical-rich dietary source adjustment category for added fruit. The majority of the respondents indicated that a green leafy salad with strawberries (72.8%),

crêpe with mixed berries (77.2%) and mixed berry compote (66.3%) would be likely options, while just over half (53.8%) of the respondents indicated that they would be likely to consume pear poached in red grape juice. Furthermore, the respondents indicated that they would be likely to consume pome fruit, as added pears or apples, as phytochemical-rich dietary source adjustment category. Just over half (56%) of the respondents indicated that they would be likely to consume rocket and pear salad. The respondents also indicated that they would be likely to consume chicken as the food vehicle category for added apple, with just over three quarters (78.3%) likely to consume a chicken breast salad with apple pieces and two-thirds (66.3%) likely to consume a chicken and apple casserole. Considering soup as a food vehicle category for fruit addition, less than two thirds (62%) of the respondents indicated that they would be likely to consume butternut and orange soup. Just over half (57.1%) of the respondents indicated that they would be likely to consume kingklip baked with naartjie segments (as added citrus fruit). There were marginal differences amongst the carrot dishes as the food vehicle category for fruit addition, with approximately two-thirds of the respondents indicating that they would be likely to consume carrots roasted in orange juice (66.3%) and carrot salad with raisins (66.3%). Consuming raw apple with its skin on was a likely option for the majority (90.8%) of the respondents (refer Table 4.6).

Various vegetables were included as options for vegetables as the phytochemical-rich dietary source adjustment category, as well as for vegetable prepared dishes as the food vehicle categories (refer Table 4.6). The majority of the respondents indicated that they would be likely to consume pasta, meat and chicken as food vehicles for added vegetables, namely spaghetti tossed in tomato pesto (83.7%), meatballs cooked in tomato sauce (81%), chicken and broccoli bake (83.2%), pasta and broccoli bake (77.8%) and chicken breast stuffed with spinach (81.5%). Approximately two thirds (64.2%) of the respondents indicated that they would be likely to consume pancakes filled with cooked spinach. More respondents, however, indicated that they would be likely to consume spinach quiche (74.4%) and roasted butternut quiche (72.8%) than onion quiche (56%), considering quiche as food vehicle category for different vegetables within the vegetable dietary source adjustment category. Considering soup as a food vehicle category for vegetable addition, the majority (86.4%) of the respondents indicated that they would be likely to consume roasted butternut soup. Just less than two thirds of the respondents indicated that they would be likely to consume broccoli soup (60.3%) and tomato soup (63.1%), and approximately half (53.3%) of the respondents that they would be likely to consume onion soup.

More respondents indicated that they would be likely rather than not likely to consume category prepared dishes with added herbs for enhanced phytochemical intake (refer Table 4.6). The majority of the respondents indicated that they would be likely to consume both food vehicle category options of chicken with added herbs, namely chicken soup with parsley (88.6%) and roast chicken with rosemary stuffing (83.7%). The majority of the respondents indicated that they would also be likely to consume egg as food vehicle category with added herbs, such as scrambled egg with parsley (87.5%) and omelette with mixed herbs (86.4%). Potato and other starch were also likely food vehicle category options for added herbs amongst the respondents. The majority indicated that they would be likely to consume boiled baby potatoes with parsley (91.4%), roasted potatoes with rosemary (86.9%), rice with mixed herbs (83.2%), and bread baked with mixed herbs (78.3%). Just less than two thirds (60.9%) of the respondents indicated that they would be likely to consume potato salad with mint. Just less than two thirds (59.3%) of the respondents also indicated that they would be likely to consume carrot salad with raisins and parsley. Water infused with mint was another likely food vehicle category option for added herbs, with the majority (72.3%) of the respondents indicating that they would be likely to consume this. Approximately two thirds of the respondents indicated that they would be likely to consume butternut soup with rosemary (64.7%) and tomato and basil soup (63.6%), while just over half (52.2%) of the respondents indicated that they would be likely to consume split pea and mint soup considering soup as a food vehicle category for added herbs. Most (71.7%) of the respondents indicated that they would be likely to consume sliced tomato salad with shredded basil, and approximately half (54.3%) that they would be likely to consume spanspek balls with shredded basil considering basil as a herb dietary source adjustment category.

4.6 Respondent likelihood to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake

The respondents' likelihood to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake is summarised in Table 4.7. Considering baked dishes as the food vehicle category with added fruit as the dietary source adjustment category, most (69%) of the respondents indicated that they would be likely to purchase and consume a blueberry muffin while less than half (45.1%) that they would be likely to purchase and consume chocolate cake baked with powdered grape pomace. Considering the addition of fibre as the dietary source adjustment category within this food vehicle category, the majority of the respondents indicated that they would be likely to purchase and consume whole wheat bread (90.3%) and a bran muffin (75.6%) for added fibre to baked dishes.

Table 4.7: Respondent likelihood to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake

Phytochemical-rich dietary source adjustment category	Food vehicle category	Category prepared dish	Respondent consumption likeliness (n = 184)									
			Extremely unlikely		Very unlikely		Unsure		Very likely		Extremely likely	
			%	n	%	n	%	n	%	n	%	n
Fruit	Baked	Blueberry muffin	8.7	16	15.2	28	7.1	13	37.5	69	31.5	58
		Chocolate cake with powdered grape pomace	11.4	21	22.3	41	21.2	39	34.2	63	10.9	20
Vegetable		Spinach muffin	14.7	27	18.5	34	21.2	39	28.8	53	16.9	31
		Bread with onion extract	9.2	17	23.4	43	25.5	47	29.4	54	12.5	23
Rooibos herbal tea		Bread with rooibos herbal tea extract	9.8	18	13	24	23.9	44	37	68	16.3	30
Fibre		Bran muffin	7.1	13	11.4	21	6	11	43.5	80	32.1	59
		Whole wheat bread	0	0	4.4	8	5.4	10	48.4	89	41.9	77
Fruit	Grains /bake	Shortbread baked with powdered orange peel and pulp[a]	12.5	23	21.7	40	19.6	36	34.8	64	11.4	21
		Shortbread baked with dried berry pulp	9.2	17	17.4	32	19	35	38.6	71	15.8	29
		Bran flakes with powdered grape pomace[b]	13.6	25	11.4	21	16.9	31	42.9	79	15.2	28
		Cereal bar with powdered citrus fruit pomace	10.9	20	12.5	23	16.9	31	45.1	83	14.7	27
Vegetable		Baked rice snacks with powdered tomato pomace	23.4	43	25	46	23.9	44	19.6	36	8.2	15
Rooibos herbal tea		Shortbread with rooibos herbal tea extract	12	22	23.5	43	21.3	39	32.2	59	10.9	20
FIbre		Whole wheat biscuits	6.5	12	9.2	17	9.8	18	44.6	82	29.9	55
Herbs		Shortbread baked with rosemary	14.1	26	25.5	47	27.2	50	24.5	45	8.7	16
Fruit	Pizza /pasta	Pasta with powdered apple pomace	9.8	18	20.7	38	25.5	47	31.5	58	12.5	23
		Pasta with powdered banana	16.3	30	20.1	37	31	57	22.8	42	9.8	18
Vegetable		Pasta dish with tomato paste containing tomato peel	8.2	15	12.5	23	20.1	37	38.6	71	20.7	38

Table 4.7 (continued)

Phytochemical-rich dietary source adjustment category	Food vehicle category	Category prepared dish	Respondent consumption likeliness (n = 184)									
			Extremely unlikely		Very unlikely		Unsure		Very likely		Extremely likely	
			%	n	%	n	%	n	%	n	%	n
Vegetable (continued)	Pizza /pasta (cont.)	Noodles with onion extract	9.2	17	17.4	32	20.1	37	38	70	15.2	28
		Lasagne sheets with spinach	7.6	14	6.5	12	9.2	17	45.7	84	31	57
Fibre		Whole wheat pizza base	6.5	12	9.2	17	9.2	17	47.3	87	27.7	51
Herbs		Herb crust pizza base	4.4	8	9.8	18	7.6	14	48.9	90	29.4	54
Green tea	Dairy	Cheddar cheese with green tea extract	21.7	40	20.1	37	28.8	53	22.3	41	7.1	13
		Yoghurt with green tea extract	13.6	25	15.2	28	21.7	40	35.9	66	13.6	25
Vegetables		Cottage cheese with onion extract	15.8	29	20.1	37	25.5	47	29.4	54	9.2	17
		Gouda cheese with carrot extract	19.6	36	20.1	37	27.7	51	26.6	49	6	11
Rooibos herbal tea	Beverage	Fruit juice with rooibos herbal tea extract	9.2	17	10.9	20	12	22	47.3	87	20.7	38
Fibre		Fruit juice with powdered cereal fibre	16.3	30	20.7	38	21.7	40	27.7	51	13.6	25
		Instant coffee with hazelnut skin powder	14.1	26	19	35	21.7	40	31	57	14.1	26
Herbs		Fruit juice with mint extract	7.1	13	16.3	30	16.9	31	41.3	76	18.5	34

[a] Pulp means the dried mashed solid fruit
[b] Pomace means the powdered solid remains after juice extraction

The respondents were further questioned about their likelihood to purchase and consume baked dishes as the food vehicle category with added vegetables and tea as dietary source adjustment categories (refer Table 4.7). Less than half of the respondents indicated that they would be likely to purchase and consume a spinach muffin (45.7%) and bread with added onion extract (41.9%) using vegetables as the dietary source adjustment category. Considering rooibos herbal tea as the dietary source adjustment category, approximately half (53.3%) of the respondents indicated that they would be likely to purchase and consume bread baked with rooibos herbal tea extract.

Considering the food vehicle category grains/bake with added fruit as dietary source adjustment category, more than half of the respondents indicated that they would be

likely to purchase and consume breakfast cereal bran flakes with powdered grape pomace (58.1%), a breakfast cereal bar with citrus fruit pomace (59.8%) and shortbread baked with dried berry pulp (54.4%). Less than half (46.2%) of the respondents indicated that they would be likely to purchase and consume shortbread biscuits with powdered orange peel and pulp using fruit as dietary source adjustment category. Considering the addition of fibre as the dietary source adjustment category within this food vehicle category, the majority (74.5%) of the respondents indicated that they would be likely to purchase and consume whole wheat biscuits as added fibre to grains/bake as the food vehicle category.

The respondents were also questioned about their likelihood to purchase and consume grains/bake as the food vehicle category with added vegetables, tea and herbs as dietary source adjustment categories. Approximately a quarter (27.8%) of the respondents indicated that they would be likely to purchase and consume baked rice snacks with added powdered tomato pomace using vegetables as dietary source adjustment category. Considering rooibos herbal tea as dietary source adjustment category, less than half (43.1%) of the respondents indicated that they would be likely to purchase and consume shortbread biscuits with rooibos herbal tea extract. Only a third (33.2%) of the respondents indicated that they would be likely to purchase and consume shortbread biscuits with rosemary as herbs added to grains/bake as the food vehicle category.

Pizza/pasta was a likely option as the food vehicle category for added vegetables as the dietary source adjustment category. The majority (76.7%) of respondents indicated that they would be likely to purchase and consume lasagne sheets with spinach. Less than two thirds (59.3%) of the respondents indicated that they would be likely to purchase and consume a pasta dish with tomato paste containing powdered tomato peel, and approximately half (53.2%) that they would be likely to purchase and consume pasta noodles with onion extract as vegetables added to pizza/pasta. The majority (75%) of the respondents indicated that they would be likely to purchase and consume a whole wheat pizza base using fibre as the dietary source adjustment category added to pizza/pasta. The majority (78.3%) of the respondents also indicated that they would be likely to purchase and consume a herb crust pizza base representing herbs as the dietary source adjustment category added to pizza/pasta. Pasta as the food vehicle category with added fruit was a less likely option. Only approximately a third (32.6%) of the respondents indicated that they would be likely to purchase and consume pasta with powdered banana and less than half (44%) that they would be likely to purchase and consume

pasta with powdered apple pomace as fruit added to pasta, replacing some of the flour (refer Table 4.7).

When questioned about their likelihood to consider green tea representing tea as the phytochemical-rich dietary source adjustment category added to dairy products as the food vehicle category (refer Table 4.7), approximately half (49.5%) of the respondents indicated that they would be likely to purchase and consume yoghurt with green tea extract, while only slightly more than a quarter (29.4%) indicated that they would be likely to purchase and consume cheddar cheese with green tea extract. Only approximately a third of the respondents indicated that they would be likely to purchase and consume cottage cheese with onion extract (38.6%) and Gouda cheese with carrot extract (32.6%) utilising vegetables as phytochemical-rich dietary source adjustment category (refer Table 4.7).

When considering beverages as the food vehicle category for added phytochemical-rich dietary source adjustment categories (refer Table 4.7), most of the respondents indicated that they would be likely to purchase and consume fruit juice with rooibos herbal tea extract (68%) and fruit juice with mint extract (59.8%). However, less than half of the respondents indicated that they would be likely to purchase and consume fruit juice with powdered cereal fibre (41.3%) and instant coffee with powdered hazelnut skin added to the coffee granules (45.1%) for added fibre.

4.7 Differences in the respondent likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

Considering the likelihood of the respondents to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake (refer Table 4.8), a significant difference ($p < 0.05$) was found between the respondents' likelihood to consume fruit, vegetables, herbs and rooibos herbal tea as phytochemical-rich dietary source adjustment options. The respondents were significantly ($p < 0.001$) more likely to consume herbs, vegetables and fruit respectively in comparison to rooibos herbal tea as dietary source adjustment category. The respondents were also more likely to consume vegetable additions than either herb ($p < 0.05$) or fruit ($p < 0.001$) additions. Furthermore, the respondents were more likely to consume herb additions to category prepared dishes than fruit additions ($p < 0.001$) as the phytochemical-rich dietary source adjustment category.

Table 4.8: Differences in the respondent likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

Likelihood to consume proficient home-cooked category prepared dishes[a]					**Significant difference**[d,e]
Dietary source adjustment category					
Rooibos herbal tea (1) (n = 7)[b]	Herbs (2) (n = 16)	Vegetable (3) (n = 13)	Fruit (4) (n = 12)		
2.92 (0.09)[c]	3.79 (0.06)	3.96 (0.07)	3.60 (0.07)		(1) – (2)[f](3)[f](4)[f] (2) – (3)(4)[f] (3) – (4)[f]
Food vehicle category with added rooibos herbal tea as dietary source adjustment category					
Vegetables (1) (n = 2)	Starch (2) (n = 2)	Fruit (3) (n = 3)			
2.77 (0.10)	3.15 (0.10)	2.86 (0.10)			(1) – (2)[f] (2) – (3)
Herbs as dietary source adjustment category					
Mint (1) (n = 3)	Parsley (2) (n = 4)	Basil (3) (n = 3)	Mixed herbs (4) (n = 3)	Rosemary (5) (n = 3)	
3.24 (0.08)	4.01 (0.07)	3.47 (0.08)	4.01 (0.06)	3.92 (0.07)	(1) – (2)[f](3)(4)[f](5)[f] (2) – (3)[f] (3) – (4)[f](5)[f]
Food vehicle category with added herbs as dietary source adjustment category					
Egg (1) (n = 2)	Chicken (2) (n = 2)	Potato (3) (n = 3)	Other starch (4) (n = 2)	Vegetable (5) (n = 4)	
4.19 (0.08)	4.14 (0.08)	4.01 (0.07)	3.93 (0.07)	3.49 (0.08)	(5) – (1)[f](2)[f](3)[f](4)[f] (4) – (1)(2)
Vegetables as dietary source adjustment category					
Broccoli (1) (n = 3)	Onion (2) (n = 2)	Spinach (3) (n = 3)	Butternut (4) (n = 2)	Tomato (5) (n = 3)	
3.72 (0.09)	3.25 (0.10)	3.73 (0.09)	3.83 (0.08)	3.91 (0.08)	(1) – (2)[f](5) (2) – (3)[f](4)[f](5)[f]
Further vegetables as dietary source adjustment category					
Broccoli (1) (n = 2)	Spinach (2) (n = 2)	Tomato (3) (n = 2)			
3.96 (0.10)	3.75 (0.09)	4.17 (0.08)			(2) – (1)(3)[f]
Quiche as food vehicle category for vegetables as dietary source adjustment category					
Onion (1) (n = 1)	Roasted butternut (2) (n = 1)	Spinach (3) (n = 1)			
3.32 (0.11)	3.63 (0.10)	3.70 (0.11)			(1) – (2)(3)
Soup as food vehicle category for vegetables as dietary source adjustment category					
Onion (1) (n = 1)	Broccoli (2) (n = 1)	Roasted butternut (3) (n = 1)	Tomato (4) (n = 1)		
3.18 (0.11)	3.24 (0.11)	4.04 (0.09)	3.40 (0.12)		(3) – (1)[f](2)[f](4)[f]

Table 4.8 (continued)

Likelihood to consume proficient home-cooked category prepared dishes[a]					**Significant difference**[d,e]
Tomato soup as food vehicle category with or without rooibos herbal tea as dietary source adjustment category					
Tomato (1) (n = 1)	Tomato with rooibos herbal tea (2) (n = 1)				
3.40 (0.12)	2.70 (0.11)				(1) – (2)[f]
Tomato soup as food vehicle category with or without basil as dietary source adjustment category					
Tomato (1) (n = 1)	Tomato and basil (2) (n = 1)				
3.40 (0.12)	3.48 (0.11)				
Butternut soup as food vehicle category with or without dietary source adjustment additions					
Roasted butternut (1) (n = 1)	Butternut and orange (2) (n = 1)	Butternut and rosemary (3) (n = 1)			
4.04 (0.09)	3.43 (0.11)	3.41 (0.10)			(1) – (2)[f](3)[f]
Carrot salad as food vehicle category with or without dietary source adjustment additions					
Raisins (1) (n = 1)	Raisins and parsley (2) (n = 1)				
3.57 (0.11)	3.45 (0.11)				(1) – (2)
Chicken as food vehicle category with added vegetables as vegetable dietary source adjustment category					
Broccoli (1) (n = 1)	Spinach (2) (n = 1)				
4.04 (0.10)	4.01 (0.10)				
Food vehicle category with added broccoli as vegetable dietary source adjustment category					
Pasta (1) (n = 1)	Chicken (2) (n = 1)				
3.89 (0.10)	4.04 (0.10)				(1) – (2)
Fruit addition as dietary source adjustment category					
Berries (1) (n = 3)	Citrus (2) (n = 2)	Pome (3) (n = 3)			
3.81 (0.08)	3.50 (0.09)	3.67 (0.08)			(1) – (2)[f](3) (2) – (3)
Poached pear dessert as food vehicle category for dietary source adjustment					
Rooibos herbal tea (1) (n = 1)	Red grape juice (2) (n = 1)				
2.96 (0.11)	3.20 (0.11)				(1) – (2)[f]
Raw apple as fruit dietary source adjustment category with or without food vehicle category					
Raw apple with skin (1) (n = 1)	Chicken salad with apple pieces (2) (n = 1)				
4.43 (0.07)	3.98 (0.09)				(1) – (2)[f]

Table 4.8 (continued)

Likelihood to consume proficient home-cooked category prepared dishes[a]					**Significant difference**[d,e]
Raw *vs* cooked apple as fruit dietary source adjustment category and chicken as food vehicle category					
Raw apple and chicken salad (1) (n = 1)	Apple and chicken casserole (2) (n = 1)				
3.98 (0.09)	3.63 (0.11)				(1) – (2)[f]
Dessert as food vehicle category with added mixed berries as fruit dietary source adjustment category					
Compote (1) (n = 1)	Crêpe (2) (n = 1)				
3.63(0.11)	3.99(0.10)				(1) – (2)[f]

[a] Mean of scale values, where 1 equals 'extremely unlikely' and 5 equals 'extremely likely'
[b] Number of set options within the dietary source adjustment or food vehicle category
[c] Values: Mean ± standard error presented as mean (standard error)
[d] Overall significant difference ($p < 0.05$) in the repeated measures analysis of variance (ANOVA)
[e] Bonferroni correction for multiple comparisons for identification of pair-wise contrasts on significance ($p < 0.05$) in the repeated measures (ANOVA). Pair-wise contrasts presented as dietary source adjustment (or food vehicle) category number in brackets, e.g. (1), different (-) to other dietary source adjustment (or food vehicle) category number(s) in brackets.
[f] Bonferroni correction for multiple comparisons for identification of pair-wise contrasts on significance ($p < 0.001$) in the repeated measures (ANOVA). Pair-wise contrasts presented as dietary source adjustment (or food vehicle) category number in brackets, e.g. (1), different (-) to other dietary source adjustment (or food vehicle) category number(s) in brackets.

Although the addition of rooibos herbal tea to proficient home-cooked category prepared dishes appeared to be a less likely dietary source adjustment category option considered by the respondents, based on a previous section (4.5), a significant difference ($p < 0.05$) was found between the use of vegetables, starch and fruit as the respective food vehicle categories for the addition of rooibos herbal tea. The respondents were more likely to consume starch-based dishes than vegetable-based dishes ($p < 0.001$) and fruit-based dishes ($p < 0.05$) respectively for the addition of rooibos herbal tea. No significant difference ($p > 0.05$) was however found between fruit and vegetables as the food vehicle category for the addition of rooibos herbal tea (refer Table 4.8).

Considering the likelihood of the respondents to consume proficient home-cooked category prepared dishes with the addition of herbs, a significant difference ($p < 0.05$) was found between mint, parsley, basil, mixed herbs and rosemary as added herb options. The respondents were significantly more likely to consume category prepared dishes with parsley ($p < 0.001$), mixed herbs ($p < 0.001$), rosemary ($p < 0.001$) and basil ($p < 0.05$) than mint, respectively. The respondents were also more likely to consume parsley than basil ($p < 0.001$) in addition to mixed herbs ($p < 0.001$) and rosemary ($p < 0.001$) than basil as respective herb additions (refer Table 4.8).

A significant difference ($p < 0.05$) was found between egg, chicken, potato, other starch and vegetables as food vehicle categories for the addition of herbs. The respondents were more likely to consume egg and chicken as respective food vehicle categories in comparison to other starch ($p < 0.05$) and vegetables ($p < 0.001$) respectively. The respondents were also more likely to consume potato than vegetables ($p < 0.05$), as well as other starch than vegetables ($p < 0.05$) as respective food vehicle categories (refer Table 4.8).

Considering vegetable additions as the phytochemical-rich dietary source adjustment category, a significant difference ($p < 0.05$) was found between the respondents' likelihood to consume broccoli, onion, spinach, butternut and tomato. The respondents were significantly ($p < 0.001$) more likely to consume tomato, butternut and spinach respectively in comparison to onion as vegetable additions. In addition to the above, further options were considered to determine a clearer comparison of vegetables the respondents would be likely to consume within it as the phytochemical-rich dietary source adjustment category. A significant difference ($p < 0.05$) was found between tomato, broccoli and spinach. The respondents were more likely to consume tomato ($p < 0.001$) and broccoli ($p < 0.05$) than spinach as respective vegetable additions (refer Table 4.8).

A significant difference ($p < 0.05$) was found between the respondents' likelihood to consume quiche as the food vehicle category with onion, roasted butternut and spinach respectively as vegetable additions. The respondents were more likely to consume quiche with spinach ($p < 0.05$) and roasted butternut ($p < 0.05$) respectively in comparison to onion as vegetable additions to quiche.

The likelihood of the respondents to consume vegetable additions in a soup as food vehicle category (refer Table 4.8) was considered and a significant difference ($p < 0.05$) was found in the respondents' likelihood to consume onion, broccoli, roasted butternut and tomato as respective vegetable dietary source adjustment categories. The respondents were less likely to consume onion in comparison to broccoli ($p < 0.001$), tomato ($p < 0.001$) and roasted butternut ($p < 0.001$) as respective vegetable additions in a soup. In addition to the above, the likelihood of the respondents to consume different tomato soup variations was considered and a significant difference ($p < 0.05$) was found between the respondents' likelihood to consume tomato soup and tomato soup with added rooibos herbal tea. The respondents were more likely to consume tomato soup in comparison to tomato soup with added rooibos herbal tea ($p < 0.001$). A further tomato soup variation was considered to determine the respondents' likelihood to consume tomato soup *vs* tomato soup with added basil (as herb addition). No significant difference ($p > 0.05$) was found between the likelihood

to consume tomato soup and the tomato soup with added basil. The likelihood of the respondents to consume butternut soup variations with or without additions was also considered. A significant difference ($p < 0.05$) was found between the respondents' likelihood to consume the roasted butternut soup, butternut and orange soup and butternut and rosemary soup variations. The respondents were more likely to consume roasted butternut soup in comparison to butternut and orange soup (as fruit addition) ($p < 0.001$) and butternut and rosemary soup (as herb addition) ($p < 0.001$). However, no significant difference ($p > 0.05$) was found between the respondents' likelihood to consume the butternut and rosemary soup and butternut and orange soup.

The likelihood of the respondents to consume carrot salad as food vehicle category with or without an addition was considered and a significant difference ($p < 0.05$) was found between the respondents' likelihood to consume carrot salad with raisins (as fruit addition) and carrot salad with raisins and parsley (as herb addition). The respondents were more likely to consume carrot salad with raisins in comparison to carrot salad with raisins and parsley ($p < 0.05$) (refer Table 4.8).

The respondents' likelihood to consume pasta *vs* chicken as the food vehicle category for added broccoli (refer Table 4.8) was considered and a significant difference ($p < 0.05$) was found. The respondents were more likely to consume chicken than pasta with broccoli ($p < 0.05$).

The likelihood of the respondents to consume fruit as phytochemical-rich dietary source adjustment category added to various food vehicle categories (refer Table 4.8) was considered and a significant difference ($p < 0.05$) was found between the respondents' likelihood to consume berries, citrus and pome fruit as additions. The respondents were more likely to consume berries in comparison to pome fruit ($p < 0.05$) and citrus fruit ($p < 0.001$) and furthermore citrus fruit in comparison to pome fruit ($p < 0.05$) as fruit additions. The likelihood of the respondents to consume different poached pear desserts as food vehicle category was also considered and a significant difference ($p < 0.05$) was found between the respondents' likelihood to consume poached pear in rooibos herbal tea and poached pear in red grape juice. The respondents were more likely to consume poached pear in red grape juice in comparison to poached pear in rooibos herbal tea ($p < 0.001$). A significant difference ($p < 0.05$) was furthermore found between the respondents' likelihood to consume raw apple with its skin on and chicken breast salad with raw apple pieces. The respondents were more likely to consume raw apple with its skin on in comparison to a chicken breast salad with raw apple pieces ($p < 0.001$). The likelihood of respondents to consume

chicken breast salad with raw apple *vs* chicken casserole with apple was also considered and a significant difference ($p < 0.05$) was found between the respondents' likelihood to consume these options as the food vehicle category. The respondents were more likely to consume chicken breast salad with raw apple in comparison to chicken casserole with apple ($p < 0.001$). When considering desserts as the food vehicle category for added mixed berries as the dietary source adjustment category for fruit, a significant difference ($p < 0.05$) was found between the likelihood of the respondents to consume compote and crêpe. The respondents were more likely to consume berry crêpe than berry compote as the food vehicle category for the addition of mixed berries ($p < 0.001$) (refer Table 4.8).

4.8 Differences in the respondent likelihood to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake

Considering the likelihood of the respondents to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake, a significant difference ($p < 0.05$) was found between the likelihood of the respondents to purchase and consume the dietary source adjustment categories of fruit, vegetables, fibre, tea and herbs. The respondents were more likely to purchase and consume commercially manufactured category prepared dishes with added fibre than added herbs ($p < 0.05$), fruit ($p < 0.001$), vegetables ($p < 0.001$) and tea ($p < 0.001$) respectively. The respondents were also more likely to purchase and consume commercially manufactured category prepared dishes with added herbs than added vegetables ($p < 0.05$) and tea ($p < 0.05$) (refer Table 4.9).

Table 4.9: Differences in the respondent likelihood to purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake

Likelihood to purchase and consume commercially manufactured category prepared dishes[a]					**Significant difference**[d.e]
Dietary source adjustment category respondents are most likely to purchase and consume					
Fibre (1) (n = 6)[b]	Fruit (2) (n = 8)	Vegetables (3) (n = 8)	Herbs (4) (n = 3)	Tea (5) (n = 5)	
3.63 (0.06)[c]	3.24 (0.08)	3.15 (0.07)	3.39 (0.08)	3.14 (0.08)	(1) – (2)[f](3)[f](4)(5)[f] (4) – (3)(5)

Table 4.9 (continued)

Likelihood to purchase and consume commercially manufactured category prepared dishes[a]					**Significant difference**[d.e]
Food vehicle category					
Baked goods (1) (n = 7)	Grains/bake (2) (i.e. biscuits, snacks, muffins, bread, breakfast cereal) (n = 8)	Dairy (3) (n = 4)	Beverages (4) (n = 4)	Pizza/Pasta (5) (n = 7)	
3.46 (0.07)	3.19 (0.08)	2.90 (0.09)	3.25 (0.08)	3.50 (0.07)	(1) – (2)[f](3)[f](4) (3) – (2)(4)[f] (5) – (2)[f](3)[f](4)
Dietary source adjustment category added to baked dishes					
Fibre (1) (n = 2)	Fruit (2) (n = 2)	Vegetables (3) (n = 2)	Rooibos herbal tea (4) (n = 1)		
4.02 (0.07)	3.38 (0.09)	3.05 (0.09)	3.31 (0.10)		(1) – (2)[f](3)[f](4)[f] (2) – (3)
Dietary source adjustment category added to pasta					
Fruit (1) (n = 2)	Vegetables (2) (n =3)				
3.04 (0.10)	3.57 (0.08)				(1) – (2)[f]
Dietary source adjustment category added to pizza					
Fibre (1) (n = 1)	Herbs (2) (n = 1)				
3.81 (0.10)	3.88 (0.09)				
Dietary source adjustment category added to shortbread biscuits					
Fruit (1) (n = 2)	Herbs (2) (n = 1)	Rooibos herbal tea (3) (n = 1)			
3.19 (0.10)	2.89 (0.10)	3.02 (0.11)			(1) – (2)
Dietary source adjustment category added to dairy products					
Green tea (1) (n = 2)	Vegetables (2) (n = 2)				
2.92 (0.10)	2.89 (0.09)				
Dietary source adjustment category added to muffins					
Blueberry (1) (n = 1)	Bran (2) (n = 1)	Spinach (3) (n = 1)			
3.74 (0.11)	3.77 (0.10)	3.00 (0.11)			(3) – (1)[f](2)[f]
Dietary source adjustment category added to fruit juice					
Fibre (1) (n = 1)	Herbs (2) (n = 1)	Rooibos herbal tea (3) (n = 1)			
2.96 (0.11)	3.39 (0.10)	3.55 (0.10)			(1) – (2)[f](3)[f]

[a] Mean of scale values where 1 equals 'extremely unlikely' and 5 equals 'extremely likely'
[b] Number of set options within the dietary source adjustment or food vehicle category
[c] Values: Mean ± standard error presented as mean (standard error)

[d] Overall significant difference ($p < 0.05$) in the repeated measures analysis of variance (ANOVA)
[e] Bonferroni correction for multiple comparisons for identification of pair-wise contrasts on significance ($p < 0.05$) in the repeated measures (ANOVA). Pair-wise contrasts presented as dietary source adjustment (or food vehicle) category number in brackets, e.g. (1), different (-) to other dietary source adjustment (or food vehicle) category number(s) in brackets.
[f] Bonferroni correction for multiple comparisons for identification of pair-wise contrasts on significance ($p < 0.001$) in the repeated measures (ANOVA). Pair-wise contrasts presented as dietary source adjustment (or food vehicle) category number in brackets, e.g. (1), different (-) to other dietary source adjustment (or food vehicle) category number(s) in brackets.

A significant difference ($p < 0.05$) was found between the respondents' likelihood to consume baked goods, grains/bake, dairy, beverages and pizza/pasta as the food vehicle category for added phytochemical-rich dietary source adjustments. The respondents were more likely to purchase and consume pizza/pasta than beverages ($p < 0.05$), grains/bake ($p < 0.001$) and dairy ($p < 0.001$) as the food vehicle category. The respondents were also more likely to purchase and consume baked goods than grains/bake ($p < 0.001$), dairy ($p < 0.001$) and beverages ($p < 0.05$) as food vehicle category and, in addition, grains/bake ($p < 0.05$) and beverages ($p < 0.001$) respectively rather than dairy as food vehicle category (refer Table 4.9).

The likelihood of the respondents to purchase and consume baked dishes as food vehicle category was considered and a significant difference ($p < 0.05$) was found between fibre, fruit, vegetables and tea as additions (refer Table 4.9). The respondents were more likely to purchase and consume baked dishes with added fibre in comparison to added fruit ($p < 0.001$), tea ($p < 0.001$) and vegetables ($p < 0.001$). The respondents were also more likely to consume baked dishes with added fruit than added vegetables ($p < 0.05$). The likelihood of the respondents to purchase and consume grains/baked dishes (as pasta) as the food vehicle for dietary additions was furthermore considered and a significant difference ($p < 0.05$) was found between fruit and vegetables as dietary source adjustment categories. The respondents were more likely to purchase and consume pasta with vegetables than fruit ($p < 0.001$) as the dietary source adjustment category.

Considering the likelihood of the respondents to purchase and consume shortbread biscuits as food vehicle with added fruit, herbs and tea, a significant difference ($p < 0.05$) was found between these dietary source adjustment categories. The respondents were more likely to purchase and consume shortbread biscuits with added fruit than herbs ($p < 0.05$). The likelihood of the respondents to purchase and consume a muffin as food vehicle with added blueberries (as fruit addition), bran (as fibre addition) and spinach (as vegetable addition) was also considered and a significant difference ($p < 0.05$) was found between the dietary source adjustments. The respondents were more likely to consume a muffin with added bran ($p < 0.001$) or blueberries ($p < 0.001$) than added spinach respectively.

A significant difference ($p < 0.05$) was found between the respondents' likelihood to purchase and consume fruit juice as the food vehicle category for added fibre, herbs and tea (refer Table 4.9) respectively. The respondents were more likely to purchase and consume fruit juice incorporating rooibos herbal tea ($p < 0.001$) or herbs ($p < 0.001$) than fibre.

4.9 Respondent demographic, health and lifestyle characteristics, perceived phytochemical importance and dietary source consumption differences in the likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

The likelihood of the respondents to purchase and consume phytochemical-rich commercially manufactured category prepared dishes for enhanced phytochemical intake in relation to their demographic, health and lifestyle characteristics was not considered for analysis as the bulk of the questions (21 of 30) referred to dishes not currently available on the South African market.

4.9.1 Respondent demographic characteristic differences

The demographic characteristics of the respondents and their likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake are presented in Table 4.10. The respondents' gender, age and whether or not they were involved in the preparation of food at home were individually found to significantly ($p < 0.05$) influence the likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical-rich intake. Considering the respondents' gender, a significant difference ($p < 0.05$) was found between the likelihood of the female and male respondents to consume dishes incorporating fruit as the dietary source adjustment category. The female respondents were more likely to consume category prepared dishes with the addition of fruit than the male respondents. A significant difference ($p < 0.05$) was also found between the respondents' age and their likelihood to consume dishes with added herbs as the dietary source adjustment category. The older respondents (55 to 64 years) were more likely to consume category prepared dishes with the addition of herbs than the younger respondents (31 to 44 years). A significant difference ($p < 0.05$) was furthermore found between the respondents' age and their likelihood to consume dishes with added fruit as the dietary source adjustment category. The older respondents (55 to 64) were more likely to consume category prepared dishes with fruit additions than the younger respondents aged 31 to 44 years ($p < 0.05$) and 45 to 54 years ($p < 0.05$) respectively. A significant difference ($p < 0.05$)

was found between the respondents who were involved in the preparation of food at home and those who were not and the likelihood to consume proficient home-cooked category prepared dishes incorporating rooibos herbal tea, herbs and fruit as dietary source adjustment categories. The respondents involved in the preparation of food at home were more likely to consume category prepared dishes with the addition of rooibos herbal tea ($p < 0.05$), herbs ($p < 0.05$) and fruit ($p < 0.05$) respectively than those who were not. The respondents' ethnicity, level of education, marital status and home language did not influence ($p > 0.05$) the respondents' likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake for any of the phytochemical dietary source adjustment categories.

Table 4.10: Demographic characteristics of the respondents most likely to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

Demographic characteristic	**Demographic category**	**Phytochemical-rich dietary source adjustment category**[a]				
		Rooibos herbal tea (n = 7)[b]	**Herbs** (n = 15)	**Vegetables** (n = 17)	**Fruit** (n = 9)	**Significant difference**[d,e]
Gender	Male (1)	2.96 (0.11)[c]	3.76 (0.08)	3.88 (0.10)	3.52 (0.10)	Fruit: (1) – (2)
	Female (2)	3.07 (0.10)	3.93 (0.06)	4.11 (0.08)	3.81 (0.08)	
Age (years)	31 – 44 (1)	3.04 (0.09)	3.81 (0.06)	4.03 (0.07)	3.65 (0.08)	Herbs: (1) – (3) Fruit: (3) – (1)(2)
	45 – 54 (2)	2.76 (0.16)	3.79 (0.10)	4.06 (0.14)	3.52 (0.15)	
	55 – 64 (3)	3.32 (0.22)	4.18 (0.11)	3.88 (0.19)	4.16 (0.14)	
Ethnicity	White (1)	3.00 (0.09)	3.86 (0.06)	4.01 (0.07)	3.68 (0.08)	
	Black (2)	3.16 (0.40)	3.96 (0.28)	4.45 (0.19)	3.81 (0.33)	
	Coloured (3)	3.14 (0.14)	3.87 (0.09)	3.98 (0.12)	3.77 (0.10)	
	Other (4)	2.29 (0.38)	3.31 (0.16)	3.67 (0.51)	3.03 (0.46)	
Level of education (highest)	Grade 12 (1)	3.10 (0.25)	3.98 (0.20)	4.07 (0.25)	3.90 (0.20)	
	Grade 12 and certificate (2)	2.50 (0.22)	3.75 (0.12)	3.95 (0.19)	3.51 (0.18)	
	Grade 12 and diploma (3)	3.09 (0.15)	3.94 (0.07)	4.12 (0.10)	3.75 (0.10)	
	Grade 12 and degree (4)	3.12 (0.12)	3.76 (0.09)	3.86 (0.12)	3.67 (0.12)	
	Postgraduate (master's / doctorate) (5)	3.03 (0.18)	3.89 (0.13)	4.12 (0.13)	3.66 (0.17)	
Marital status	Married/living together with children (1)	3.07 (0.11)	3.89 (0.06)	4.07 (0.08)	3.73 (0.09)	

Table 4.10 (continued)

Demographic characteristic	Demographic category	Phytochemical-rich dietary source adjustment category[a]				
		Rooibos herbal tea (n = 7)[b]	**Herbs** (n = 15)	**Vegetables** (n = 17)	**Fruit** (n = 9)	**Significant difference**[d,e]
	Married/living together without children (2)	3.12 (0.17)	3.98 (0.12)	4.09 (0.13)	3.83 (0.14)	
	Single and living with children (3)	2.62 (0.24)	3.58 (0.13)	3.89 (0.16)	3.46 (0.17)	
	Single and living without children (4)	3.00 (0.15)	3.77 (0.13)	3.85 (0.17)	3.56 (0.15)	
Home language	English (1)	3.13 (0.11)	3.96 (0.07)	4.02 (0.10)	3.76 (0.09)	
	Afrikaans (2)	2.90 (0.11)	3.74 (0.07)	3.97 (0.08)	3.61 (0.09)	
	Xhosa (3)	2.33 (0.67)	3.73 (0.62)	4.39 (0.24)	3.33 (0.67)	
	Other (4)	3.79 (0.17)	4.13 (0.24)	4.50 (0.32)	4.18 (0.22)	
Involved in the preparation of food at home	Yes (1)	3.12 (0.08)	3.91 (0.06)	4.06 (0.07)	3.77 (0.07)	Rooibos herbal tea: (1) – (2) Herbs: (1) – (2) Fruit: (1) – (2)
	No (2)	2.71 (0.16)	3.67 (0.10)	3.86 (0.14)	3.43 (0.13)	

[a] Mean of scale values where 1 equals 'extremely unlikely' and 5 equals 'extremely likely'
[b] Number of set options within the dietary source adjustment or food vehicle category
[c] Values: Mean ± standard error presented as mean (standard error)
[d] Overall significant difference ($p < 0.05$) in the repeated measures analysis of variance (ANOVA)
[e] Bonferroni correction for multiple comparisons for identification of pair-wise contrasts on significance ($p < 0.05$) in the repeated measures analysis of variance (ANOVA). Pair-wise contrasts presented as dietary source adjustment category number in brackets, e.g. (1), different (-) to other dietary source adjustment category number(s) in brackets.

4.9.2 Respondent health and lifestyle characteristic differences

The respondents' biographic characteristics did not influence ($p > 0.05$) their likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake for any of the phytochemical dietary source adjustment categories (refer Table 4.11).

Table 4.11: Health and lifestyle characteristics of the respondents most likely to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

Health and lifestyle characteristic	Health and lifestyle category	Phytochemical-rich dietary source adjustment category[a]				
		Rooibos herbal tea (1) (n = 7)[b]	**Herbs (2)** (n = 15)	**Vegetables (3)** (n = 17)	**Fruit (4)** (n = 9)	**Significant difference**[d]
Smoking status[e]	Non-smoker	2.96 (0.09)[c]	3.82 (0.06)	3.98 (0.07)	3.64 (0.08)	

Table 4.11 (continued)

Health and lifestyle characteristic	Health and lifestyle category	Phytochemical-rich dietary source adjustment category[a]				
		Rooibos herbal tea (1) (n = 7)[b]	Herbs (2) (n = 15)	Vegetables (3) (n = 17)	Fruit (4) (n = 9)	Significant difference[d]
	Current smoker	3.11 (0.15)	3.96 (0.12)	4.10 (0.15)	3.84 (0.14)	
	Former smoker	3.25 (0.27)	3.91 (0.17)	4.10 (0.15)	3.74 (0.19)	
Alcohol consumption[f]	None	3.09 (0.13)	3.93 (0.09)	4.12 (0.10)	3.80 (0.10)	
	Less than three times per week	3.00 (0.10)	3.79 (0.07)	3.94 (0.08)	3.64 (0.08)	
	Three or more times per week	3.97 (0.22)	3.94 (0.14)	4.08 (0.17)	3.69 (0.19)	
Dietary supplement usage[g]	Never	2.70 (0.16)	3.83 (0.10)	3.90 (0.13)	3.53 (0.15)	
	Seldom	3.19 (0.16)	3.92 (0.11)	4.14 (0.11)	3.82 (0.15)	
	When remembered	3.18 (0.20)	3.91 (0.16)	3.93 (0.20)	3.68 (0.19)	
	Fairly regularly	3.14 (0.21)	3.71 (0.18)	3.98 (0.20)	3.68 (0.20)	
	Regularly	3.01 (0.13)	3.87 (0.07)	4.05 (0.10)	3.72 (0.09)	
Level of physical activity[h]	Physically active	3.08 (0.10)	3.81 (0.07)	3.92 (0.09)	3.64 (0.08)	
	Not physically active	2.92 (0.11)	3.91 (0.07)	4.13 (0.08)	3.76 (0.09)	

[a] Mean of scale values where 1 equals 'extremely unlikely' and 5 equals 'extremely likely'
[b] Number of set options within the dietary source adjustment or food vehicle category
[c] Values: Mean ± standard error presented as mean (standard error)
[d] No overall significant difference ($p > 0.05$) in the repeated measures analysis of variance (ANOVA)
[e] Current smoker included those who smoked any tobacco in the past 12 months and included those who had quit within the past year. Former smoker included those who had quit more than a year ago (Yusuf *et al*., 2004:939)
[f] Protective alcohol usage was defined as consumption three or more times a week (Yusuf *et al*., 2004:939)
[g] Dietary supplement was defined as a vitamin, a mineral, a herb or other botanical, an amino acid, a dietary substance for use by man to supplement the diet by increasing the total daily intake, or a concentrate, metabolite, constituent, extract or combinations of these ingredients (Halsted, 2003:1007S)
[h] Physically active was defined as regular involvement of moderate (walking, cycling or gardening) or strenuous exercise (jogging, football and vigorous swimming) for four hours or more a week (Yusuf *et al*., 2004:939)

4.9.3 Respondent perceived phytochemical importance and dietary source consumption differences

The respondents' perceived importance of phytochemicals in addition to their phytochemical-rich dietary source consumption with reference to their likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake is presented in Table 4.12. The likelihood of the respondents to consume additions of fruit, vegetables, rooibos herbal tea and herbs to proficient home-cooked category prepared dishes was investigated for enhanced phytochemical intake. Concerning the respondents' awareness of the role phytochemicals play in the human diet, a significant difference ($p < 0.05$) was found in their likelihood to consume rooibos herbal tea added to category prepared dishes for enhanced phytochemical intake. The respondents who

considered phytochemicals to be very necessary to support human health were more likely to consume rooibos herbal tea added to category prepared dishes in comparison to those respondents who considered phytochemicals to be necessary to support health and well-being ($p < 0.05$) and those respondents who did not know the importance of phytochemicals in the diet ($p < 0.05$).

Table 4.12: Respondent perceived phytochemical importance and dietary source consumption in comparison to the phytochemical-rich dietary source adjustment categories to proficient home-cooked category prepared dishes

Phytochemical importance and daily dietary source consumption		**Phytochemical-rich dietary source adjustment category**				
		Fruit (n = 9)[a]	**Vegetables** (n = 17)	**Herbs** (n = 15)	**Rooibos herbal tea** (n = 7)	**Significant difference**[d,e]
Perceived importance of phytochemicals	Very necessary (1)	4.16 (0.13)[b,c]	4.30 (0.16)	4.17 (0.12)	3.63 (0.18)	Rooibos herbal tea: (1) – (2)(4)
	Necessary to support health (2)	3.65 (0.13)	3.82 (0.13)	3.77 (0.10)	2.92 (0.15)	
	Not very necessary (3)	3.30 (0.42)	4.00 (0.43)	4.00 (0.23)	2.91 (0.22)	
	Do not know (4)	3.65 (0.08)	4.06 (0.07)	3.84 (0.06)	2.96 (0.09)	
Daily fruit servings	None to 1 serving (1)	3.61 (0.10)	4.06 (0.09)	3.82 (0.07)	2.93 (0.12)	
	2 – 4 servings (2)	3.76 (0.09)	3.97 (0.09)	3.87 (0.07)	3.07 (0.10)	
	3 – 5 servings (3)	3.85 (0.22)	4.03 (0.22)	3.97 (0.16)	3.40 (0.25)	
	More than 5 servings (4)	2.40 (<0.01)	4.33 (<0.01)	3.88 (<0.01)	1.00 (<0.01)	
Daily vegetable servings	None to 1 serving (1)	3.45 (0.12)	3.82 (0.13)	3.68 (0.10)	2.80 (0.13)	Vegetables: (1) – (2) Fruit: (1) – (2)
	2 – 4 servings (2)	3.80 (0.08)	4.15 (0.07)	3.93 (0.06)	3.11 (0.98)	
	3 – 5 servings (3)	3.73 (0.16)	3.90 (0.20)	3.93 (0.16)	3.17 (0.24)	
	More than 5 servings (4)	5.00 (<0.01)	3.00 (<0.01)	4.75 (<0.01)	3.29 (<0.01)	

Table 4.12 (continued)

Daily whole grain servings	None (1) (n = 22)	3.61 (0.18)	4.17 (0.15)	3.82 (0.14)	2.97 (0.24)	
	1 serving (2)	3.62 (0.10)	3.99 (0.11)	3.80 (0.08)	2.97 (0.11)	
	2 servings (3)	3.70 (0.11)	3.98 (0.10)	3.82 (0.08)	3.05 (0.13)	
	3 servings (4)	4.14 (0.19)	4.06 (0.21)	4.16 (0.16)	3.48 (0.26)	
	More than 3 servings (5)	3.66 (0.20)	3.97 (0.18)	4.02 (0.14)	2.68 (0.32)	
Daily tea consumption	None (1)	3.28 (0.15)	3.73 (0.16)	3.48 (0.13)	2.50 (0.17)	Rooibos herbal tea: (1) – (2)(3)[f] Herbs: (1) – (2)(3)[f](4) Fruit: (1) – (3)(4)
	1 cup (2)	3.71 (0.10)	4.03 (0.09)	3.88 (0.07)	3.14 (0.13)	
	2 – 3 cups (3)	3.86 (0.10)	4.11 (0.10)	4.00 (0.07)	3.24 (0.11)	
	4 – 6 cups (4)	3.93 (0.16)	4.20 (0.14)	4.04 (0.12)	3.17 (0.17)	
	More than 6 cups (5)	3.60 (0.72)	4.11 (0.45)	4.10 (0.40)	2.48 (1.20)	

[a] Number of set options within the dietary source adjustment or food vehicle category
[b] Mean of scale values where 1 equals 'extremely unlikely' and 5 equals 'extremely likely'
[c] Values: Mean ± standard error presented as mean (standard error)
[d] Overall significant difference ($p < 0.05$) in the repeated measures analysis of variance (ANOVA)
[e] Bonferroni correction for multiple comparisons for identification of pair-wise contrasts on significance ($p < 0.05$) in the repeated measures (ANOVA). Pair-wise contrasts presented as perceived phytochemical importance or daily dietary source consumption option number in brackets, e.g. (1), different (-) to other perceived phytochemical importance or daily dietary source consumption option number(s) in brackets.
[f] Bonferroni correction for multiple comparisons for identification of pair-wise contrasts on significance ($p < 0.001$) in the repeated measures (ANOVA). Pair-wise contrasts presented as perceived phytochemical importance or daily dietary source consumption option number in brackets, e.g. (1), different (-) to other perceived phytochemical importance or daily dietary source consumption option number(s) in brackets.

Concerning the consumption of phytochemical-rich dietary sources by the respondents, significant differences ($p < 0.05$) were singly found between their daily vegetable intake and their likelihood to consume vegetable and fruit additions to proficient home-cooked category prepared dishes, their daily tea consumption and the likelihood to consume rooibos herbal tea, herb and fruit additions to proficient home-cooked category prepared dishes for enhanced phytochemical intake (refer Table 4.12). The respondents who consumed none to one serving of vegetables daily were less likely to consume category prepared dishes for enhanced phytochemical intake with added vegetables than those respondents who consumed two to four servings ($p < 0.05$) of vegetables daily. Those respondents who consumed none to one serving of vegetables daily were also less likely to consume category prepared dishes for enhanced phytochemical intake with added fruit than those who

consumed two to four servings ($p < 0.05$) of vegetables daily. The respondents who did not consume tea were less likely to consume category prepared dishes with added rooibos herbal tea than those respondents who consumed one cup ($p < 0.05$) or two to three cups ($p < 0.001$) of tea daily. These respondents were also less likely to consume category prepared dishes with herb additions than those respondents who consumed one cup ($p < 0.05$), two to three cups ($p < 0.001$) or four to six cups ($p < 0.05$) of tea daily. They were furthermore less likely to consume category prepared dishes with fruit additions than those respondents who consumed two to three cups ($p < 0.05$) or four to six cups ($p < 0.05$) of tea daily.

CHAPTER FIVE
SUMMARY AND DISCUSSION OF RESULTS

5.1 Respondent sample as a health-conscious consumer group

Studies have found that health-conscious consumers tend to be female, older, more educated (Girois *et al*., 2001: 418; Divine & Lepisto, 2005: 275), higher income earners, physically active and individuals with a healthier body weight status (Robinson & Smith, 2003: 177). Kraft and Goodell (1993: 18) argue that individuals who pursue a wellness-oriented lifestyle are those concerned with nutrition and physical fitness. De Jong *et al.* (2003: 280) and Kirk *et al.* (1999: 72) further state that individuals who use dietary supplements are typically non-smokers, light drinkers, tend to consume a diet with adequate nutrients (De Jong *et al.,* 2003: 280) and are more likely to participate in other behaviour associated with improved health, including regular exercise (Kirk *et al.,* 1999: 72). The attributes of the respondents of this study are concurrent with the characteristics of the findings above pertaining to health-conscious consumers. The majority of respondents who participated in this study were female, white, 31 to 44 years of age and had obtained grade 12 and a diploma or a degree. In addition, the majority of the respondents were non-smokers, most were regular dietary supplement users, and most engaged in regular physical activity and consumed alcohol less than three times per week.

5.2 Respondent phytochemical awareness and dietary source consumption

Although the majority of the respondents were well educated, and most practiced lifestyle behaviours ascribed to being health-conscious, the overall respondent awareness of phytochemicals and the role these compounds play in the human diet was low. *Allium* compounds had the lowest respondent recognition, followed closely by polyphenols and isoflavones. The respondents of this study had lower recognition of isoflavones than those of the studies by O'Connor and Venter (2012: 66), who found it to be 20.9% amongst health-conscious consumers in the City of Cape Town obtained from two adjoining sub-councils and Braun and Venter (2008: 35), who found it to be 42.9% amongst health food store customers in Cape Town, SA. The 38% recognition of flavonoids in this study is very similar to the flavonoid recognition of 32.4% in the study of O'Connor and Venter (2012: 66) in Cape Town, SA. An online survey conducted amongst adult consumers in the USA found the awareness of functional foods to be low, with only 15% of the respondents stating they had heard of the term before taking part in the survey (Urala *et al*., 2011: 407). Another survey conducted amongst consumers in the USA found overall awareness of phytochemicals to be quite high, with 90% of the respondents aware of antioxidants, 88% of

carotenoids, 67% of flavonoids, 67.2% of isoflavones and 43% of phytochemicals (Miller, 2002: 77). In a survey that took place in the West Indies, where the participating respondents had to be responsible for the purchase and preparation of food, public knowledge of antioxidants was high. Of the 77% of respondents who claimed they were aware of antioxidants, 69.7% categorised them as 'very important'. The respondents further classed fruit and vegetables as 'good' sources of antioxidants, with vitamin C as the most recognised antioxidant (Boodhu & Badrie, 2007: 23).

Approximately half of the respondents in this study were not aware of the importance of phytochemicals in the human diet, while just more than a third thought they were necessary to support health and well-being. It was not surprising that the respondent awareness of the importance of phytochemicals in the human diet in this study was low. The low understanding of the role phytochemicals play in the diet was also encountered by Braun and Venter (2008: 34) amongst health food store customers in Cape Town. The study found that although more participants were familiar with the term 'phytonutrients', few were aware of the role they played in the human diet. Phytochemicals are also commonly referred to as 'phytonutrients' (Holst & Williamson, 2008: 73), which may have resulted in some confusion amongst the respondents, as the questionnaire in this study only made reference to phytochemicals.

South Africans are not achieving the minimum daily required fruit and vegetable intakes to support a healthy lifestyle (Naude, 2013: S49). This study supports this finding, as few respondents indicated that they consumed the recommended three to five servings of vegetables daily, while only half of the respondents indicated that they consumed the recommended two to four servings of fruit daily. Fruit consumption was found to be better amongst adults in the European Union, with 62% consuming three or more portions a day in a study conducted in Ireland, Spain, France and The Netherlands (Southon, 2000: 215). Elhatton (2002: 21) suggests consuming four to six cups of tea daily (720 g to 1 080 g). In comparison to this guideline, the respondents' consumption of tea in this study was exceptionally low. The respondents were found to consume between none and three cups of tea daily, with only a few consuming more than three cups daily. The whole-grain intake varied amongst respondents, with about 10% consuming the recommended three servings daily (Girois *et al*., 2001: 418) and about five percent consuming more than three servings daily. Similarly, findings from a British survey found the daily consumption of whole grains to be low, with approximately one-third of adults not consuming whole-grain foods and, amongst those who did consume whole grains, most consumed less than three servings daily (Lang *et al*., 2003: 481). Findings obtained from a random sample of over 9 000 American adults found the

participants to consume one serving of whole grains daily, with 36% averaging less than this each day. Only eight percent of the participants met the recommended three servings daily (Cleveland *et al*., 2000: 331S).

Price is a common factor impacting on food choice and could be an underlying factor affecting dietary choice in this study. The higher price of healthier dishes, such as those that incorporate whole grains, may contribute towards the limited number of servings consumed. Temple *et al*. (2011: 55) compared the prices of six commonly consumed foods with healthier versions in South African supermarkets (e.g. whole-wheat bread in place of white bread). Healthier foods typically cost between 10% and 60% more when compared on a weight basis (rand per 100 g) and between 30% and 110% more when compared by the cost of food energy (rand per 100 kilojoule (kJ)). Data from both the USDA and private companies in America identified a number of barriers to the consumption of whole grains (Adams & Engstrom, 2000: 339S) that include difficulties in identifying whole-grain foods, the poor palatability of whole-grain breakfast cereals and the higher cost of whole-grain foods (Lang & Jebb, 2003: 126). Some consumers have suggested improving the taste of whole grains, such as adding sweetness (Adams & Engstrom, 2000: 341S). In SA, less healthy foods often replace healthier versions due to their price, which may be the case regarding the consumption of fruit, vegetables and whole grains (Temple & Steyn, 2011: 507). While the majority of the respondents in this study had no urgent need to practice a healthy lifestyle, as only few had developed lifestyle diseases, they appeared interested to do so, as they indicated that they would be likely to to consume proficient home-cooked and purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake even though their knowledge of phytochemicals was limited.

5.3 Respondent stage of change in relation to their phytochemical-rich dietary source consumption

Fairly consistent patterns were found throughout the respondents' current daily intake of phytochemical-rich dietary sources of vegetables, fruit, whole grains and tea and their stage of change. The respondents who consumed the fewest servings of vegetables, namely none to one serving daily, were either not intending changing or considering changing in the next 30 days their current intake to two or more servings daily. Conversely, most of the respondents who consumed three or more servings of vegetables daily had already done so for longer than six months. Similarly, most of respondents who consumed two to four servings of fruit daily were either in the process of implementing this or had done so for longer than six months. Regarding the respondents' current daily whole-grain intake, most of

the respondents who consumed none to one serving or two servings or more daily were either not intending changing their current intake or considering changing in the next 30 days their current intake to at least three servings a day. Conversely, most of the respondents who consumed three servings or more of whole grains daily had already done so for longer than six months. Amongst the respondents who consumed none to one cup and two to three cups of tea daily, most were either not intending changing their current intake or considering changing in the next 30 days to increase their daily consumption to between four and six cups. Most of the respondents who consumed more than three cups of tea daily were in the process of changing or had currently implemented the practice for longer than six months.

The above suggests that the respondents with the lowest daily intake of phytochemical-rich dietary sources were those who had not considered change or were still considering changing to increase their intake of these dietary sources. However, the respondents who were consuming more servings of phytochemical-rich dietary sources were those who had already taken action to increase their intake of these dietary sources.

5.4 Research questions one and two: Respondent likelihood to consume proficient home-cooked and purchase and consume commercially manufactured category prepared dishes for enhanced phytochemical intake

As can be deduced from the presented results, the majority of the respondents indicated that they would be willing to make dietary changes in order to enhance their phytochemical intake. This included consuming proficient home-cooked and purchasing and consuming commercially manufacted category prepared dishes with various phytochemical-rich dietary sources incorporated as ingredients. This is despite the low incidence of chronic disease amongst the respondents. Only a small percentage of the respondents had been diagnosed with a lifestyle disease, with the highest percentage amongst the respondents diagnosed with obesity, followed by diabetes mellitus or CVD and cancer (excluding melanoma and skin cancer). The most prevalent lifestyle disease within the respondents' family history was cancer, followed by diabetes mellitus and CVD. This is also not withstanding the indication that humans are often unwilling to change established food preferences, even when the habitual diet poses a risk of chronic disease (Temple & Steyn, 2011: 505).

5.5 Research questions three and four: Differences in the respondent likelihood to consume dietary source adjustment and food vehicle category/categories of proficient home-cooked category prepared dishes for enhanced phytochemical intake

The respondents were significantly more likely to consume category prepared dishes with added berries in comparison to pome and citrus fruit as the dietary source adjustment category for enhanced phytochemical intake. Considering berries, the respondents were significantly more likely to consume mixed berries added to a crêpe in comparison to compote as the food vehicle category for fruit addition. The South African Berry Producers Association states that the local market has grown over the past five years, in line with international trends, which has seen the demand for berries escalate at a faster rate than any other fruit. Popular varieties include raspberries and blueberries (*Farmer's Weekly*, 2012). Considering pears as the food vehicle category for the addition of rooibos herbal tea, the respondents were significantly more likely to consume poached pear in red grape juice in comparison to poached pear in rooibos herbal tea. Raw apple was overall a more likely option to consume as the dietary source adjustment category in comparison to cooked apple. Apple added to a chicken salad was significantly more likely to be consumed by the respondents than chicken and apple casserole, although the respondents were significantly more likely to consume raw apple with skin on in comparison to raw apple being part of chicken breast salad. Apple is typically consumed in its raw form rather than in its cooked form due to its convenience. The South African Food Price Monitor report for February 2014, produced by the National Agricultural Marketing Council, found the average South African's food basket to include 1 kg of apples and 1 kg of bananas as the primary sources of fruit (National Agricultural Marketing Council, 2014). According to Agbola *et al*. (2003: 669) South African households allocate their expenditure on fruit to buy apples, followed by citrus fruits and banana, in that order. Other than baked apples, dishes that encompass cooked apple that are typically consumed in SA are possibly only apple with pork and apple pie.

The respondents were significantly more likely to consume vegetables as the dietary source adjustment category for proficient home-cooked category prepared dishes than herbs, fruit and rooibos herbal tea for enhanced phytochemical intake. Vegetables are commonly used as ingredients in mixed dishes and are an important contributory source to the daily vegetable intake (Mangal *et al*., 1995: 1626; O'Brien *et al*., 2003: 724). A study conducted by Krebs-Smith *et al*. (1995: 1626) found composite foods to account for 29% of the vegetable intake amongst adult Americans. O'Brien *et al*. (2003: 724) found composite foods to account for 27% of vegetable intake in the North/South Ireland Food Consumption Survey. In the study by Krebs-Smith *et al*. (1995: 1626) popular options for vegetables added to category

prepared dishes were tomato, butternut, spinach and broccoli, while onion was a less likely option. Onions are highly versatile, are used as an ingredient in numerous dishes and are accepted by almost all traditions and cultures. A study of the importance of composite foods to estimate fruit and vegetable intake found the largest dietary contribution in composite dishes to be carrots, tomatoes, mushrooms, onions and peppers (O'Brien *et al*., 2003: 718).

Fruit, in contrast, is less commonly used as an ingredient than vegetables in composite dishes (O'Brien *et al*., 2003: 724). The familiarity of the inclusion of vegetables above fruit as an ingredient in composite dishes may explain why the respondents were significantly more likely to consume vegetables than fruit as the dietary source adjustment category for enhanced phytochemical intake. More respondents were drinking less tea (as daily cups), rather than more tea. As tea is not a commonly used ingredient incorporated into recipe formulations, this could be the reason why rooibos herbal tea was the less likely dietary source adjustment category for enhanced phytochemical intake.

The addition of herbs significantly influences the flavour and acceptability of meals. Herbs possess phytochemicals, some having powerful antioxidant properties (Tapsell, 2008: 133) comparable with those of vegetables. Very high levels of phenolic compounds present in herbs may increase the antioxidant capacity with just a few grams added to the dish (Tapsell, 2008: 136). In addition to providing phytochemicals such as antioxidants to dishes, herbs can be used in recipes to replace less desirable ingredients, such as salt, fat and sugar, for example in marinades, dressings, stir-fry dishes, casseroles, soups and curries (Tapsell *et al*., 2006: S4). The respondents were significantly more likely to consume category prepared dishes with added parsley than with added rosemary, basil or mint, but not added mixed herbs as the dietary source adjustment category for enhanced phytochemical intake. Parsley is a popular culinary herb, used in its fresh or dry form, in many different dishes around the world (Kamel, 2013: 2). While parsley was a likely option for herbs added to category prepared dishes, the respondents were significantly less likely to consume carrot salad with raisins and parsley than carrot salad with raisins.

As the food vehicle category for the addition of rooibos herbal tea, the respondents were significantly more likely to consume starch-based category prepared dishes than vegetable or fruit as the food vehicle categories. Rooibos herbal tea added to starch as the food vehicle category may be a familiar choice as Tiger Brands launched a rooibos and rye bread to the South African market in November 2011 (Euromonitor International, 2013).

The respondents indicated that they would be likely to consume egg, chicken, potato, other starch and water as the food vehicle category for added herbs, while vegetable was a less likely option. Soup as the food vehicle for added herbs was a further likely option, with the respondents indicating that they would be likely to consume chicken soup with parsley, butternut soup with rosemary, tomato and basil soup and split pea and mint soup. The respondents indicated that they would also be likely to consume tomato and spanspek respectively as food vehicle category for added basil.

Chicken was a significantly more likely option than pasta as the food vehicle category for added broccoli, and broccoli a more likely option than spinach as the dietary source adjustment category added to chicken as the food vehicle category. Pasta and meat (meatballs) were likely options as food vehicle categories for added tomato. When considering soup as the food vehicle for added vegetables, the respondents were likely to consume roasted butternut, tomato and broccoli respectively, while onion, again, was a less likely option. Onions are primarily consumed for their distinctive flavour and their ability to enhance the flavours of other ingredients (Teare Ketter & Randle, 1998: 178), with the main reason for their avoidance said to be bitterness (Drewnowski & Gomez-Carneros, 2000: 1430). Considering tomato soup variations, the respondents were more likely to consume tomato soup without additions. The respondents were also more likely to consume butternut soup without additions. Roasted butternut soup without additions was a significantly more likely option than butternut and orange soup and butternut soup with rosemary. The respondents were likely to consume carrots as the food vehicle category for added fruit, namely carrots roasted in orange juice and carrot salad with raisins. Considering quiche as the food vehicle for added vegetables, the respondents were more likely to consume spinach and roasted butternut respectively, while onion, again, was a less likely option. According to Griffiths *et al*. (2002: 604), the prominent role of onions sometimes appears to be surprising due to their wide usage although they are often less visible compared to other commodities. Individuals may as a result unknowingly consume onion in various composite dishes but overlook its presence. O'Brien *et al*. (2003: 718) found through the Ireland Food Consumption Survey that over 60% of all onions are consumed in composite dishes in the North and South of Ireland. As the respondents may not be familiar with onion as a dominant flavour in dishes, its inclusion may be overlooked, whereas in this study, through the questionnaire application focusing on onion, it may have unfairly influenced the findings towards the likelihood to consume onion as phytochemical-rich dietary source adjustment category.

A study conducted by Labadarios *et al*. (2011: 6) found the majority of South Africans to consume a diet low in variety and therefore were not found to be in line with the South African Food Based Dietary Guideline (SAFBDG) of “enjoy a variety of foods” (Steyn, 2013: S13). Pedro *et al*. (2008: 616) found dietary variety amongst South African children to be limited, also stating that it has not varied from 1995 to 2003. Conservative eating patterns may consequently be ingrained in children who then continue to limit dietary variety into adulthood. It therefore could be said that South Africans are conventional consumers who enjoy a limited variety of foods. Considering the findings of the above study, the respondents may have answered positively toward food they were familiar with when considering whether they would consume category prepared dishes for enhanced phytochemical intake. The less likely responses to certain dishes indicated may have been as a result of unfamiliarity and the conservative palate of some respondents. Such examples may have included spanspek balls with shredded basil, fruit infused with rooibos herbal tea, soup made with rooibos herbal tea replacing some of the stock, fish baked with naartjie segments and chicken and apple casserole.

Numerous factors have been found to affect food choice, namely attitudes, food preferences, and food habits, along with taste, satiety, price, gender, social position, knowledge of eating behaviour, and social networks (Wardle *et al*., 2000: 269; Satia *et al*., 2002: 247; Zandstra *et al*., 2001: 75). Wądołowska *et al*. (2008: 123) found sensory attributes (taste, aroma, texture, visual appearance) and functional factors (accessibility, freshness, durability, quality, packaging, information, easy to store and use, convenience) to significantly affect food choice amongst Polish subjects. Age and gender were also found to greatly motivate food choice, while health and price were moderate influences. Region of residence, level of education, and economic status were found to affect food choice to a lesser extent (Wądołowska *et al*., 2008: 124). A systematic review of psychological determinants predicting fruit and vegetable intake in adult populations identified habit, motivation, goals and beliefs about capabilities, and knowledge and taste to be the most consistent variables predicting dietary behaviour (Guillaumie *et al*., 2010: 6). Availability and taste preferences have also been identified as barriers to the daily intake of fruit and vegetables in SA (Naude, 2013: S53). The respondents’ dietary habits, food preferences and their perceived taste of the provided food pairings may have played a role in the likelihood of some of the respondents to consume certain category prepared dishes for enhanced phytochemical intake. Furthermore, limited dietary variety in the respondents’ home may have caused reluctance in their indicated likelihood to consume certain other food pairings.

5.6 Research questions five and six: Differences in the respondent likelihood to purchase and consume dietary source adjustment and food vehicle category/categories of commercially manufactured category prepared dishes for enhanced phytochemical intake

The respondents were significantly more likely to purchase and consume commercially manufactured category prepared dishes with added fibre, than added fruit, vegetables, herbs and tea as the dietary source adjustment categories for enhanced phytochemical intake. The respondents were also significantly more likely to purchase and consume commercially manufactured category prepared dishes with added herb additions, than vegetable or tea additions. The current availability of whole-grain products on the market may have influenced the likelihood of the respondents to consume whole grains based on its familiarity. Commercial options of whole grain products include whole-grain varieties of bread, breakfast cereals, whole grain pasta, rice, biscuits and crackers (Lang & Jebb, 2003: 125), amongst others. According to Smith *et al*. (2003: 464), bread and breakfast cereals are the most popular sources of whole grains based on convenience, taste and availability. In a UK survey of British adults, over 40% of whole grains came from whole-grain varieties of bread and just over one-third came from whole-grain breakfast cereals. Whole-grain pasta, rice and other cereals contributed to three percent of whole-grain intake. Of the other whole grain foods, a substantial portion came from whole grain varieties of biscuits and crackers (Lang *et al*., 2003: 479).

The respondents were significantly more likely to purchase and consume pizza/pasta than beverages, grains/bake and dairy as the food vehicle category for enhanced phytochemical intake. The respondents were also significantly more likely to purchase and consume baked goods than grains/bake, dairy and beverages as food vehicle category. Fibre (as bran) added to a muffin was a significantly more likely addition to muffins to be consumed than added blueberry (fruit addition) or spinach (vegetable addition). Although fibre was a likely option added to commercially manufactured category prepared dishes, the respondents were less likely to consume fruit juice with added fibre. The respondents were significantly more likely to purchase and consume a pasta dish with added vegetables in comparison to added fruit, and more likely to purchase and consume pizza with added herbs in comparison to added fibre as the dietary source adjustment category. Purchasing and consuming shortbread biscuits with added fruit was a more likely option than such biscuits with added rooibos herbal tea or herbs as the dietary source adjustment categories for enhanced phytochemical intake. The respondents were equally likely to purchase and consume dairy

products (cheese and yoghurt) as the food vehicle category with added green tea (as extract) and added vegetables (as extract) as the dietary source adjustment categories.

5.7 Research question seven: Respondent likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake in relation to the respondent demographic, health and lifestyle characteristics, perceived phytochemical importance and dietary source consumption

According to Kiefer *et al*. (2005: 194) there are significant gender-specific differences in many areas of nutrition, several of which emerge in childhood or adolescence. Women have a greater awareness and better knowledge of nutrition and consume more fruit, vegetables and whole-grain products than men. The female respondents in this study were significantly more likely to consume category prepared dishes with the addition of fruit than the male respondents. Furthermore, the older respondents (55 to 64 years) were significantly more likely to consume category prepared dishes with the addition of herbs than the younger respondents (31 to 44 years). The older respondents (55 to 64 years) were also significantly more likely to consume category prepared dishes with fruit additions than the younger respondents aged 31 to 44 years and 45 to 54 years respectively. The consumption of fruit increases with advancing age and is more prevalent amongst females (Li *et al*., 2000: 777). The respondents involved in the preparation of food at home were significantly more likely to consume category prepared dishes with the addition of rooibos herbal tea, herbs and fruit respectively than those who were not. The respondents involved in the preparation of food at home may have been more familiar with certain ingredients and flavour combinations than those not involved with the preparation of food at home, and may therefore be more open to consuming category prepared dishes with the addition of rooibos herbal tea, herbs and fruit.

The respondents who considered phytochemicals to be very necessary to support human health were significantly more likely to consume rooibos herbal tea added to category prepared dishes for enhanced phytochemical intake in comparison to those respondents who considered phytochemicals to be necessary to support health and well-being and those respondents who did not know the importance of phytochemicals in the diet.

Concerning the consumption of phytochemical-rich dietary sources by the respondents, those who consumed none to one serving of vegetables daily were significantly less likely to consume category prepared dishes for enhanced phytochemical intake with added vegetables than the respondents who consumed two to four servings of vegetables daily. Those respondents who consumed none to one serving of vegetables daily were also significantly less likely to consume category prepared dishes for enhanced phytochemical

intake with added fruit than those who consumed two to four servings of vegetables daily. The respondents who did not consume tea were significantly less likely to consume category prepared dishes with added rooibos herbal tea than those respondents who consumed one cup or two to three cups of tea daily. The respondents who did not consume tea were also significantly less likely to consume category prepared dishes with herb additions than those respondents who consumed one cup, two to three cups or four to six cups of tea daily. The respondents who did not consume tea furthermore were significantly less likely to consume category prepared dishes with fruit additions than those respondents who consumed two to three cups or four to six cups of tea daily.

This indicates that the respondents with lower daily intakes of phytochemical-rich dietary sources compared to respondents with higher daily intakes were less likely to consume category prepared dishes to which these sources could be added for enhanced phytochemical intake. It also indicates that it is the respondents with higher daily intakes of phytochemical-rich dietary sources who are likely to consume category prepared dishes with such additions.

5.8 Study strengths and limitations

Although studies were found in relation to consumer awareness, knowledge and understanding of phytochemicals (Miller, 2002: 77; Braun & Venter, 2008: 35; O'Connor & Venter, 2012: 66), no similar studies were found when online journal searches were conducted pertaining to the likelihood of consumers in the professional sector, or other occupational groups, making dietary adjustments to enhance phytochemical intake. The respondent awareness of phytochemicals provided contextual backing to the research that primarily focused on the respondent's likelihood to make dietary adjustments in order to enhance their phytochemical intake. The lack of available studies therefore limits the discussion of the results found in this study, as they cannot be compared to a wide range of findings. Even information on the types of food commonly consumed by adult South Africans is limited (Van Heerden & Schönfeldt, 2011: 10). In assessing the availablility of food intake data for SA, Van Heerden and Schönfeldt (2011: 15) found no studies since 2000 pertaining to the food intake of the middle-class urban white, coloured and black populations in SA. The availability of such data could have strengthened the discussion of the results of this study. However, these findings are new, which consequently can provide strength to the study, as the findings can be used to educate the public on the importance of a diet rich in phytochemicals and ways in which they can increase their daily phytochemical intake to prevent and reduce lifestyle diseases. This information can be conveyed through the food

industry, dieticians, health-care practitioners and government alike. In addition, information was obtained which can assist the food industry in the selection of dietary source adjustment categories and sources and food vehicle categories for the development of dishes with an enhanced phytochemical content.

The phytochemical-rich dietary source adjustment and food vehicle pairing options provided in the study to represent the proficient home-cooked and commercially manufactured category prepared dishes can be queried, as they cannot be considered equally and fully representative. Although these pairings were evaluated for content and face validity, the selection may bias the findings due to a possible lack of equal and collective representation. The study nevertheless provides a platform from which to proceed for research in the field.

The research was restricted to a limited population size (n = 184) of predominantly white-collar workers of occupations representing the professional sector who were 31 to 65 years of age, obtained from within the boundaries of the City of Cape Town. As convenience purposive sampling was used, it infers that sampling bias occurred. The research was not extended to other occupational groups, geographical areas and age groups due to time constraints and availability of resources. The research was restricted to fruit, vegetables, fibre, herbs and tea as phytochemical-rich dietary sources and commonly consumed and readily available foods as food vehicle categories (chicken, fish, egg, potato, other starch, etc.). Therefore the results do not represent all the options that could be utilised as category prepared dishes.

The Mediterranean diet has been associated with a reduced risk of CDL such as cancer and CVD. Herbs such as basil, rosemary and thyme, amongst others, are frequently incorporated into Mediterranean dishes in considerable amounts, which may help explain some of the protective effects observed in populations adhering to traditional Mediterranean diets (Tapsell *et al*., 2006: 83). While herbs were included in this study, spices were omitted, and while spices could have been included as a phytochemical-rich dietary source adjustment category for enhanced phytochemical intake, their inclusion would have increased the length of the questionnaire quite considerably. The questionnaire was already somewhat long, and extending the length was purposefully avoided on the basis of the target sample being busy professionals with limited time.

The popularity and consumption of soy products tend to vary amongst population groups in SA. A study conducted by Bosman *et al*. (2009: 425) found that almost two-thirds of Indians (65%) and black people (64%) eat or drink soy products, while only 22% of white people

consume soy products. Considering current dietary consumption patterns and the limited dietary variety of the South African population, commonly consumed and widely available foods were chosen to be included in this study that did not include soy as representative of a phytochemical-rich dietary source adjustment category, based on the varying consumption by the different population groups.

A further limitation was the exclusion of children who may benefit considerably from such dietary adjustments. Poor childhood nutrition has been thought to increase morbidity and mortality from chronic diseases such as CVD and diabetes (Margolis, 2010: 133), and evidence indicates adult diseases are influenced by a variety of early-life exposures that may play a role in the premature asymptomatic phases of the disease process (Galobardes *et al*., 2006: 91).

CHAPTER SIX
CONCLUSIONS

The conclusions of the study are presented in five sections. The first section (6.1) indicates the respondent's phytochemical awareness and dietary source consumption. The second section (6.2) pertains to the respondent's likelihood to consume proficient home-cooked and commercially manufactured category prepared dishes for enhanced phytochemical intake, which relates to the first two research questions of the study. The third section (6.3) covers the differences in the respondent's likelihood to consume dietary source adjustment categories added to food vehicle categories of proficient home-cooked and commercially manufactured prepared dishes for enhanced phytochemical intake, relating to research questions three through to six. The fourth section (6.4) and the fifth section (6.5) relates to the last research question and covers the respondent perceived importance of phytochemicals, dietary source consumption, and the respondent's demographic, health and lifestyle characteristics in relation to their likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake.

6.1. Respondent phytochemical awareness and dietary source consumption

The respondents' awareness of phytochemicals was low, with them also correspondingly not aware of the role phytochemicals play in the human diet. The results pertaining to the respondent awareness of phytochemicals in this study were not found to be in complete agreement with similar studies. The respondents in this study had lower recognition of flavonoids, carotenoids, isoflavones and phytochemicals than those in a survey conducted by Miller (2002: 77). The awareness of isoflavones was also found to be low in a study by Braun and Venter (2008: 35) and O'Connor and Venter (2012: 66), while the recognition of flavonoids in this study was very similar to the flavonoid recognition in the study by O'Connor and Venter (2012: 66). Adding fruit, vegetables, whole grains, tea and herbs to prepared dishes for enhanced phytochemical intake may be a method these respondents could use to increase their low consumption of these phytochemical-rich dietary sources.

6.2. Respondent likelihood to consume proficient home-cooked and commercially manufactured category prepared dishes for enhanced phytochemical intake

The respondents in this study were likely to consume home-cooked and commercially manufactured category prepared dishes with dietary adjustments for enhanced phytochemical intake. This finding, despite their low incidence of CDL and limited awareness of phytochemicals, could possibly be ascribed to them practising various activities related to a healthy lifestyle, though not consuming an adequate intake of fruit, vegetables, whole

grains and tea. Their consumption of fruit, vegetables, whole grains and tea were below the consumption guidelines.

6.3. Differences in the respondent likelihood to consume dietary source adjustment categories added to food vehicle categories of proficient home-cooked and commercially manufactured category prepared dishes for enhanced phytochemical intake

Although the respondents were likely to consume proficient home-cooked and commercially manufactured category prepared dishes for enhanced phytochemical intake, some phytochemical-rich dietary source adjustment and food vehicle categories were more likely options than others, as can be deduced from the information below.

6.3.1. Fruit as the phytochemical-rich dietary source adjustment category in proficient home-cooked category prepared dishes for enhanced phytochemical intake

The respondents were likely to consume the options of pome fruit (as apples and pears) and berries as phytochemical-rich dietary source adjustment category. Citrus fruit was a less likely option to consume as phytochemical-rich dietary source adjustment category. The category prepared dishes most likely to be consumed by the respondents were raw apple with its skin on, chicken breast salad with apple pieces, crêpe with mixed berries and green leafy salad with strawberries. Mixed berry compote was a less likely option to be consumed by the respondents than crêpe with mixed berries as dessert options. Pear poached in red grape juice, rocket and pear salad, chicken and apple casserole and Kingklip fish baked with naartjie segments were also less likely options to be consumed than the above by the respondents as category prepared dishes.

South Africans are said to enjoy the taste of apples, which are a popular choice due to their affordability (Temple & Steyn, 2011: 505). It can therefore be concluded that the respondents found apple a likely option to utilise for enhanced phytochemical intake due to its familiarity and enjoyable taste. It may further be concluded that apple in its cooked form may have been a more likely choice if dishes incorporating cooked apple in a dessert were presented as options in the questionnaire, as only options of savoury dishes incorporating apple were provided. Cooked apple, however, may result in the addition of sugar, which should either be avoided or limited through the use of ingredients such as dates and honey to provide sweetness. Texture plays an essential role in food preferences, with textural qualities often linked to more wholesome foods (Szczesniak & Kahn, 1971: 280). The preference for raw apple may fall into the category of a healthy dietary choice based on its texture. The

consumption of berries is increasing in SA (*Farmer's Weekly*, 2012), which may be a contributory factor to their likelihood of being consumed in a dessert and added to a salad as category prepared dishes for enhanced phytochemical intake. Only one option of citrus fruit was provided, therefore no noteworthy conclusions could be made.

6.3.2. Vegetables as phytochemical-rich dietary source adjustment category in proficient home-cooked category prepared dishes for enhanced phytochemical intake

A number of vegetables were likely options for enhancing phytochemical intake, with the respondents most likely to consume tomato, butternut, broccoli and spinach. Carrot was a further likely option to be consumed for enhanced phytochemical intake by the respondents, with onion the least likely option to be consumed. The category prepared dishes most likely to be consumed by the respondents were chicken and broccoli bake, meatballs cooked in tomato sauce, spaghetti with tomato pesto, pasta and broccoli bake, roasted butternut soup, roasted butternut quiche, spinach quiche and chicken breast stuffed with spinach. Category prepared dishes less likely to be consumed by the respondents were broccoli soup, tomato soup, butternut and orange soup, carrots roasted in orange juice, carrot salad with raisins and pancakes filled with cooked spinach. However, these category prepared dishes were more likely options to be consumed than carrot salad with raisins and parsley, onion quiche and onion soup.

While onion is commonly consumed in composite dishes (O'Brien *et al*., 2003: 718), its presence is complimentary to enhance the flavours of other ingredients (Teare Ketter & Randle, 1998: 178). Tomato is also commonly consumed in composite dishes (O'Brien *et al*., 2003: 718) but the difference between tomato and onion inclusions is that tomato is typically added to perform the role of the main flavour in a dish, for example in sauces. It could therefore be assumed that onion did not feature well in this study due to its dominant role in the set options of dishes presented in the questionnaire. For some vegetables, they too may have been less likely options to act as the main flavour in a dish, as dishes with food vehicles imparting some flavour and substance were more likely to be consumed. Such examples include certain soups, namely tomato soup and broccoli soup. The less likely consideration of consuming these dishes may have been due to the acidity of the tomato in the tomato soup, and the dominant flavour of broccoli in the broccoli soup. It could be concluded that a category prepared dish made with tomato, butternut, broccoli and spinach as the respective phytochemical-rich dietary source is more likely to be consumed when paired with pasta, red meat (as meatballs), chicken and egg (as quiche) as food vehicles. While there are numerous recipes incorporating orange juice in butternut soup, the respondents found this to

be a less likely option when compared to butternut soup on its own as roasted butternut soup. Therefore, butternut and orange soup being a less likely option may not be due to its unfamiliarity, but rather the possible dislike of these paired flavours. Pancakes as the food vehicle for added spinach was not a likely option for the respondents, which may be due to the association of pancakes with sweet additions, such as syrup and sugar, rather than with a savoury filling. The likelihood of consuming category prepared dishes with spinach in savoury dishes, namely chicken and egg, fared well amongst the respondents. As only savoury dishes were provided as options in the questionnaire, a conclusion cannot be completely drawn. Carrot represented as carrot salad as the food vehicle category was a likely option for the addition of fruit (as raisins), but was a less likely option for the addition of herbs (as parsley). This may be due to the popularity of herbs added to cooked dishes, as presented below.

6.3.3. Herbs as the phytochemical-rich dietary source adjustment category in proficient home-cooked category prepared dishes for enhanced phytochemical intake

Parsley, mixed herbs, mint and rosemary as additions to foods were likely to be consumed by the respondents. The category prepared dishes most likely to be consumed by the respondents with added herbs were boiled baby potatoes with parsley, chicken soup with parsley, scrambled egg with parsley, omelette with mixed herbs, rice with mixed herbs, bread baked with mixed herbs, roasted potatoes with rosemary, roast chicken with rosemary stuffing, water infused with fresh mint and sliced tomato salad with shredded basil. Butternut soup with rosemary, tomato and basil soup and potato salad with mint were less likely category prepared dishes to be consumed by the respondents in comparison to the above, but were more likely options than spanspek balls with shredded basil and split pea and mint soup.

When considering parsley, the food vehicle categories likely to be consumed were potato, egg and chicken. Boiled baby potatoes with parsley was a more likely option than potato salad with mint. The addition of herbs may be a more likely option when added to warm dishes rather than cold dishes such as salads, as carrot salad with added parsley mentioned above was not as likely to be consumed by the respondents. Egg (as quiche) and other starch, namely bread and rice, were likely options when paired with mixed herbs. Mixed herbs can be a versatile way to achieve enhanced phytochemical content of dishes as they enhance the flavour of a dish without dominating it. Potato and chicken were likely options when paired with rosemary. As soups, other than chicken soup, vegetable soups were less likely options for the addition of herbs, such as split pea and mint soup, tomato and basil

soup and butternut soup with rosemary. Basil paired with tomato was a likely option with tomato soup a less likely option, as per the above, in comparison to sliced tomato as the option for the addition of basil. Spanspek as fruit for the addition of herbs was a less likely option, but as no other fruit options were provided in the questionnaire, a conclusion cannot be appropriately drawn.

6.3.4. Rooibos herbal tea as the phytochemical-rich dietary source adjustment category in proficient home-cooked category prepared dishes for enhanced phytochemical intake

The respondents in this study did not find the addition of rooibos herbal tea to category prepared dishes a likely option for enhanced phytochemical intake when compared to fruit, vegetables and herbs. Furthermore, the respondents were most likely to consume starch and fruit as the food vehicles for the addition of rooibos herbal tea. Starch was found to be the most likely option for the addition of rooibos herbal tea, as risotto prepared with rooibos herbal tea and bread baked with rooibos herbal tea. The most likely option of fruit prepared with rooibos herbal tea was pear poached in rooibos herbal tea, with prunes and plum less likely options as prunes stewed in rooibos herbal tea and plum compote prepared with rooibos herbal tea. When comparing the likelihood of the respondents to consume mixed berry compote, double the number of respondents was likely to consume this dish compared to plum compote prepared with rooibos herbal tea. Considering the tomato soup variations, about double the number of respondents were also likely to consume tomato soup and tomato soup with basil in comparison to tomato soup prepared with rooibos herbal tea.

6.3.5. Baked dishes as the food vehicle category in commercially manufactured category prepared dishes for enhanced phytochemical intake

The respondents were most likely to consume fibre and herbs as the phytochemical-rich dietary source adjustment category added to baked category prepared dishes. The category prepared dishes most likely to be consumed by the respondents were whole wheat bread, whole wheat biscuits, bran muffins and herb crust pizza base. The category prepared dishes least likely to be consumed were shortbread baked with powdered orange peel and pulp, chocolate cake with powdered grape pomace, spinach muffins, bread with onion extract, baked rice snacks with powdered tomato pomace, shortbread with rosemary, and shortbread with rooibos herbal tea.

The strong likelihood of the respondents to consume fibre added to baked dishes may be due to its familiarity, as whole wheat bread, whole wheat biscuits and bran muffins are

currently sold commercially in SA. As herbs are typically consumed on a pizza, such as mixed herbs and oregano, this may be a reason for the strong likelihood of the respondents to consume a herb crust pizza base.

Considering the options of shortbread biscuits, the respondents were least likely to consume shortbread biscuits with added rosemary and most likely to consume shortbread biscuits baked with dried berry pulp. As added berries were a likely option for the respondents in proficient home-cooked category prepared dishes, it is not surprising that the respondents were most likely to consume shortbread baked with dried berry pulp. Fruit added to a muffin (as blueberries) was a more likely option than vegetables added to a muffin (as spinach).

6.3.6. Pasta as the food vehicle category in commercially manufactured category prepared dishes for enhanced phytochemical intake

The respondents were more likely to consume vegetables than fruit added to pasta. The category prepared dishes most likely to be consumed by the respondents were lasagne sheets with added spinach, noodles with onion extract and pasta with tomato paste containing tomato peel.

The strong likelihood of the respondents to consume lasagne sheets with added spinach may be due to its familiarity, as pasta with added spinach is widely sold in supermarkets in SA. Vegetables such as tomato and onion are typically added to pasta dishes, consequently these flavours would be familiar and therefore a more likely choice by the respondents to be consumed with pasta. This could be the reason for the likelihood of the respondents to consume a pasta dish with tomato paste containing tomato peel and noodles with onion extract rather than pasta with powdered apple pomace and pasta with powdered banana. The addition of fruit to pasta may pose a problem due to the unfamiliarity of these food combinations.

6.3.7. Dairy as the food vehicle category in commercially manufactured category prepared dishes for enhanced phytochemical intake

The respondents were most likely to consume tea added to dairy (as extract). Vegetables added to dairy (as extract) were also a likely option.

Both yoghurt and cheese with added foodstuffs are familiar to South African consumers. Fair Cape Dairies launched Rooiboost, a drinking yoghurt that provides the equivalent of six cups of rooibos herbal tea in a single 100 mL shot (*Foodstuff South Africa*, 2010). This may have

resulted in the likelihood of the respondents to consume yoghurt with green tea extract. Other ingredients can also be found in yoghurt, such as fruit pulp. The addition of foodstuffs to cheese is growing in SA, with both local and imported cheeses being sold in major retail stores. Despite this, the respondents were not as likely to consume cheese as the dairy food vehicle category compared to yoghurt.

6.3.8. Beverages as the food vehicle category in commercially manufactured category prepared dishes for enhanced phytochemical intake

The respondents were most likely to consume rooibos herbal tea and herbs added to beverages as the food vehicle. The category prepared dishes most likely to be consumed were fruit juice with rooibos herbal tea and fruit juice with mint extract. The respondents were least likely to consume fruit juice with powdered cereal fibre and instant coffee with hazelnut skin powder. While fibre was a likely option added to food, it was not as likely to be consumed added to beverages. Ice tea and similar beverages are familiar to South Africans, which may be the reason for the likelihood of the respondents to consume fruit juice with rooibos herbal tea. Mint added to beverages is a likely option with the respondents likely to consume fruit juice with mint and, as above, water with mint was a further likely option. It could therefore be concluded that the respondents were more likely to consume mint added to beverages than to food. No conclusions could be made pertaining to the reason for the respondents not being too likely to consume instant coffee with hazelnut skin powder, as it is not known how many of the respondents did not drink coffee.

6.4. Respondent perceived phytochemical importance and dietary source consumption and the likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

Considering the respondent perceived importance of phytochemicals, the respondents who considered phytochemicals to be very necessary to support human health were more likely to consume rooibos herbal tea added to category prepared dishes than those who considered phytochemicals to be necessary to support health and well-being and those who did not know the role phytochemicals played in the diet.

The respondents who consumed none to one serving of vegetables daily were less likely to consume category prepared dishes with added vegetables and added fruit than those who consumed two to four servings of vegetables daily. The respondents who did not consume tea were less likely to consume category prepared dishes with added rooibos herbal tea than those who consumed one cup or two to three cups of tea daily. The respondents who did not

consume tea were also less likely to consume category prepared dishes with added herbs than those who consumed one cup, two to three cups or four to six cups of tea daily. The respondents who did not consume tea were less likely to consume category prepared dishes with fruit additions than those who consumed two to three cups or four to six cups of tea daily. In consideration of the respondent consumption of phytochemical-rich dietary sources it can be concluded that the respondents who consumed the least amount of fruit, vegetables and tea were least likely to consume phytochemical-rich dietary sources for enhanced phytochemical intake; however, these respondents would have the greatest need for dietary adjustments for enhanced phytochemical intake based on their low intake of these foods.

6.5. Respondent demographic, health and lifestyle characteristics and the likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical intake

The respondents' gender, age and whether or not they were involved in the preparation of food at home influenced their likelihood to consume proficient home-cooked category prepared dishes for enhanced phytochemical-rich intake. More female than male respondents were likely to consume added fruit for enhanced phytochemical intake. The older respondents (55 to 64 years) were also more likely to consume proficient home-cooked category prepared dishes with added fruit than the younger respondents (31 to 44 years). The older respondents (55 to 64 years) were also more likely to consume proficient home-cooked category prepared dishes with added herbs than the younger respondents (31 to 44 years). The respondents involved in the preparation of food at home were more likely to consume proficient home-cooked category prepared dishes with rooibos herbal tea, herbs and fruit respectively added than those who were not involved in the preparation of food at home.

CHAPTER SEVEN
RECOMMENDATIONS

Numerous recommendations have been cautiously made due to the study limitations. The recommendations were based on the low consumption of phytochemical-rich dietary sources amongst the respondents, and the likelihood of the majority of the respondents to make dietary changes for enhanced phytochemical intake. In addition, no studies of a similar nature were found. The recommendations provided can also be considered for future studies related to this research.

Although only a few respondents had developed lifestyle diseases, most to the majority were practising various health-related lifestyle activities. The respondents were also likely to make dietary adjustments even though their awareness of phytochemicals was limited. The general sentiment of the respondents, when the questionnaires were collected, was a feeling of overwhelming disbelief at their lack of awareness of phytochemicals and the role they play in the human diet. Education is therefore required to convey the importance of consuming a phytochemical-rich diet to reduce the risk for the onset of CDL. Once a basic understanding of these compounds is achieved, consumers can be further educated on ways to incorporate phytochemical-rich dietary sources into category prepared dishes at home. The food industry can in addition consider the development of phytochemically enhanced commercially manufactured dishes for enhanced phytochemical intake. Such endeavours would succeed in achieving increased phytochemical intake, as the respondents in this study indicated the likelihood to purchase and consume such proficient home-cooked and commercially manufactured category prepared dishes.

Awareness of these compounds and the role they play in the prevention of CDL can be achieved through utilising dieticians, health-care practitioners, food-, nutrition- and health-related government departments, food manufacturers and retail supermarkets. Only once awareness of the common phytochemicals is achieved can the public be further educated on the lesser-known phytochemicals and their health benefits. Charlton *et al*. (2004: 801) found the major source of nutrition information amongst Black urban women in SA to be the media, in particular radio and television. While the media were the most popular source of information, some negative aspects were associated with it, such as a lack of trust in it providing scientific information, the information provided being misleading or designed to promote unscrupulous sales (Charlton *et al*., 2004: 807). The most credible source of nutrition information was that conveyed by health professionals (Charlton *et al*., 2004: 808), who then become the proposed group to be utilised to provide education on phytochemicals.

Dieticians, health-care practitioners and food-, nutrition- and health-related government departments can make use of the findings of this study to educate consumers on the vital role phytochemicals play in reducing the risk of the development of CDL. They first and foremost should educate consumers on responsible food choices, which can then be followed by education on the recommended dietary intakes of fruit, vegetables, whole grains and tea for the prevention of lifestyle diseases. Suggestions can be made to flavour dishes with added herbs (instead of salt) and adding a variety of vegetables to composite dishes such as soups, stews and casseroles and in quantities that can contribute to the consumption of a vegetable serving. The incorporation of phytochemical-rich dietary sources into dishes can be promoted by supermarkets during promotions, such as for Heritage Day, with examples of vegetable and fruit kebabs and preparing marinades with herbs as recipe ingredient. The emphasis should be on the encouragement of the replacement of unhealthy food choices with fruit, vegetables and whole grains, as well as the replacement of unhealthy beverages with healthy choices such as flavoured teas, black tea, rooibos and herbal teas. As the respondents in this study indicated that they would be likely to consume water with mint and fruit juice with rooibos herbal tea, these can be used as options for healthy beverages. To date, no South African interventions have been aimed specifically at improving fruit and vegetable consumption other than the National Department of Health's Nutrition Directorate promoting the dietary guideline of "Eat plenty of vegetables and fruit" (Schneider *et al*., 2007: 722). Before guidelines are established and promoted, education should be undertaken to assist consumers to understand the reasons for dietary change.

The findings from this study can also be used to educate consumers on recipe development through the publication of simple step-by-step recipes in magazines, newspapers, leaflets and e-mail communication to create proficient home-cooked category prepared dishes for enhanced phytochemical intake for those who are not familiar with food preparation. Recipes can also be printed on food packaging for the incorporation of a purchased product into a dish for enhanced dietary phytochemicals. The responsibility of the aforementioned communication should be that of food editors, supermarkets, food manufacturers, medical aids, dieticians, health care practitioners, food-, nutrition- and health-related government departments and chefs. Recommendations should include the incorporation of vegetables, in particular tomato, butternut, spinach and broccoli, herbs such as parsley, mixed herbs and rosemary and fruit such as berries and raw apple into category prepared dishes at home for enhanced phytochemical intake. The use of food vehicle categories should include chicken, potato, egg and other starch, namely rice and bread, due to the likelihood of respondents in this study to consume these foods as food vehicles. The findings from this study can

additionally be used by chefs to create prepared dishes for enhanced dietary phytochemicals to serve in restaurants.

Although the respondents in this study were not very likely to consume rooibos herbal tea added to category prepared dishes at home they indicated that they would be likely to consume rooibos herbal tea added to yoghurt and fruit juice. This finding should be considered when developing commercially manufactured category prepared dishes. Recommended dietary source adjustment categories in the commercial sector should include those rich in dietary fibre as whole grains, based on the likelihood of respondents in this study to consume these options. The food industry should further focus on the development of category prepared dishes with incorporated waste products such as fruit peels for added phytochemicals. The food industry can use the findings from this study as a guide in the development of category prepared dishes targeted at consumers working in the professional sector who possibly have less time to prepare healthy dishes at home but who can afford to purchase commercially manufactured dishes. The food industry should pay close attention when marketing prepared dishes for enhanced phytochemical intake to ensure consumers fully understand the health benefits, considering that claims cannot be made. Gilbert (2000: 24) suggests that health claims and product information should be available to the consumer in various formats, including on product labels and in the media. Wansink and Cheney (2005: 387) propose that information pertaining to health claims should be conveyed to consumers primarily though product labels, point-of-purchase displays and educational campaigns. They further state that labels are often perceived by the consumer as being unclear or misleading and therefore the onus falls on the government and health and medical practitioners to provide clarity (Wansink & Cheney, 2005: 388). Surveys were compiled in which American adults were questioned about their interest in and awareness of health-promoting foods (Schmidt, 2000: 16). From the results a list was compiled that included broad suggestions on the ways to communicate the health benefits of foods to consumers. The list consisted of the importance of education by health professionals and marketers, focusing on the positive aspects of eating rather than focusing on what foods to eat, backing claims up with scientific evidence and ensuring the communication provided was accurate (Schmidt, 2000: 17). Supermarkets can use the findings from this study to develop category prepared dishes to serve at the deli for consumers to purchase for breakfast, lunch or dinner as a ready-made take-away option. The most influential factors to affect food choice have been found to be taste, food preferences of family members and price (Charlton *et al*., 2004: 808), which should be considered in product development efforts for enhanced phytochemical intake.

Marketing campaigns and strategies to create awareness of phytochemicals should be targeted at females between 55 and 64 years of age who are involved in the preparation of food at home. Lake *et al*. (2006: 475) found the responsibility for food preparation by adults living within shared households in the UK to be predominantly that of females. As most of the respondents in this study were female and, were involved in the preparation of food at home, they may play a major role in influencing the diet of those living in the household such as that of their partner and children. Conversely, Jensen (2011: 333) found men to be increasingly responsible for household grocery shopping. This may mean that in today's society, women are no longer solely in control of duties concerning food, such as shopping and meal preparation, allowing men to have input in what is purchased and consumed. Further consideration should be given to the fact that the older individuals in this study (55 and 64 years) were more likely to consume herbs and fruit added to category prepared dishes, the female respondents more likely to consume fruit added to category prepared dishes than the male respondents, and the respondents involved in the preparation of food at home more likely to consume rooibos herbal tea, herbs and fruit added to category prepared dishes for enhanced phytochemical intake.

While recommendations have been made, the most important would be to expand upon the current research overcoming the limitations by using a larger and more representative sample group. Research can even be expanded upon to incorporate qualitative research on the factors influencing food choice regarding the consumption of phytochemical-rich food.

If a study of this nature was ever to be repeated or expanded upon, consideration should be given to the inclusion of soy and spices as phytochemical-rich dietary source adjustment categories. While meat and meat products are commonly consumed as sources of protein by upper-class urban consumers in SA (MacIntyre *et al*., 2002: 246), soy can be considered in future studies to replace meat in some dishes based on its health benefits. Soy contains the isoflavones genistein and daidzein. The consumption of soy in high amounts in Southeast Asian populations is associated with the reduced incidence of certain cancers and CVD (Barnes, 1998: 386). Bosman *et al*. (2009: 425) found that South African consumers enjoyed the taste of soy and would consume it more often if it was readily available and a larger product range existed in the market.

Spices are capable of providing a marked increase in the dietary phenolic content and antioxidant capacity of dishes (Ninfali *et al*., 2005: 264). The use of spices can be incorporated into sweet and savoury dishes both in the commercial sector as well as dishes prepared at home. Savoury commercial options include cheese, beverages, and prepared

fish and meat dishes. Sweet commercial options, which though should be consumed occasionally, include ice cream with pineapple, cumin and coconut, custard with spices such as cinnamon and nutmeg, milk tart with cardamom, jelly with ginger, chilli lemon sorbet, steamed ginger and golden syrup pudding, chocolate and red chilli mousse, mint ice cream, etc. (*Woolworths Taste*, 2013).

A further consideration if a study of this nature were ever to be repeated is that of children utilised as the study sample. A growing body of evidence indicates that adult diseases are influenced by various early-life exposures (Kuh & Hardy, 2002: 285; Davey-Smith, 2003: 618; Kuh & Ben-Shlomo, 2003: 1122). Rose (1982: 1600) some time ago already reported that the correlation between cholesterol level, systolic and diastolic blood pressure and CHD mortality increased over time, suggesting that the induction period between exposure to risk factors and CHD mortality may extend over decades. Margolis (2010: 132) found most types of childhood morbidity to be associated with poorer adult health, regardless of family background, adult socioeconomic status and health behaviour. In view of the above, future studies should consider the role of dietary habits incorporating phytochemical-rich sources for children in the prevention of CDL.

Considerable evidence exists demonstrating the role vegetables, fruit and whole grains and even regular tea consumption play in the prevention of CDL. The recommended dietary intakes of phytochemical-rich dietary sources should be promoted and emphasised as a minimum requirement, while caution should be exercised for herbs and teas, as no official dietary recommendations have been established to date and toxicity levels have not been established for all herbs and spices. While most of the respondents indicated that they would be likely to make dietary adjustments to enhance their phytochemical intake, only a third of these respondents were aware of the compounds. In summary, there is an urgent need to raise consumer awareness in order for dietary change to occur for the prevention of the escalating CDL incidence in SA. In this study it was especially those respondents who had implemented dietary change to consume higher intakes of phytochemical-rich dietary sources (i.e. daily vegetable serving intake and tea consumption) who were likely to consume category prepared dishes for enhanced phytochemical intake.

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APPENDIX A

Letter granting ethical clearance

Cape Peninsula University of Technology

Enquiries:
Dr M Opperman
Faculty of Applied Sciences
Chair: Ethics Committee
Tel: (021) 953-8677 or 460-4213
Email: oppermanm@cput.ac.za

08 May 2012

Ms S Mager
Consumer Science: Food and Nutrition
Cape Peninsula University of Technology

Dear Ms Mager

Dietary adjustments consumers from the professional sector in the City of Cape Town are prepared to make to enhance phytochemical intake – Ref 06/2012

The Ethics Committee has considered your application for Ethics approval for the above project and would like to advise that approval for the project is hereby granted.

We wish you every success with your research.

Kind regards

Dr Maretha Opperman (RD (SA))
Senior Lecturer/Researcher
Department of Agriculture and Food Science
Functional Foods Research Unit
CPUT

APPENDIX B

Letter to the company manager to recruit respondents

Cape
Peninsula
University
of Technology

The Company Manager / Representative

RE: **Assistance in respondent recruitment for MTech Consumer Science: Food and Nutrition research (by Ms S Mager) entitled "Dietary adjustments consumers from the professional sector in the City of Cape Town are prepared to make to enhance phytochemical intake"**

Ms Shelley Mager is a registered MTech Consumer Science: Food and Nutrition-student with the Faculty of Applied Sciences at the institution (the Cape Peninsula University of Technology, CPUT). To obtain her qualification she needs to undertake a research study. She opted to determine the dietary adjustments consumers from the professional sector in the City of Cape Town are prepared to make to enhance phytochemical intake.

To obtain this information she needs respondents' representative of the professional sector (characterised by the professionals and technicians and associate professionals standard occupation classification of the International Labour Organisation) to complete a questionnaire which will take about 20 minutes of their time. The results will contribute to the small body of existing consumer research in this field in South Africa. The findings from this research will provide the food industry and health professionals with ways to consider to enhance phytochemical intake. An enhanced phytochemical intake is indicated to contribute to a decreased risk of developing the chronic degenerative diseases of lifestyle.

The research proposal of Ms Mager was approved by the Faculty of Applied Sciences Research Committee and the research has also received ethical approval from the Faculty of Applied Sciences Research Ethics Committee (Ref 06/2012).

Your assisting Ms Mager in the above regard is highly appreciated.

Ms I Venter
Supervisor and Senior lecturer: Consumer Science: Food and Nutrition

Dr S Crafford
Head of Department: Agricultural and Food Sciences

PO Box 1906 Bellville 7535 South Africa
086 123 2768

APPENDIX C

Participant information and consent form

Cape Peninsula
University of Technology

PARTICIPANT INFORMATION AND CONSENT FORM

TITLE OF THE RESEARCH PROJECT: Dietary adjustments consumers from the professional sector in the City of Cape Town are prepared to make to enhance phytochemical intake.

PRINCIPAL INVESTIGATOR: Ms Shelley Mager.

ADDRESS: Programme: Consumer Science: Food and Nutrition, Department of Agricultural and Food Sciences, Cape Peninsula University of Technology (CPUT).

CONTACT DETAILS: (021) 531 4735 / 082 505 2845 and shelley.mager@live.co.za

You have been invited to take part in a research study. Please read through the information presented here, which will provide you with an understanding of the study and what you will be required to do. Your involvement is ***voluntary*** and you may withdraw from participating at any time. This research study has been approved by the Faculty of Applied Sciences Research Ethics Committee, CPUT.

Brief description and objectives of the research study

Phytochemicals are compounds naturally present in plant foods that include fruit, vegetables and whole grains and have been linked to the reduction in the risk of major chronic diseases of lifestyle. South African diets appear to be deficient in these compounds, therefore increasing the risk for the development of these diseases. Research is required to determine the dietary changes professionals are prepared to make to increase their phytochemical intake. To obtain this information 169 employees of the professional sector in the City of Cape Town are required to participate in a consumer survey that will entail the completion of a short questionnaire. The questions are related to suggestions of the types of food and beverages consumers from the professional sector in the City of Cape Town would be willing to consume at home, as well as the commercially produced foods and beverages they would be willing to purchase for the purpose of enhancing dietary phytochemical intake.

Why you have been chosen to participate

Employees from the professional sector are specifically required to participate in this research survey for they have the financial means, and possibly also the willingness, to make dietary changes. Participants are required to be between the ages of 31 to 65 years in order to form a representative sample of both the young and middle adulthood groupings. The adult phase is a fundamental stage in life for the prevention of the majority of chronic diseases. The professional sector chosen for the purpose of this study includes the following occupations: Professionals (listed as Major Group 2) and Technicians and Associate Professionals (listed as Major Group 3) of the International Standards Classification of Occupations (ISCO) (see attachment A).

What you will be required to do

You will be required to complete a short questionnaire on your own, without the assistance of the researcher. The questions will be related to dietary adjustments you would be willing to make in order to enhance your dietary phytochemical intake. You will also be required to

disclose your age, gender, ethnicity, home language, highest level of education, occupation and lifestyle information. For the major part of the questionnaire the questions will require answering from a set of fixed responses provided by the researcher.

Benefits of taking part in this research

There is no direct personal benefit from taking part in this research, however, it may create awareness and offer ideas in the preparation of food and beverages at home and when purchasing food and beverages for increased phytochemical intake. The research can be used to benefit researchers in the same field of study and may assist the food industry in the development of innovative food and beverages to enhance dietary phytochemicals of the consumer.

Confidentiality of information gathered from this research project

The information obtained from this research survey will be handled in a confidential manner, although it may be used in the publication of a scientific journal. If published in a scientific journal, the identity of the participants' will remain strictly confidential. The researcher will be involved in capturing the data (using a password protected computer) and the statistician in the analysis of the data (based on the participant study codes and using a password protected computer).

Remuneration and costs involved

You will not be paid to take part in this research study nor are there any costs involved if you participate.

For queries and additional information

You may contact Ms Irma Venter on (021) 460 3428 and venteri@cput.ac.za if you have any further queries regarding this research study.

You will receive a copy of this consent form for your own records.

By signing below, I …….. agree to take part in a research study entitled Dietary Adjustments Consumers of the Professional Sector in the City of Cape Town are Prepared to Make to Enhance Phytochemical Intake.

I declare that:

- I have read this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this research study is voluntary and I have not been pressured to take part.
- I may choose to leave the research study at any time.

Signed……..……..at (place)……..……..……..on (date)……2012.

APPENDIX D

International Standard Classification of Occupations

INTERNATIONAL STANDARD CLASSIFICATION OF OCCUPATIONS

1. Major Group 1: Legislators, senior officials and managers

2. Major Group 2: Professionals
   - 2.1. Physical, mathematical and engineering science professionals
     - 2.1.1. Physicists, chemists and related professionals
     - 2.1.2. Mathematicians, statisticians and related professionals
     - 2.1.3. Computing professionals
     - 2.1.4. Architects, engineers and related professionals
   - 2.2. Life science and health professionals
     - 2.2.1. Life science professionals
     - 2.2.2. Health professionals (except nursing)
     - 2.2.3. Nursing and midwifery professionals
   - 2.3. Teaching professionals
     - 2.3.1. College, university and higher education teaching professionals
     - 2.3.2. Secondary education teaching professionals
     - 2.3.3. Primary and pre-primary education teaching professionals
     - 2.3.4. Special education teaching professionals
     - 2.3.5. Other teaching professionals
   - 2.4. Other professionals
     - 2.4.1. Business professionals
     - 2.4.2. Legal professionals
     - 2.4.3. Archivists, librarians and related information professionals
     - 2.4.4. Social science and related professions
     - 2.4.5. Writers and creative or performing artists
     - 2.4.6. Religious professionals

3. Major Group 3: Technicians and associate professionals
   - 3.1. Physical and engineering science associate professionals
     - 3.1.1. Physical and engineering science technicians
     - 3.1.2. Computer associate professionals
     - 3.1.3. Optical and electronic equipment operators
     - 3.1.4. Ship and aircraft controllers and technicians
     - 3.1.5. Safety and quality inspectors
   - 3.2. Life science and health associate professionals
     - 3.2.1. Life science technicians and related associate professionals
     - 3.2.2. Modern health associate professionals (except nursing)
     - 3.2.3. Nursing and midwifery associate professionals
     - 3.2.4. Traditional medicine practitioners and faith healers
   - 3.3. Teaching associate professionals
     - 3.3.1. Primary education teaching associate professionals
     - 3.3.2. Pre-primary education teaching associate professionals
     - 3.3.3. Special education teaching associate professionals
     - 3.3.4. Other teaching associate professionals
   - 3.4. Other associate professionals
     - 3.4.1. Finance and sales associate professionals
     - 3.4.2. Business services agents and trade brokers

3.4.3. Administrative associate professionals
3.4.4. Customs, tax and related government associate professionals
3.4.5. Police inspectors and detectives
3.4.6. Social work associate professionals
3.4.7. Artistic, entertainment and sports associate professionals
3.4.8. Religious associate professionals

4. Major Group 4: Clerks

5. Major Group 5: Service workers and shop and market sales workers

6. Major Group 6: Skilled agricultural and fishery workers

7. Major Group 7: Craft and related trade workers

8. Major Group 8: Plant and machine operators and assemblers

9. Major Group 9: Elementary occupations

10. Major Group 10: Armed forces

Obtained from: Bureau of Statistics. 2009. International standard classification of occupations. http://www.iol.org/public/english/bureau/stat/isco88/major.htm [7 August 2011].

APPENDIX E

Final research questionnaire

DIETARY ADJUSTMENTS CONSUMERS FROM THE PROFESSIONAL SECTOR IN THE CITY OF CAPE TOWN ARE PREPARED TO MAKE TO ENHANCE PHYTOCHEMICAL INTAKE

The prevalence of chronic diseases of lifestyle is rapidly increasing in South Africa and dietary behaviour is believed to be a major contributory factor.

Research is lacking and required in South Africa to determine the willingness of South African consumers to make dietary adjustments for enhanced phytochemical intake to assist in the alleviation of these diseases.

Your participation in this survey is greatly appreciated.

The information you supply in this questionnaire will be treated as confidential.

Please do not write your name on the questionnaire.

The completion of this questionnaire will take approximately 20 minutes.

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF FOOD AND AGRICULTURAL SCIENCES

PROGRAMME: CONSUMER SCIENCE: FOOD AND NUTRITION

INSTRUCTIONS FOR COMPLETION

Tick (✓) one option that best describes your answer for each question, unless otherwise indicated.

Please ensure you answer each question.

Where you are asked to supply an answer, print clearly.

If you make a mistake, colour the block in and mark your answer in the next appropriate block.

Please do not consult anyone during the completion of this questionnaire.

For office use only

SECTION A: PHYTOCHEMICAL AWARENESS AND INTAKE

1. Before this study had you heard of phytochemicals or any of the following compounds that are phytochemicals?
(more than one option may be chosen)

		Yes	No	
1.1	Phytochemicals	1	2	1.1
1.2	Allium compounds	1	2	1.2
1.3	Carotenoids	1	2	1.3
1.4	Flavonoids	1	2	1.4
1.5	Isoflavones	1	2	1.5
1.6	Polyphenols	1	2	1.6

2. How important do you think phytochemicals and the compounds mentioned in the previous question are in the human diet?

Very necessary as not consuming them may cause illness and disease	1	
Necessary to support health and well-being	2	
Not very necessary as the body can make them	3	
Do not know	4	2

3. How many servings of vegetables do you usually consume daily (count one serving as = 1/2 cup raw or cooked vegetables OR one cup raw leafy vegetables)?

None to 1 serving	1	
2 to 4 servings	2	
3 to 5 servings	3	
More than 5 servings	4	3

4. How many servings of fruit do you usually consume daily (count one serving as = one medium-sized fruit OR 1/2 cup cut-up fruit or fruit juice)?

None to 1 serving	1	
2 to 4 servings	2	
3 to 5 servings	3	
More than 5 servings	4	4

5. How many servings of whole grains do you consume daily (count one serving as = 1 slice whole grain bread, 1/2 cup cooked brown rice, 1/2 cup whole wheat pasta or about 1 cup ready-to-eat whole grain cereal)?

None	1	
1 serving	2	
2 servings	3	
3 servings	4	
More than 3 servings	5	5

6. How many cups (one cup = 1 small mug) of tea (black tea, rooibos, green tea and all other herbal teas) do you drink daily?

None	1	
One cup	2	
2 to 3 cups	3	
4 to 6 cups	4	
More than 6 cups	5	6

SECTION B - HOUSEHOLD FOOD PREPARATION DIETARY ADJUSTMENTS

		Yes	No	
7.	Are you usually involved in the preparation of food at home?	1	2	7

8. How willing would you be to consume the following proficiently-prepared foodstuffs at home:

		Extremely unlikely	Very unlikely	Unsure	Very likely	Extremely likely	
8.1	Vegetable soup in which part of the stock is replaced with rooibos herbal tea?	1	2	3	4	5	8.1
8.2	Tomato soup in which part of the stock is replaced with rooibos herbal tea?	1	2	3	4	5	8.2
8.3	Tomato soup?	1	2	3	4	5	8.3
8.4	Tomato and basil soup?	1	2	3	4	5	8.4
8.5	Roasted butternut soup?	1	2	3	4	5	8.5
8.6	Butternut and orange soup?	1	2	3	4	5	8.6
8.7	Butternut and rosemary soup?	1	2	3	4	5	8.7
8.8	Split pea and mint soup?	1	2	3	4	5	8.8
8.9	Onion soup?	1	2	3	4	5	8.9
8.10	Broccoli soup?	1	2	3	4	5	8.10
8.11	Chicken soup with parsley?	1	2	3	4	5	8.11
8.12	Sliced tomato salad with shredded basil?	1	2	3	4	5	8.12
8.13	Potato salad with mint?	1	2	3	4	5	8.13
8.14	Rocket and pear salad?	1	2	3	4	5	8.14
8.15	Green leafy salad with strawberries?	1	2	3	4	5	8.15
8.16	Carrot salad with raisins?	1	2	3	4	5	8.16
8.17	Carrot salad with raisins and parsley?	1	2	3	4	5	8.17
8.18	Carrots roasted in orange juice?	1	2	3	4	5	8.18
8.19	Chicken breast salad with apple pieces?	1	2	3	4	5	8.19
8.20	Onion quiche?	1	2	3	4	5	8.20
8.21	Roasted butternut quiche?	1	2	3	4	5	8.21
8.22	Spinach quiche?	1	2	3	4	5	8.22
8.23	Pancakes filled with cooked spinach?	1	2	3	4	5	8.23
8.24	Traditional omelette with mixed herbs?	1	2	3	4	5	8.24
8.25	Scrambled egg with parsley?	1	2	3	4	5	8.25
8.26	Risotto made with rooibos herbal tea (rice cooked to a creamy and sticky consistency)?	1	2	3	4	5	8.26
8.27	Rice with mixed herbs?	1	2	3	4	5	8.27
8.28	Spaghetti tossed in tomato pesto (paste of crushed sundried tomatoes, pine nuts and olive oil)?	1	2	3	4	5	8.28
8.29	Pasta and broccoli bake?	1	2	3	4	5	8.29
8.30	Chicken and broccoli bake?	1	2	3	4	5	8.30
8.31	Kingklip fish baked with naartjie segments?	1	2	3	4	5	8.31
8.32	Bread baked with rooibos herbal tea?	1	2	3	4	5	8.32
8.33	Bread baked with mixed herbs?	1	2	3	4	5	8.33
8.34	Boiled baby potatoes with parsley?	1	2	3	4	5	8.34
8.35	Roasted potatoes with rosemary?	1	2	3	4	5	8.35
8.36	Plum compote made with rooibos herbal tea (plums cooked in syrup)?	1	2	3	4	5	8.36
8.37	Prunes stewed in rooibos herbal tea?	1	2	3	4	5	8.37
8.38	Pears poached in rooibos herbal tea?	1	2	3	4	5	8.38
8.39	Pears poached in red grape juice?	1	2	3	4	5	8.39
8.40	Raw apple with skin?	1	2	3	4	5	8.40
8.41	Mixed berry compote (berries cooked in syrup)?	1	2	3	4	5	8.41
8.42	Crêpe (very thin pancake) with mixed berries?	1	2	3	4	5	8.42
8.43	Spanspek balls with shredded basil?	1	2	3	4	5	8.43
8.44	Chicken breast stuffed with spinach?	1	2	3	4	5	8.44
8.45	Chicken and apple casserole?	1	2	3	4	5	8.45
8.46	Roasted chicken with rosemary stuffing?	1	2	3	4	5	8.46
8.47	Meatballs cooked in tomato sauce?	1	2	3	4	5	8.47
8.48	Water infused with fresh mint?	1	2	3	4	5	8.48

9. Would you be prepared to increase your intake of:

		Not intending to change	Considering changing in the next 30 days	Committing to change in the next 30 days	In the process of implementing	Currently implemented (longer than 6 months)	
9.1	Tea (black tea, green tea, rooibos or any other herbal tea) to consume 4 to 6 cups daily?	1	2	3	4	5	9.1
9.2	Whole grains to consume at least 3 servings daily?	1	2	3	4	5	9.2
9.3	Fruit to consume at least 2 fruit servings daily?	1	2	3	4	5	9.3
9.4	Vegetables to consume at least 3 vegetable servings daily?	1	2	3	4	5	9.4
9.5	Fruit and vegetables to consume at least 5 servings of these daily?	1	2	3	4	5	9.5

SECTION C - COMMERCIAL DIETARY ADJUSTMENTS

10.

How willing would you be to purchase and consume the following products, currently available and may be available in the future:

		Extremely unlikely	Very unlikely	Unsure	Very likely	Extremely likely	
	Ready-to-eat						
10.1	Blueberry muffin?	1	2	3	4	5	10.1
10.2	Bran muffin?	1	2	3	4	5	10.2
10.3	Spinach muffin?	1	2	3	4	5	10.3
10.4	Whole wheat biscuits?	1	2	3	4	5	10.4
10.5	Whole wheat bread?	1	2	3	4	5	10.5
10.6	Bread with added rooibos herbal tea extract?	1	2	3	4	5	10.6
10.7	Bread with added onion extract?	1	2	3	4	5	10.7
10.8	Shortbread biscuits with added dried berry pulp (dried mashed solid fruit)?	1	2	3	4	5	10.8
10.9	Shortbread biscuits with added powdered orange peel and pulp (powdered peel and solid fruit parts)?	1	2	3	4	5	10.9
10.10	Shortbread biscuits with added rosemary?	1	2	3	4	5	10.10
10.11	Shortbread biscuits with added rooibos herbal tea extract?	1	2	3	4	5	10.11
10.12	Baked rice snacks with added powdered tomato pomace (powdered solid remains after juice extraction)?	1	2	3	4	5	10.12
10.13	Breakfast cereal bar made with added citrus fruit pomace (mashed solid remains after juice extraction)?	1	2	3	4	5	10.13
10.14	Breakfast cereal bran flakes with added powdered grape pomace (powdered solid remains after juice extraction)?	1	2	3	4	5	10.14
10.15	Chocolate cake baked with powdered grape pomace (powdered solid remains after juice extraction) replacing some of the flour?	1	2	3	4	5	10.15
10.16	Cheddar cheese with added green tea extract?	1	2	3	4	5	10.16
10.17	Gouda cheese with added carrot extract?	1	2	3	4	5	10.17
10.18	Cottage cheese with added onion extract?	1	2	3	4	5	10.18
10.19	Yoghurt with added green tea extract?	1	2	3	4	5	10.19
10.20	Fruit juice with added mint extract?	1	2	3	4	5	10.20
10.21	Fruit juice with added rooibos herbal tea extract?	1	2	3	4	5	10.21
10.22	Fruit juice with added powdered cereal fibre?	1	2	3	4	5	10.22
10.23	Pasta dish with added tomato paste containing powdered tomato peel?	1	2	3	4	5	10.23
	To be prepared for consumption as dish/beverage						
10.24	Herb crust pizza base?	1	2	3	4	5	10.24
10.25	Whole wheat pizza base?	1	2	3	4	5	10.25
10.26	Pasta with added powdered apple pomace (powdered solid remains after juice extraction) replacing some of the flour?	1	2	3	4	5	10.26
10.27	Pasta made with added powdered banana replacing some of the flour?	1	2	3	4	5	10.27
10.28	Pasta noodles with added onion extract?	1	2	3	4	5	10.28
10.29	Lasagne sheets with added spinach?	1	2	3	4	5	10.29
10.30	Instant coffee with added powdered hazelnut skin added to the coffee granules?	1	2	3	4	5	10.30

SECTION D - DEMOGRAPHIC CHARACTERISTICS

11. In which age category do you fall?

31-44 years	1	
45-54 years	2	
55-65 years	3	11

12. What is your gender?

Male	1	
Female	2	12

13. What is your ethnicity?

White	1	
Black	2	
Coloured	3	
Other (please specify)	4	13

14. What is your highest level of education?

Grade 12 (matric)	1	
Grade 12 + Certificate	2	
Grade 12 + Diploma	3	
Grade 12 + Degree	4	
Postgraduate (Masters/Doctorate)	5	14

15. What is your current occupation? (Consider Addendum A for the indication).

_____ 15

16. What is your marital status?

Married / living together with children	1	
Married / living together without children	2	
Single and living with children	3	
Single and living without children	4	16

17. What is your home language?

English	1	
Afrikaans	2	
Xhosa	3	
Other (please specify)	4	17

18. What is your smoking status?

Non-smoker	1	
Current smoker (Persons who smoked in the past 12 months and those who quit smoking within the past year)	2	
Former smoker (Persons who quit smoking more than a year ago)	3	18

19. What is your weekly alcohol use?

I do not consume alcohol	1	
Less than 3 times per week	2	
3 or more times per week	3	19

20. Do you take dietary supplements (Defined as a vitamin, mineral, herb, plant extract, amino acid, metabolite, constitute, or extract, or a combination of any of these ingredients)?

Never	1	
Seldom	2	
When I remember	3	
Fairly regularly	4	
Regularly	5	20

21. Are you physically active (Being physically active means regular moderate exercise [walking, cycling or gardening] or strenuous exercise [jogging, football and vigorous swimming] for 4 hours or more a week)?

Yes	1	
No	2	21

22. Have you been diagnosed with any of these chronic diseases of lifestyle?

		Yes	No	
22.1	Obesity	1	2	22.1
22.2	Diabetes mellitus	1	2	22.2
22.3	Cardiovascular disease	1	2	22.3
22.4	Cancer (excluding melanoma and skin cancer)	1	2	22.4

23. Do you have a family history of any of the following lifestyle diseases?

		Yes	No	
23.1	Obesity	1	2	23.1
23.2	Diabetes mellitus	1	2	23.2
23.3	Cardiovascular disease	1	2	23.3
23.4	Cancer (except melanoma and skin cancer)	1	2	23.4

Thank you for participating in this research survey entitled "*Dietary adjustments consumers from the professional sector in the City of Cape Town are prepared to make to enhance phytochemical intake*".
Your questionnaire is of great importance in this study.

APPENDIX F

Framework of questions (n = 48) included for the data analysis of proficient home-cooked category prepared dishes for enhanced phytochemical intake (question 8 of the questionnaire)

TABLE 1: FRAMEWORK FOR QUESTIONS (N = 48) INCLUDED IN QUESTION 8 OF THE QUESTIONNAIRE

QUESTION 8: How willing would you be to consume the following proficiently-prepared foodstuffs at home?

Phytochemical-rich dietary source adjustment category	**Food vehicle categories and specific phytochemical-rich dietary source adjustment categories**		
Rooibos (n = 7)	**Fruit (n = 3)**	**Vegetables (n = 2)**	**Other starch (n = 2)**
- Vegetable soup in which part of the stock is replaced with rooibos herbal tea (1:18)* -Tomato soup in which part of the stock is replaced with rooibos herbal tea (1:22) - Risotto made with rooibos herbal tea (1:94) - Pears poached in rooibos herbal tea (1:130) - Bread baked with rooibos herbal tea (1:160) - Prunes stewed in rooibos herbal tea - Plum compote made with rooibos herbal tea	- Prunes stewed in rooibos herbal tea (8.37)** - Plum compote made with rooibos herbal tea (8.36) - Pears poached in rooibos herbal tea (8.38) *- Pears poached in red grape juice (8.39)**** - Scrambled egg with parsley (8.25) - Traditional omelette with mixed herbs (8.24)	- Vegetable soup in which part of the stock is replaced with rooibos herbal tea (8.1) - Tomato soup in which part of the stock is replaced with rooibos herbal tea (8.2) - Chicken soup with parsley (8.11) - Roast chicken with rosemary stuffing (8.46)	- Risotto made with rooibos herbal tea (8.26) - Bread baked with rooibos herbal tea (8.32) - Bread baked with mixed herbs (8.33) - Rice with mixed herbs (8.27)
Herbs (n = 16)	**[Egg (n = 2)]**	**[Chicken (n = 2)]**	**[Other starch (n = 2)]**
- Split pea and mint soup (2:26) - Water infused with fresh mint - Chicken soup with parsley (3: 38) - Scrambled egg with parsley (4:31) - Roast potatoes with rosemary (5:80) - Boiled baby potatoes with parsley (5:94) - Potato salad with mint - Bread baked with mixed herbs	**[Vegetables (n = 5)]** - Split pea and mint soup (8.8) - Sliced tomato salad with shredded basil (8.12) -Tomato and basil soup (8.4) - Butternut and rosemary soup (8.7) - Carrot salad with raisins and parsley (8.17)	**[Potato (n = 3)]** - Boiled baby potatoes with parsley (8.34) - Potato salad with mint (8.13) - Roasted potatoes with rosemary (8.35)	**[Fruit (n = 1)]** - Spanspek balls with shredded basil (8.43) **[Other (n = 1)]** - Water infused with mint (8.48)

<table>
<tr><th>Phytochemical-rich dietary source adjustment category</th><th colspan="3">Food vehicle categories and specific phytochemical-rich dietary source adjustment categories</th></tr>
<tr><td rowspan="4">- Rice with mixed herbs

- Traditional omelette with mixed herbs

- Spanspek balls with shredded basil (6:62)

- Sliced tomato salad with shredded basil

- Tomato and basil soup

- Butternut and rosemary soup

- Roast chicken with rosemary stuffing

- Carrot salad with raisins and parsley</td><td>Mint (n = 3)****</td><td>Parsley (n = 4)</td><td>Rosemary (n = 3)</td></tr>
<tr><td>- Water infused with fresh mint (8.48)

- Potato salad with mint (8.13)

- Split pea and mint soup (8.8)</td><td>- Chicken soup with parsley (8.11)

- Boiled baby potatoes with parsley (8.34)

- Scrambled egg with parsley (8.25)

- Carrot salad with raisins and parsley (8.17)</td><td>- Roasted potatoes with rosemary (8.35)

- Roast chicken with rosemary stuffing (8.46)

- Butternut and rosemary soup (8.7)</td></tr>
<tr><td>Mixed herbs (n = 3)</td><td>Basil (n = 3)</td><td rowspan="2"></td></tr>
<tr><td>- Traditional omelette with mixed herbs (8.24)

- Bread baked with mixed herbs (8.33)

- Rice with mixed herbs (8.27)</td><td>- Spanspek balls with shredded basil (8.43)

- Sliced tomato salad with shredded basil (8.12)

-Tomato and basil soup (8.4)</td></tr>
<tr><td>Vegetables (n = 13)</td><td>[Other starch (n = 3)]</td><td>[Chicken (n = 2)</td><td>[Egg (n = 3)]</td></tr>
<tr><td rowspan="4">- Onion soup (4:42)

- Broccoli soup (4:48)

- Tomato soup (4:54)

- Roasted butternut soup

- Pasta and broccoli bake (5:18)

- Spaghetti tossed in tomato pesto (6:62)

- Onion quiche (7:10)

- Roasted butternut quiche

- Spinach quiche (7:29)

- Chicken and broccoli bake

- Chicken breast stuffed with spinach

- Pancakes filled with cooked spinach (8:24)</td><td>- Pasta and broccoli bake (8.29)

- Pancakes filled with cooked spinach (8.23)

- Spaghetti tossed in tomato pesto (8.28)</td><td>- Chicken and broccoli bake (8.30)

- Chicken breast stuffed with spinach (8.44)</td><td>- Onion quiche (8.20)

- Roasted butternut quiche (8.21)

- Spinach quiche (8.22)</td></tr>
<tr><td>[Soup (n = 4)]</td><td>[Animal source (n = 1)]</td><td rowspan="2"></td></tr>
<tr><td>- Onion soup (8.9)

- Broccoli soup (8.10)

- Roasted butternut soup (8.5)

-Tomato soup (8.3)</td><td>- Meatballs cooked in tomato sauce (8.47)</td></tr>
<tr><td>Broccoli (n = 3)</td><td>Onion (n = 2)</td><td>Tomato (n = 3)</td></tr>
<tr><td>- Broccoli soup (8.10)

- Pasta and broccoli bake (8.29)

- Chicken and broccoli bake (8.30)</td><td>- Onion quiche (8.20)

- Onion soup (8.9)</td><td>- Tomato soup (8.3)

- Meatballs cooked in tomato sauce (8.47)

- Spaghetti tossed in tomato pesto (8.28)</td></tr>
</table>

Phytochemical-rich dietary source adjustment category	**Food vehicle categories and specific phytochemical-rich dietary source adjustment categories**		
- Meatballs cooked in tomato sauce			*- Tomato soup in which part of the stock is replaced with rooibos herbal tea (8.1)* *- Tomato and basil soup (8.4)*
	Spinach (n = 3)	**Butternut (n = 2)**	
	- Spinach quiche (8.22) - Pancakes filled with cooked spinach (8.23) - Chicken breast stuffed with spinach (8.44) *- Spinach muffin (10.3)*	- Roasted butternut soup (8.5) - Roasted butternut quiche (8.21) *- Butternut and rosemary soup (8.7)*	
Fruit (n = 12)	**[Salad (n = 3)]**	**[Animal source (n = 3)]**	**[Dessert (n = 3)]**
- Green leafy salad with strawberries - Rocket and pear salad (3:9) - Crêpe with mixed berries - Mixed berry compote - Pears poached in red grape juice - Chicken breast salad with apple pieces (3:40) - Chicken and apple casserole - Raw apple with skin - Kingklip fish baked with naartjie segments - Carrot salad with raisins (5:88) - Butternut and orange soup (8:14) - Carrots roasted in orange juice	- Green leafy salad with strawberries (8.15) - Rocket and pear salad (8.14) - Carrot salad with raisins (8.16) *- Carrot salad with raisins and parsley (8.17)*	- Kingklip fish baked with naartjie segments (8.31) - Chicken and apple casserole (8.45) - Chicken breast salad with apple pieces (8.19)	- Crêpe with mixed berries (8.42) - Mixed berry compote (8.41) - Pears poached in red grape juice (8.39)
	[Other (n = 1)]	**[Vegetables (n = 2)]**	
	- Raw apple with skin (8.40)	- Carrots roasted in orange juice (8:18) - Butternut and orange soup (8:6)	
	Berries (n = 3)	**Citrus (n = 3)**	**Dried fruit (n = 1)**
	- Green leafy salad with strawberries (8.15) - Crêpe with mixed berries (8.42) - Mixed berry compote (8.41) *- Blueberry muffin (10.1)*	- Kingklip fish baked with naartjie segments (8.31) - Carrots roasted in orange juice (8:18) - Butternut and orange soup (8:6)	- Carrot salad with raisins (8.16)

Phytochemical-rich dietary source adjustment category	Food vehicle categories and specific phytochemical-rich dietary source adjustment categories		
	Pome (apples and pears) (n = 5)		
	- Pears poached in red grape juice (8.39) - Rocket and pear salad (8.14) - Raw apple with skin (8.40) - Chicken breast salad with apple pieces (8.19) - Chicken and apple casserole (8.45) *- Pears poached in rooibos herbal tea (8.38)*		

* Dishes obtained or adapted from the following references for the phytochemical-rich dietary source adjustment categories (first table column):

1. Rooibos Limited. 2009. *A touch of rooibos*. Clanwilliam: Rooibos Limited: 18, 22, 94, 130, 160.
2. Vassallo, J. 2004. *Vegetarian perfection*. Dingley: Hinkler Books: 16, 26.
3. Nelson, D. 2006. *Quick and tasty chicken*. Cape Town: Don Nelson Publishers: 9, 38, 40.
4. Price, J. 2000. *The complete vegetarian cookbook*. Sydney: Murdoch Books: 31, 42, 48, 54.
5. Fraser, L. 1995. *The essential vegetarian cookbook.* London: Anness Publishing Limited: 18, 80, 88, 94.
6. Anon. 2008. Mixed melons with feta and a lemon basil source. *Food & Home Entertaining*: 62.
7. Nelson, D. 2006. *Quick and tasty vegetarian*. Cape Town: Don Nelson Publishers: 10, 29.
8. R. Carroll. 2000. *Vegetarian delights*. Victoria: Bonza Books: 14, 24.

** Indicates question number in questionnaire for the questions used to represent the food vehicle categories and specific phytochemical-rich dietary source adjustment categories

*** Italic question indications: Additional dish obtained from another phytochemical-rich dietary source adjustment category

**** Highlighted indications: Specific phytochemical-rich dietary source adjustment categories

APPENDIX G

Framework of questions (n = 30) included for the data analysis of commercially manufactured category prepared dishes for enhanced phytochemical intake (question 10 of the questionnaire)

TABLE 1: FRAMEWORK FOR QUESTIONS (N = 30) INCLUDED IN QUESTION 10 OF THE QUESTIONNAIRE:

Question 10: How willing would you be to purchase and consume the following products, currently available and may be available in the future?

Phytochemical-rich dietary source adjustment category	**Food vehicle categories and specific phytochemical-rich dietary source adjustment categories**		
Tea (n = 5)	**Grains/bake (n = 2)**	**Dairy (n = 2)**	**Beverage (n = 1)**
- Shortbread biscuits with added rooibos herbal tea extract - Bread with added rooibos herbal tea extract (1)* - Cheddar cheese with added green tea extract (2) - Yoghurt with added green tea extract - Fruit juice with added rooibos herbal tea extract	- Shortbread biscuits with added rooibos herbal tea extract (10.11)** - Bread with added rooibos herbal tea extract (10.6)	- Cheddar cheese with added green tea extract (10.16) - Yoghurt with added green tea extract (10.19)	- Fruit juice with added rooibos herbal tea extract (10.21)
Fibre (n = 6)	**Beverages (n = 2)**	**Grains/bake (n = 3)**	**Pizza/pasta (n = 1)**
- Bran muffin - Whole wheat biscuits - Whole wheat bread - Fruit juice with added powdered cereal fibre - Whole wheat pizza base - Instant coffee with added powdered hazelnut skin added to the coffee granules (5)	- Fruit juice with added powdered cereal fibre (10.22) - Instant coffee with added powdered hazelnut skin added to the coffee granules (10.30)	- Bran muffin (10.2) - Whole wheat biscuits (10.4) - Whole wheat bread (10.5)	- Whole wheat pizza base (10.25)

Phytochemical-rich dietary source adjustment category	**Food vehicle categories and specific phytochemical-rich dietary source adjustment categories**		
Vegetables (n = 8)	**Dairy (n = 2)**	**Grains/bake (n = 3)**	**Pizza/pasta (n = 3)**
- Gouda cheese with added carrot extract - Cottage cheese with added onion extract - Pasta dish with added tomato paste containing dried powdered tomato peel (3) - Baked rice snacks with added powdered dried tomato pomace - Spinach muffin - Bread with added onion extract - Pasta noodles with added onion extract - Lasagne sheets with added spinach	- Gouda cheese with added carrot extract (10.17) - Cottage cheese with added onion extract (10.18)	- Baked rice snacks with added powdered dried tomato pomace (10.12) - Spinach muffin (10.3) - Bread with added onion extract (10.7)	- Pasta dish with added tomato paste containing dried powdered tomato peel (3) - Pasta noodles with added onion extract (10.28) - Lasagne sheets with added spinach (10.29)
Herbs (n = 3)	**Beverages (n = 1)**	**Grains/bake (n = 1)**	**Pizza/pasta (n = 1)**
- Fruit juice with added mint extract - Herb crust pizza base - Shortbread biscuits with added rosemary	- Fruit juice with added mint extract (10.20)	- Shortbread biscuits with added rosemary (10.10)	- Herb crust pizza base (10.24)

Phytochemical-rich dietary source adjustment category	**Food vehicle categories and specific phytochemical-rich dietary source adjustment categories**		
Fruit (n = 8)	**Grains/bake (n = 6)**	**Pizza/pasta (n = 2)**	
- Shortbread biscuits with added dried berry pulp - Shortbread biscuits with added powdered dried orange peel and pulp - Breakfast cereal bar with added citrus fruit pomace - Breakfast cereal bran flakes with added powdered grape pomace - Chocolate cake baked with powdered dried grape pomace replacing some of the flour - Blueberry muffin (4) - Pasta with added powdered dried apple pomace replacing some of the flour - Pasta with added powdered dried banana replacing some of the flour	- Shortbread biscuits with added dried berry pulp (10.8) - Shortbread biscuits with added powdered dried orange peel and pulp (10.9) - Breakfast cereal bar with added citrus fruit pomace (10.13) - Breakfast cereal bran flakes with added powdered grape pomace (10.14) - Chocolate cake baked with powdered dried grape pomace replacing some of the flour (10.15) - Blueberry muffin (10.1) *- Shortbread biscuits with added dried berry pulp (10.8)**** *- Shortbread biscuits with added powdered dried orange peel and pulp (10.9)*	- Pasta with added powdered dried apple pomace replacing some of the flour (10.26) - Pasta with added powdered dried banana replacing some of the flour (10.27)	

* Dishes obtained or adapted from the following references for the phytochemical-rich dietary source adjustment categories (first table column):

1. Wang, R., Zhou, W. & Isabelle, M. 2007. Comparison study of the effect of green tea extract (GTE) on the quality of bread by instrumental analysis and sensory evaluation. *Food Res Int*, 40(4): 470-479.

2. Han, J., Britten, M., St-Gelais, D., Champagne, C.P., Fustier, P., Salmieri, S. & Lacroix, M. 2011. Effect of polyphenolic ingredients on physical characteristics of cheese. *Food Res Int*, 44(1): 494-497.

3. Reboul, E., Borel, P., Mikail, C., Abou, L., Charbonnier, M., Caris-Veyrat, C., Goupy, P., Portugal, H., Lairon, D. & Amiot, M. 2005. Enrichment of tomato paste with 6% tomato peel increases lycopene and β-carotene bioavailability in men. *J Nutr*, 135(4): 790-794.

4. Rupasinghe, H.P., Wang, L., Huber, G.M. & Pitts, N.L. 2008. Effect of baking on dietary fibre and phenolics of muffins incorporated with apple skin powder. *Food Chem*, 107(3): 1217-1224.

5. Contini, M., Baccelloni, S., Frangipane, M.T., Merendino, N. & Massantini, R. 2012. Increasing espresso coffee brew antioxidant capacity using phenolic extract recovered from hazelnut skin waste. *J Funct Foods*, 4(1): 137-146.

** Indicates question number in questionnaire

*** Italic question indications: Additional dish obtained from another phytochemical-rich dietary source adjustment category