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Effect of Fluid Substitutions on the Total Antioxidant Capacity of Breads: Comparing the Indigenous Herbal Teas Rooibos and Honeybush with Black Tea

by

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Thesis submitted in fulfilment of the requirements for the degree Master of Technology: Consumer Science: Food and Nutrition

in the Faculty of Applied Sciences

at the Cape Peninsula University of Technology

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Cape Town
May 2011

DECLARATION

I, Nina Lee Septoe, declare that the contents of this dissertation/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**

ACKNOWLEDGEMENTS

I wish to thank:

- My parents, for always showing encouragement and support throughout the process.

- Irma Venter, for being not only my supervisor and an excellent guide in the subject matter but who had tremendous patience and encouragement throughout the process

- Fanie Rautenbach for assisting with experiments, as well as research.

- Professor Jeanine Marnewick, for taking the time to proof read all writings and for assistance and guidance throughout the process.

- Mariette Hattingh and Emma Longman, for all their assistance during my studies.

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SUMMARY

Oxidative stress has been implicated in the development of a number of chronic degenerative diseases. These diseases can often be prevented by dietary and lifestyle changes. One major dietary aspect is increasing the intake of plant foods, such as fruit and vegetables as they are rich in the major nutrient and non-nutrient antioxidants. The South African population does not have an adequate intake of fruit and vegetables and many barriers have been noted against increasing the intake of these foods. Other avenues should therefore be sought to increase the antioxidant intake. One such avenue is to use a basic food item consumed often as an antioxidant carrier to increase the antioxidant intake.

Much interest has developed in functional foods and their therapeutic effects as well as the use of nutraceuticals in food product development and food fortification. Tea and its polyphenols, due to the antioxidant properties, is a potentially viable option for nutraceutical and functional food use. Rooibos and honeybush herbal teas, native to South Africa, can be potential nutraceutical sources to increase antioxidant levels of food due to their unique polyphenol content.

The objective of the study was to increase the total antioxidant capacity (TAC) of a basic food item consumed regularly by most South Africans, such as brown bread through fluid manipulation using rooibos, honeybush and black teas respectively, as the replacement fluid for water in a standardised bread recipe formulation. The TAC of these experimental breads were compared to the TAC of the bread produced with no fluid manipulation (control bread) and a commercially processed bread (reference bread). The experimental breads were prepared using 2% weight per volume (w/v) and 5% (w/v) concentration levels for rooibos, honeybush and black tea respectively. To ascertain the TAC of the experimental breads, the fluorescein($_{FL}$)-based oxygen radical absorbance

capacity ($ORAC_{FL}$) method was used. The hydrophilic (H)-$ORAC_{FL}$ assay was used as the teas contain polyphenols which favour a water environment. The results indicated that the H-$ORAC_{FL}$ of the control bread using water as the fluid and the commercial reference bread was significantly different ($p < 0.05$ for each) to all the experimental bread formulations besides for the 2% (w/v) honeybush experimental bread formulation. The 2% (w/v) honeybush experimental bread formulation was therefore not considered for the consumer acceptance testing. There was no significant difference ($p > 0.05$) in the H-$ORAC_{FL}$ of the 2% (w/v) rooibos and black tea experimental bread formulations, but the H-$ORAC_{FL}$ of the 5% (w/v) black tea experimental bread formulation was significantly ($p < 0.05$) higher than that of the 5% (w/v) rooibos experimental bread formulation. This particular experimental bread formulation had a “golden-orange” colour with a pungent smell due to the increase in rooibos concentration. The 5% (w/v) black tea experimental bread formulation, however, had noted negative sensory attributes of being densely textured with a very dark colour and a pungent and overpowering taste of black tea. These sensory attributes and TAC results lead to the rooibos experimental breads containing 5% (w/v) (as bread A) and 2% (w/v) (as bread B) chosen for the consumer acceptance testing and rooibos being a proudly South African product.

The participants (n = 85) of the consumer acceptance testing participated voluntarily and were regular bread consumers. The sample was mostly female (57.6%), in the age group of 18 to 24 years (54.1%), with an education level of between three to four years post-matric/-grade 12 (71.7%) and single, living on their own without children (76.4%). They also represented a sample which had characteristics of a healthy lifestyle. Most participants perceived themselves as being of an optimal body weight (55.2%) and the majority was non-smokers (74.1%), physically active (63.5%), having no family history of chronic disease (69.4%) and not consuming dietary supplements (70.5%).

Three sensory attributes of the experimental breads were rated for the acceptance testing and included appearance/colour, flavour/taste and texture/mouthfeel. Both the experimental bread formulations was accepted favourably regarding the above-mentioned sensory attributes. The three liking acceptance categories, ‘neither like nor dislike’ (neutral response), ‘like’ and ‘like very much’ were the most commonly indicated by the participants which also resulted in the experimental breads being rated as fair, good and very good according to the development scores. Although both breads were very similarly scored, there was a trend for bread A to be rated slightly higher regarding the above-mentioned sensory attributes. The acceptance category, ‘like’/good was scored the highest for bread A according to the sensory attributes of appearance/colour (56.5%), flavour/taste (55.3%) and texture/mouthfeel (50.6%).

There was no significant association/difference ($p > 0.05$ for each) between the participants’ demographic characteristics and their overall acceptance of the experimental breads. Most of the participant biographic characteristics also had no significant ($p > 0.05$ for each) impact on the sensory attribute acceptance of the experimental breads. Although the majority (75%) of the participants consumed rooibos, there was no significant ($p > 0.05$) association/difference between the participants’ tea consumption and their acceptance of the experimental breads. Although most participants (64%) had no awareness of functional foods, most indicated willingness to purchase foods with added health benefits (93%) and to pay more for foods with added health benefits (73%).

These results indicated a general acceptance of bread with functional food characteristics and the possibility of purchasing such products with added health benefits and even at a higher price premium.

Keywords: bread, rooibos, honeybush, black tea, total antioxidant capacity, fluid manipulation, recipe formulation, antioxidants, health benefits, polyphenols

CLARIFICATION OF BASIC TERMS AND CONCEPTS

Antioxidant – A substance/compound which can hinder the reactions of free radicals such as reactive oxygen species of oxygen. Antioxidants include the vitamins C and E, certain carotenoids and bioflavonoids (Gallagher, 2004:75).

Carotenoids – Yellow or red pigments found in certain vegetables such as carrots, butternut and sweet potato, leafy vegetables and egg yolk (Gallagher, 2004:75). Carotenoids can be converted to vitamin A in the body which aids vision and gene regulation (Gallagher, 2004:77).

Flavonoids/Bioflavonoids – A subclass of phenol phytochemicals which are found in plants and act as free radical scavengers (Mathai, 04:302). A group of vitamin-like substances found in plants which demonstrate antioxidant properties (Gallagher, 2004:75).

Functional foods – Foods or components of foods which demonstrate additional properties and health benefits other than basic nutritional properties (Earl, 2004: 364).

Nutraceuticals – Food or part of a food which can provide medical or health benefits, including the prevention and /or treatment of degenerative disease (Kalra, 2003:1).

Phenolics/Phenols – Polyhydroxylated phytochemicals which protect plants from oxidative damage. Phenols include the subclass of flavonoids, which scavenge free radical compounds. Phenolic flavonoids are antioxidants which may prevent chronic lifestyle diseases, through their free radical scavenging properties (Mathai, 2004:306). Flavonoids include the group anthocyanins which give the bluish-red pigments to fruits including blueberries, grapes, cranberries and raspberries as well as the flavanols which are present in black and green tea

(Mathai, 2004:306). Isoflavones, a further phenol subclass, found in beans and other legumes, have shown health benefits including a reduced risk of heart disease by lowering cholesterol levels (Mathai, 2004:306). Isoflavones include phytoestrogens which have shown beneficial effects against the reduction in risk of prostate cancer as well as hormone-related tumors (Mathai, 2004:307).

Phytochemicals – Substances which exist naturally in plants that act as natural defence systems and have shown potential in reducing certain degenerative diseases (Mathai, 2004:303).

Total antioxidant capacity – The concept originated from chemistry and has been applied to medicine and nutrition, that examines the strategies of antioxidant defence, development of assay systems and comparison of applying *in vitro* dietary composition data to *in vivo* plasma and tissue status (Sies, 2007:1493).

CHAPTER 1
INTRODUCTION

1.1. Statement of the research problem

The development of functional foods, the extraction of compounds from medicinal plants for potential therapeutic use and the importance of antioxidant protection against the damage caused by oxidative stress is in the forefront of nutritional research. Dietary recommendations to maintain health is therefore expected to stay in the forefront due to the high incidence of chronic degenerative diseases (Rice-Evans, 2001:797). In South Africa in particular, an increasing pattern has been observed related to chronic degenerative diseases (Bradshaw *et al.,* 2003:682). Many extracted plant compounds are used therapeutically in these diseases (Rao & Rao, 2007:208). The main focus of functional food development is reducing the risk of these degenerative diseases through dietary means (Brophy & Schardt, 1999:1). It also includes utilising plant compounds in such food product development.

Research has demonstrated a strong association between food consumption and maintenance of health (Chan, 1999:79). Regarding the degenerative diseases, especially cancer and coronary heart disease, there has been a growing interest in the role food antioxidants could play in the prevention and treatment thereof. This includes the antioxidant nutrients such as vitamins C, E and beta-carotene and other antioxidant phytochemicals such as polyphenols, flavonoids and lycopene (Chan, 1999:78-79). The essential role which antioxidants play is to control free radical formation within the body (Atoui *et al.,* 2005:27). Degenerative diseases including heart disease and cancer have shown to have free radical involvement which results in oxidative stress (Wu *et al.,* 2004:418). Many studies demonstrate that an excess of free radicals through its role in oxidative stress is a major contributor to ageing and to certain degenerative diseases of ageing such as cancer, cardiovascular disease, cataracts, immune system decline and brain dysfunction (Atoui *et al.,* 2005:27).

Fruits and vegetables are believed to protect against the development of cancer and other degenerative diseases which have been related to their antioxidant properties. Many fruits and vegetables are excellent sources of vitamins A, C and E as well as minerals but they also have specific compounds with high antioxidant activity (Dufresne & Farnworth, 2001:407). Studies have shown that the South African population does not consume the recommended intake of a minimum of five servings of fruit and vegetables per day (Love & Sayed, 2001:S29), and also consume more refined grain products and not unrefined wholegrains as advised by the South African food-based dietary guidelines (FBDGs) (Vorster & Nell, 2001:S19). Currently there is an increased need to find methods to increase the antioxidant intake of the South African population to prevent the development of chronic degenerative diseases in later life. Chronic disease such as obesity, hypertension and high cholesterol are major contributors to human death in South Africa (Bradshaw *et al.,* 2003:687). Antioxidant intake can be increased through the adequate intake of fruits, vegetables (Love & Sayed, 2001:S25) and wholegrains (Vorster & Nell, 2001:S23) that requires a change in dietary behaviour to follow on consumer education if not adequately consumed or the consumption of food which is consumed on a regular basis, such as a staple food, but with added health benefits such as antioxidant addition to it. Consumption of such a staple food, if sensorically acceptable to consumers, will not require a major change in dietary behaviour.

1.2. Background of the research problem

Polyphenolic compounds, mainly flavonoids which are found in plants, are very important in the defence against oxidation (Dufresne & Farnworth, 2001:407). In the West, black tea is one of the most commonly consumed teas and are the major source of phenolic compounds, which is one of the major contributors to the beneficial effects of tea relating to its antioxidant activity and free radical scavenging ability (Alamjano *et al.*, 2008:56). Tea contains high levels of catechins and other polyphenols such as quercetin, myricetin and kaempferol (Dufresne & Farnworth, 2001:408) which has powerful antioxidant properties. These tea components can protect low-density lipoprotein (LDL) from oxidation via the regeneration of tocopherol (vitamin E), an important antioxidant (Dufresne & Farnworth, 2001:407).

As the interest in health, health consciousness and the need for longevity, feeling better and staying healthier increases so does the consumption of overall herbal tea on an annual rate of 15 to 20% (Sage Group, 2004 cited in McKay & Blumberg, 2007:11). The 2003 Gallop study, done by the Sage Group, 2004 (cited in McKay & Blumberg, 2007:11), reported that adults are making a concerted effort to increase the consumption of food and beverages high in antioxidants. An exploratory study has shown that tea and coffee, as part of beverages consumed by the South African population made the largest contribution to the total antioxidant capacity (TAC) of the South African diet followed by grains (Louwrens *et al.,* 2009:201). However, this consumption does not meet the recommended beverage consumption guidance, which includes tea as a beverage, of four to six cups per day (Popkin *et al.,* 2006:532).

Rooibos (*Aspalathus linearis*) and honeybush (*Cyclopia species*) which are both South African herbal teas, contain a complex mixture of polyphenolic compounds; rooibos containing a unique dihydrochalcone glucoside aspalathin as well as a cyclic dihydrochalcone, aspalalinin (Marnewick, 2009:279) as well as luteolin, an important flavone also found in honeybush (Marnewick *et al.*, 2000:158; Marnewick *et al.*, 2005:194; Marnewick *et al.,* 2009:221). Although having different phytochemical profiles extracts of both rooibos and honeybush herbal teas have shown to possess antioxidant and chemopreventative properties (Marnewick *et al.*, 2005:194; McKay & Blumberg, 2007:11; Marnewick *et al.,* 2009:221). Rooibos also contains other polyphenols such as flavonols, flavones and dihydrochalcones, with honeybush containing flavones and flavanones unlike green and black tea (Marnewick *et al*., 2000:164). Rooibos has become a popular health beverage which contains no harmful stimulants and no caffeine with only trace amounts of tannins (Marnewick *et al*., 2000:158). Through on going research it appears that herbal teas have the potential of becoming a valuable dietary source of natural antioxidants which counteract the damaging effects of free radicals in the body (McKay & Blumberg, 2007:1).

1.3. Research aim and objectives

The overall aim of this experimental research was to achieve an increase in the dietary antioxidant level of a staple food such as bread which is consumed by most of the South African population (Steyn *et al.,* 2003:631). The increased consumer demand for foodstuffs with added health benefits including wheat based products that have been fortified with minerals, vitamins, essential oils and natural antioxidants supports this aim (Wang *et al.,* 2007:470).

The objectives of the research were as follows: (i) to manipulate the fluid, water, commonly used in the recipe formulation of brown bread as the food vehicle, by replacing it with rooibos and honeybush, two proudly South African products, and black tea to increase the TAC of the bread through antioxidant provision. The TAC of the control bread, using water as fluid, was used as a comparison for the TAC of the experimental breads where the fluid content was replaced with rooibos, honeybush and black tea, respectively. Considering this objective, the null hypothesis for the experimental study was formulated as no significant difference between the TAC of the control bread formulation containing water as a fluid ingredient and the correspondent experimental bread formulations containing rooibos, honeybush and black tea respectively; and (ii) to determine whether bread with an increased TAC, compared to that of the control bread, was sensorically acceptable to consumers as a potential food product. As part of this objective it was also determined whether any participant characteristic (as their demographic characteristics, their biographic characteristics, their functional food awareness, their willingness to purchase foods with added health benefits and/or their tea consumption) was associated with the acceptance of a sensory attribute (as the bread colour, flavour/taste and/or texture) of the bread with an increased TAC.

CHAPTER 2
LITERATURE STUDY

Based on evidence that supports the association between diet and chronic disease development, dietary guidelines have been formulated throughout the world for the prevention of degenerative diseases such as cancer, cardiovascular disease and diabetes (Lajolo, 2002:147). One of the main recommendations of these guidelines is to increase the consumption of plant based foods (Rao & Rao, 2007:208). Plant foods are good sources of biologically active phytochemicals, plant based substances that have numerous beneficial health effects on the body (Temple, 2000:449). Various phytochemicals have been researched regarding their antioxidant activity, their ability to decrease platelet aggregation and reduction of blood pressure as well as their antibacterial and antiviral activities; and include lycopene found in tomatoes, watermelon and guava and the phenolics found in ginger and tea (green and black) (Ferrari & Torres, 2003:253). The consumption of tomato and tomato products, such as tomato sauce, juice and pasta, which contain increased levels of carotenoids have shown to decrease oxidative damage to deoxyribonucleic acid (DNA) thereby protecting the cells from mutations and cancer development. Consumer intake of tea, especially green and black tea, has also been shown to decrease total cholesterol. Green tea contains epigallocatechin gallate (EGCG) which is a strong antioxidant and has anti-inflammatory properties and antimicrobial activity (Ferrari & Torres, 2003:257).

Where only a number of guidance systems have existed towards food intake a Beverage Guidance System has been developed in the United States (US) which focuses on obtaining a fluid intake on a daily basis from beverages which have a lower energy/caloric content, but a higher nutrient content (Popkin *et al.,* 2006:229). A variety of combinations of beverages may be used to fulfill the beverage requirements, and along with the fluid volume necessary substances to the body (Popkin *et al.,* 2006:530). Due to the fact that tea contains a variety of increased levels of flavonoids and antioxidants, as well as providing the amino acid theanine, it is taken up in the Beverage Guidance System. Regular consumption of five to six cups/day could prove to be beneficial for human health (Popkin *et al.,* 2006:532).

Both the need and opportunity has arisen for the development of food and food products which can assist in addressing those conditions which have become critical health issues worldwide (Lajolo, 2002:147). Foods which have been fortified, enriched and restored as well as those foods with high bioavailability of nutrients should be made available through governmental intervention as well as through new food product technology to allow consumers easier access to these beneficial foods (Lajolo, 2002:146). Foods that present one or more beneficial functions to human health may be regarded as functional food products (Ferrari & Torres, 2003:251). Such foods include plant foods as well as beverages of grapes, red wines and beers which contain polyphenolics as phytochemicals, which have shown to inhibit LDL oxidation and in doing so reducing the risk of atherosclerosis (Ferrari & Torres, 2003:256). Governmental legislation is imperative in this process to protect the public's health and the consumer's welfare as well as stimulate technological development in advocating such functional foods (Lajolo, 2002:147).

This literature study focuses on highlighting the beneficial attributes of using plant foods to increase the TAC and the use of a commonly consumed beverage such as tea to increase the TAC of a staple food as the suitable food vehicle to increase the phytochemical intake of consumers from a young age which could be beneficial to health. The development of a suitable food vehicle for improving health has the possibility of becoming a functional food which contributes beneficial health attributes other than satisfying hunger.

2.1 Oxidative stress

Molecules or molecular fragments which contain one or more unpaired electrons are known as free radicals. The unpaired electron(s) normally gives a free radical considerable more reactivity (Valko *et al.*, 2007:47). During normal cellular metabolism, free radicals are produced and include reactive oxygen species (ROS) and reactive nitrogen species (RNS) (Radak *et al.,* 2008:153). Other metabolic activities also produce free radicals and ROS (Dufresne & Farnworth, 2001:407). ROS are to a great extent products from the aerobic metabolism. Certain organisms make use of ROS for a variety of tasks including cell signaling (Radak *et al.*, 2008:153). Free radicals and ROS are also produced naturally to assist in neutralising important pathogens, such as microbes and viruses (Dufresne & Farnworth, 2001:407). Recent theories on aging incorporates that although ROS are by-products of the aerobic metabolism when in excess they still are the main cause of cellular damage and ageing (Radak *et al.*, 2008:153).

Free radicals are found and operate at low but measurable concentrations in cells (Valko *et al.,* 2007:51). As indicated, both ROS and RNS can be harmful or beneficial to a living system as they participate in dual roles (Valko *et al.,* 2007:47). The balance between their rates of production and their rates of removal by antioxidants will determine their “steady state” of concentrations (Valko *et al.,* 2007:51). Oxygen free radicals which are created through aerobic metabolism are mostly removed by antioxidants (Sung *et al.,* 2000:527). The negative effect of ROS and RNS result when the number of highly reactive oxygen containing radicals exceeds the needs of the cell or is trapped inadequately (Dufresne & Farnworth, 2001:407). The imbalance between antioxidants and pro-oxidants such as free radicals are referred to as oxidative stress (Sung *et al.,* 2000:527). Oxidative stress occurs when ROS, including other free radicals, react with important cellular components such as genetic material, proteins or lipids, causing cell damage and in some cases even cell death.

2.2 Dietary antioxidants

The research surrounding antioxidants is an area of growing interest. Free radicals, as indicated, result from the normal metabolism within the body, but are also found in external sources such as ultraviolet light (UV), pollutants and in some cases fried foods (Williamson, 1996:7). As previously explained free radicals are harmful molecules. They are highly unstable due to the molecule having one or more unpaired electron(s) (Parnes, 2007:1). As a result free radicals will then scavenge the body for additional electrons and in doing so damage cells by modifying important cellular components such as proteins, DNA and lipids (Williamson, 1996:7). The oxidative process which occurs in the body is the equivalent of the one that causes apples to go brown, oils to become rancid and spoil due to exposure to air, light and heat and causes a chemical change which results in undesirable flavours as well as colour changes (Labensky & Hause, 2003:129). It is impossible to avoid the production of free radicals as they occur both within the body, such as through aerobic respiration, cellular metabolism and inflammation and outside the body, through environmental factors like sunlight, smoking, alcohol and pollution. The body's antioxidant system is not perfect and through the ageing process oxidative cellular damage increases and accumulates (Parnes, 2007:1).

There is a constant need to replenish the antioxidant capacity within the body as although antioxidants neutralise free radicals, antioxidants in doing so become oxidised themselves. Antioxidants work in two ways: as chain breakers or as preventative antioxidants. Chain breaking occurs when a free radical either releases or accepts an electron and a second radical is formed (Parnes, 2007:2). This molecule then continues the process with a third molecule and unstable products are continuously being generated. This process will continue until a chain breaking antioxidant stabilises the free radical. Chain breaking antioxidants include β-carotene and vitamins C and E (Parnes, 2007:2), all of which are widely available in plant foods such as sweet potato, carrots, spinach, broccoli and cabbage (Parnes, 2007:5).

Preventative antioxidants reduce the rate at which the chains begin by scavenging those free radicals which initiate the oxidation chain. The effectiveness of antioxidants in the body depends on which free radicals are involved, how and where they are generated and where the target of damage is (Parnes, 2007:2). β-carotene is the most commonly found carotenoid; however, currently lycopene is consumed in the same amounts as β-carotene. Various coloured fruit and vegetables are sources of carotenoids. Carrots, pumpkin, apricots and sweet potato are good sources of α-carotene and β-carotene, while pink grapefruit, tomatoes and watermelon are good sources of lycopene. The ability of carotenoids to act as antioxidants is based on the singlet oxygen quenching properties and the ability to trap peroxyl radicals. Of the natural carotenoids, lycopene is among the most efficient singlet oxygen quenchers (Pavia & Russel, 1999:427). Plant variety, time of harvest, ripeness and growing and storage conditions are all factors influencing the carotenoid concentrations in fruits and vegetables. The availability and absorption of carotenoids can be influenced by cooking, chopping and pureeing of vegetables as it results in smaller particle size and plant cell distributions (Pavia & Russel, 1999:428).

Antioxidants are nutrients, which include vitamins and minerals, many phytochemicals and certain enzymes which are proteins found in the body which assists with certain chemical processes in the body (Parnes, 2007:1). However, for enzymes to function an adequate intake of nutrients such as certain minerals are required. This is particularly important in the case of glutathione perioxidase, a preventative antioxidant enzyme which requires the intake of the mineral selenium (Anderson, 2004:120). In addition to the carotenoids indicated in the above phytochemicals also include the large group of polyphenols. Polyphenolic phytochemicals are found in plants where they perform various functions including providing the colour of leaves, flowers and fruit, anti-microbial and antifungal functions, protection from damage caused by solar UV radiation as well as antioxidant protection from free radicals which are generated as a result of the photosynthesis process (Stevenson & Hurst, 2007:2900). A human diet which contains significant amounts of polyphenolics, will signify their potential health benefits of being antioxidants along with other potential benefits including the regulation of cellular processes, such as inflammation (Stevenson & Hurst, 2007:2900). Polyphenolic phytochemicals when in high concentrations and in the presence of other antioxidants, such as tocopherols and ascorbic acid, provide high antioxidant ability within the plant tissues where they are found, which in turn increases the potential antioxidant effect of the food in which they are incorporated (Stevenson & Hurst, 2007:2903).

It is believed that antioxidants assist in the prevention of chronic diseases such as cancer, heart disease, stroke, Alzheimer's disease, rheumatoid arthritis and cataracts (Parnes, 2007:1). These diseases are the result of the underlying mechanism known as oxidative stress. Certain antioxidants that can decrease LDL oxidation include vitamin C, vitamin E, selenium, β-carotene and flavonoids (Krummel, 2004:876). However, further research is needed to ascertain the effect of increasing the antioxidant treatment earlier on in life to be effective in disease prevention (Kris-Etherton *et al.*, 2004:639).

The National Research Council of the US has developed dietary reference intakes (DRIs) for the antioxidant micronutrients vitamin C, vitamin E and selenium. The DRI for vitamin C in the age group 31 to 50 years is 90 milligram (mg)/day for males and 75 mg/day for females; for vitamin E in the same age group for males and females it is 15 mg/day; for selenium in the same age group for both males and females it is 55 microgram (µg)/day; and for vitamin A (the DRI can be used as a reference for beta-carotene) in the same group it is 900 ɥg/day for males and 700 ɥg/day for females (Earl, 2004:367).

2.3 Tea and herbal tea

Approximately 2.5 million metric tons of dried tea is produced annually. India, China, Sri-Lanka, Russia and Japan are the largest producing countries of tea (Wu & Wei, 2002:443).

2.3.1 General consumption and uses

Tea is the most popular consumed beverage in the world second to water (Wu & Wei, 2002:443). A summarised report on South African food consumption studies indicate the average daily per capita intakes of foods and beverages commonly consumed. The average consumption of black tea within rural areas of South Africa for the different age groups are as follows: age group one to five years old 224.7 g/person/day; age group six to nine years old 264.5 g/person/day; age group ten years and older 468.8 g/person/day. The average black tea consumption within urban areas of South Africa of the same summarised report are as follows: age group one to five years old 224.2 g/person/day; age group six to nine years old 250.0 g/person/day; age group ten years and older 441.4 g/person per day (Nel & Steyn, 2002:75-92).

Tea has recently received much attention due to its health benefits and many tea companies have conceptualised on this theory (Langley-Evans, 2001:75). Official health claims cannot be allocated to teas or herbal teas, but it can however be classified as an important part of a healthy diet (Dufresne & Farnworth, 2001:416). Health claims on food products not only assist consumers in making better informed decisions regarding food choices, but permits strong marketing incentives by food product developers to increase product differentiation based on health related positioning (Verbeke *et al.,* 2009:684). Regarding qualified health claims for green tea, in the US the Food and Drug Administration (FDA) announced that limited evidence supports the labeling of green tea as reducing the risk of prostate cancer and breast cancer (Vastag, 2006:13). Until 2003 the FDA had not released regulations for qualified health claims, which may be influenced by the lack of resources available to consider scientific evidence for petitions submitted to the agency (Vastag, 2006:14).

Tea is considered a healthy drink being a source of pharmalogically active molecules, as well as a contributor of antioxidants and a potential functional food due to its health benefits. New product development and uses are constantly emerging to increase the consumption of tea, even by those who do not currently consume tea by making it more accessible through products such as iced tea or encapsulated green tea extracts, and in doing so increasing tea's status as a functional food (Dufresne & Farnworth, 2001:416).

2.3.2. Types

For many centuries people have been brewing tea made from the leaves of the *Camellia sinensis* plant, making tea one of the most popular beverages worldwide (McKay & Blumberg, 2002:1) (Hilal & Engelhardt, 2007:414). The origins of all teas are from the same plant, *Camellia Sinensis*, and from this plant green tea, oolong tea and black tea originate (Hilal & Engelhardt, 2007:414). A white tea is produced by plucking only the bud or rather the first leaves of the plant which are dried with minimal processing. This allows the white leaf hairs to be left intact and so providing the white appearance of the tea (Hilal & Engelhardt, 2007:415). The three categories of tea include black, green and oolong with black tea accounting for 80% of the total tea intake (St-Onge, 2005:9).

2.3.2.1. Black, green, oolong and white teas

Although there are many varieties of tea (*Camellia sinensis*), they can be classified as four types, namely: green (unfermented), white (unfermented), oolong (partially fermented) and black (fermented) teas (Cheng, 2006:305).

Green tea is produced from the leaves of *Camellia sinensis*, which are rolled and steamed to minimise oxidation (Rusak *et al.,* 2008:852), and are ready for consumption as an infusion. Black tea is produced through the process of drying, maceration and fermentation of the leaves, and produces a tea with a bitter taste, which is often the reason for black tea being consumed with milk (Langley-Evans, 2001:75). Oolong tea has an appearance and taste somewhere between green and black tea that could be due to the fact it has a shorter fermentation period than black tea (Rusak *et al.,* 2008:853).

By putting green tea through the process of pan frying or steaming the tea leaves the characteristic tea catechins in green tea are preserved (Yang *et al.,* 2009:11). During the fermentation of green tea (*Camellia sinensis*) to black tea which represents the largest consumption of tea, enzymatic oxidation or fermentation occurs, which results in the polymerisation of flavanols to tannins and other compounds (Heim *et al*., 2002:573; Yang *et al.,* 2009:11). These condensed tannins, or proanthocyanidins consist of flavanol units which are relevant to the human diet; such compounds consists of (+)-catechin and (-)-epicatechin monomers which are also found in foods such as red wines, grape seeds, apples and cocoa (Heim *et al*., 2002:573).

In the processing of oolong tea, by only crushing the rim of the tea leaf, oolong tea retains the higher amounts of catechins and newly formed oligomers of catechins such as theasinensis (Yang *et al.,* 2009:11). Little research is found on white tea which is the least processed and rarest teas of all. The young tea leaves or buds which are covered with tiny, silvery hairs are only harvested once a year in early spring is used in the making of white tea. Immediately after picking, the white tea is steamed and dried to prevent oxidation which gives white tea its delicate light taste (Rusak *et al.,* 2008:853).

2.3.2.2. Rooibos and honeybush

The demand for rooibos herbal tea has been on the increase since the 1990s, when the trade sanctions against South Africa were lifted (McKay & Blumberg, 2007:2). As with many other herbal infusions used for traditional purposes, most of the health benefits and therapeutic practices of both rooibos and honeybush are based on folklore rather than scientific proof. However, more recent studies have shown the positive benefits of both these herbals linked to their phytochemical content (McKay & Blumberg, 2007:2; Marnewick *et al.*, 2000:158).

Rooibos (*Aspalathus linearis*) is a shrub-like bush native to the Cedarberg Mountains in the Western Cape region in South Africa, where it is cultivated for commercial use. During production, the leaves and stems can be bruised and fermented before drying. The unfermented plant material which is dried after harvesting remains green and is referred to as “green” rooibos. However, during fermentation the colour of the plant material changes from green to red with oxidation of the polyphenols and then referred to as “red bush tea”, “red tea”, “rooibos”, “rooibosch”, “rooitea” or “rooitee” (McKay & Blumberg, 2007:2). Due to it containing no harmful stimulants, such as caffeine, and trace amounts of tannins, rooibos has gained popularity as a health beverage (Marnewick *et al.,* 2000:158).

Honeybush (*Cyclopia species* such as *C. intermedia*) is a woody shrub, grown on the mountain slopes of the Langkloof district between the Eastern and Western Cape regions in South Africa (McKay & Blumberg, 2007:7). Although the smallest worldwide, but highest in biodiversity, the Cape Floral Kingdom accounts for 80% of the Fynbos biome which both the rooibos and honeybush species belong to (Marnewick, 2009:279). It is not widely cultivated with most of the commercially available product collected from the natural plant (McKay & Blumberg, 2007:7). Most parts of the plant is used for making the herbal infusion including the leaves, stems and flowers which are harvested to produce what is known as “heuningtee”, “bergtee”, “boertee”, “bossiestee” and “bush tea” (McKay & Blumberg, 2007:2). During production, plant material is fermented and then dried with the plant material changing colour from green to dark brown as the phenolic compounds are oxidised (McKay & Blumberg, 2007:8). An infusion made form honeybush also contains no caffeine and has low tannin content, similar properties to that of rooibos (Marnewick, 2009:279).

Rooibos and honeybush contain a variety of flavonoids and phytochemicals but each plant has its own specific type; rooibos contains flavonols, flavan-3-ols (catechins), flavones, dihydrochalcones, proanthocyanadins and phenolic acids, while honeybush contains isoflavones, coumestans, inositol and xanthones. The phenolic constituents of rooibos are unique compared to that of *Camellia sinensis* as to date, rooibos is the only source of aspalathin, a C-C linked dihydrochalcone glucoside. This unique chemical characteristic is used as a chemical marker during quality control and authentication of plant material. An additional rare compound found in rooibos is nothofagin, a 3-dehydroxy dihydrochalcone (Marnewick, 2009:279). Honeybush and rooibos also both have specific fragrances when made into an infusion. The aromatic components in honeybush are attributed to the monoterpene alcohols which are present; these monterpene alcohols provide the sweet, floral and fruity tones of the tea (Marnewick, 2009:280). Although having different phytochemical profiles, studies have shown that both rooibos and honeybush possess antioxidant properties, chemoprotective potential and immune modulating effects. One component found in honeybush, mangiferin, has shown protective effects such as reducing blood cholesterol and triglycerides in cholesterol fed mice (McKay & Blumberg, 2007:10).

2.3.3. General chemical composition

Much of the recent interest in plant polyphenols have focused on their benefits for human health, with particular interest in the polyphenols in fruits, vegetables, green tea, red wine and cocoa (Dreosti, 2000:692). The complex chemical composition of tea includes polyphenols (in particular catechins), caffeine and minerals and other unidentified compounds (Wu & Wei, 2002:443). Tea is also a good dietary source of antioxidant nutrients which includes carotenoids, tocopherols and vitamin C, besides the non-nutrient antioxidant phytochemicals known as flavonoids (Wu & Wei, 2002:443). Tea is recognised to contain increased levels of the polyphenolic flavonoids which may provide up to 45% of the daily consumption of antioxidants (Langley-Evans, 2001:75).

In fresh leaf tea and green tea the most abundant group of phenolic compounds are catechins (flavanols) (Hilal & Engelhardt, 2007:415). The polyphenol catechins include: (-)-epigallocatechin gallate, (-)-epicatechin gallate, (-)-epigallcatechin, (-)-epicatechin, (+)-gallocatechin and (+)-catechins (Wu & Wei, 2002:443). Tea is a good source of proanthocyanidins. Black tea is higher in bisflavanols compared to green tea which is higher in proanthocyanidins (Hilal & Engelhardt, 2007:415). Although certain vegetables, wine, fruit juices and chocolate contain flavonoids, it is suggested that up to 60% of intake may come from tea consumption (Langley-Evans, 2001:76). The flavour compound linalool is found in black tea as well as herbs such as coriander, lavender, sage and thyme (Dufresne & Farnworth, 2001:406).

The tannins found in black tea are the oxidised polyphenols which may aid in the defence against oxidative stress (Wu & Wei, 2002:443). These tannins do not contain tannic acid but rather beneficial catechins (Anon, 2007:1). Tannins have an inhibiting affect on the absorption of iron when included in the diet at increased levels (South & Miller, 1998:167) especially non heme iron which comes from plant sources including grains, cereals and leafy greens (Anon, 2007:1). Studies have shown that the consumption of tannin-containing beverages such as black tea with a meal can contribute to reduced iron absorption (Disler *et al.,* 1975:193). The inhibition of iron absorption can be minimised through the reduced consumption of black tea with meals and through consuming black tea either one hour prior to meal consumption or one hour post meal consumption (Anon, 2007:2).

2.3.4. Flavonoid composition of tea and other dietary sources

Flavonoids are plant pigments that are derived from phenylalanine and often display the colours of the flowering parts of plants (Yao *et al.*, 2004:113). Flavonoids form part of the single most widely found group of polyphenolic antioxidant phytochemicals, which fruit, vegetables, certain beverages and grains are rich sources of (Rice-Evans, 2001:797). The most widespread flavonoids found in the diet are catechin and quercetin which are found in many fruits and vegetables, red wine, green tea as well as chocolate (Rice-Evans, 2001:804).

The increase in research surrounding flavonoids was aided by the discovery of the French paradox, i.e. low incidence of coronary heart disease, due to among other dietary factors, the flavonoid content of red wine consumed despite an increased intake of saturated fats among the population in France (Nijveldt *et al.*, 2001:418) this is also referred to as the Mediterranean diet. Flavonoids are important for human health due to their pharmalogical properties as free radical scavengers (Yao *et al.*, 2004:113). In human health, many studies have suggested that flavonoids could have protective effects against cardiovascular diseases, cancers and other age-related diseases (Yao *et al.*, 2004:113).

2.3.4.1. Chemical structure and classes of flavonoids

Flavonoids form part of a broad class of low molecular weight, secondary plant phenolics which are characterised by the flavan nucleus (Heim *et al.*, 2002:572). The flavonoid nucleus consists of three phenolic rings referred to as the A, B and C rings (Aisling Aherne & O'Brien, 2002:75). There are many aspects which influence the chemical nature of flavonoids such as their structural class, degree of hydroxylation, other substitutions and conjugations and degree of polymerisation (Yao *et al.*, 2004:113). Flavonoids are classed depending on the oxidation level of the central C-ring (Rice-Evans, 2001:797). Dietary flavonoids also differ in arrangements of the hydroxyl, methoxy and glycosidic side groups and in the conjugation of the A- and B- rings. In foods, flavonoids mainly exist as 3-*O*-glycosides and polymers. There are several structures which exist and polymers form a substantial fraction of dietary flavonoid intake (Heim *et al.*, 2002:573). The majority of flavonoids are glycosylated in their natural dietary forms with the exception of the catechins (Rice-Evans, 2001:797).

Flavonoids are classified into a number of chemical classes such as flavonones, flavones, isoflavonoids, flavans (flavanols), anthocyanins and flavonols which are all commonly found in the diet (Yao *et al.*, 2004:115). The most common flavonoid class found in foods is the flavonols, with quercetin, kaempferol and myricetin being the most common compounds (Yao *et al.*, 2004:116).

2.3.4.2. Tea as a major dietary flavonoid source

Tea is one of the best sources of the flavonoid catechins with epigallocatechin gallate (EGCG) being the major catechin in tea. Besides EGCG tea also contains gallocatechin (GC), epigallocatechin (EGC) and epicatechin gallate (ECG). It also contains catechin and epicatechin (EC) making green tea a beverage with the highest level of phenolic compounds amongst foods (Yao *et al.*, 2004:116). Catechins are colourless, water soluble compounds which impart the bitterness and astringency to green tea infusions. Most of the characteristics associated with manufactured tea are directly or indirectly linked with the modifications which occur in the catechins (Wang *et al.*, 2000:152). However, catechins and EC are also found in chocolate, black grapes, red wine and apples. The most important flavonols in tea include quercetin, kaempferol and rutin, while the main phenolic acids in tea are caffeic, quinic and gallic acids (Dufresne & Farnworth, 2007:405).

Studies have shown that green tea produces the highest level of antioxidant activity with that of black tea being lower. Catechins are the main flavonoids in green tea whereas in the production of black tea, a large part of the catechins are polymerised into theaflavins and thearubigens which give the characteristic properties and taste of black tea (Cheng, 2006:304).

2.3.4.3. Other dietary flavonoid sources

The Mediterranean diet has been associated with many health positives especially those relating to the high content of antioxidant phytochemicals, which is due to the higher intake of vegetables and fruit (Vasilopoulou, 2005:33). Current research has shown that an increase in vegetables and fruits is recommended to improve health (Chu *et al.,* 2000:563). The traditional Greek diet includes a serving of wild greens, which are collected from the lands throughout Greece; these wild greens contain both the flavonols quercetin and kaempferol, both important antioxidants (Vasilopoulou, 2005:34). The greens are central to the traditional Greek diet and are prepared using virgin olive oil. Since research has shown the significance of consuming such plants this may contribute to the apparent health promoting effects of the Mediterranean diet (Vasilopoulou, 2005:35).

One particular group of vegetables, the *Cruciferae* family, has been shown to be rich sources of carbohydrates, vitamin C and polyphenols (Chun *et al.,* 2004:192). In a study of men aged 40 to 60 years, which investigated the relationship between vegetable and fruit consumption with prostate cancer (Cohen *et al.,* 2000:61), the primary findings demonstrated the protective effects of both total and cruciferous vegetable intake (Cohen *et al.,* 2000:63). Two independent studies (Chun *et al.,* 2004:195; Karadeniz *et al.,* 2005:302) both demonstrated that red cabbage has the highest phenolic content. Other vegetables with high antioxidant activity included red radish, spring onion, potato and onion (Karadeniz *et al.,* 2005:302). Certain parts of vegetables such as that of the purple and green leaves of sweet potatoes and the outer leaves, such as in the first and second layers of onions, contain high localised levels of quercetin (Chu *et al.,* 2000:563).

Phenolic compounds contribute to the antioxidant activity of certain fruits, such as quince, pear, apple and grape (Karadeniz *et al.,* 2005:299). The average flavonoid content of fruits in descending order are quince, grape, apple, pomegranate and pear (Karadeniz *et al.,* 2005:301). Pomegranate, although having a lower level of total phenolics, has the highest antioxidant activity, which may be due to pomegranates having increased levels of anthocyanins (Karadeniz *et al.,* 2005:300). Flavonones, flavones and flavanols are found in citrus fruits (Yao *et al.,* 2004:116). Strawberries and other berries have high levels of anthocyanins and isoflavonoids are found exclusively in soy foods (Yao *et al.,* 2004:115). Catechins are mostly found in red wine (Yao *et al.,* 2004:116).

2.3.5. Health promoting benefits of flavonoids through tea consumption

Tea is considered one of the richest sources of flavonoid content and is as a result high in antioxidants, along with other beneficial compounds. It is also a beverage which is considered safe, as it is brewed from boiled water thus providing a safe drink for those people who do not have access to safe water. Tea is inexpensive, does not cause intoxication and is available to all social classes in all countries (Trevisanato & Kim, 2000:1). The antioxidant flavonoids of tea appear to be absorbed by the human gastrointestinal tract (Sharma *et al.,* 2007:787). The antioxidant capacity of tea is attributed to the flavonoid components which include theaflavins, bisflavanols and theaflavic acids. When these components are consumed they have the ability to act as free radical scavengers (Sharma *et al.,* 2007:787). Several studies have shown that the polyphenolic components present in tea may reduce the risk of some degenerative diseases (Almajano *et al.,* 2008:56). The protective effects of flavonoids in life systems are linked to their capacity and ability to transfer the electrons of free radicals, chelate metal ions, activate antioxidant enzymes, reduce alpha-tocopherol radicals and inhibit oxidases (Heim *et al.*, 2002:573). Flavonoids can therefore prevent the damage caused by free radicals in a number of ways, including direct scavenging of free radicals. The flavonoid is oxidised by the radical with a resultant more stable, less reactive radical (Nijveldt *et al.,* 2001:419). The most beneficial health property of flavonoids are attributed to their antioxidant and chelating abilities, as well as their ability to inhibit LDL oxidation and so demonstrating cardioprotective effects (Heim *et al.*, 2002:572). As mentioned about 60% of flavonoids within the diet are attributed to the consumption of tea making it an important source of dietary flavonoids (Trevisanato & Kim, 2000:2).

The beneficial effects of tea can be divided into two sections; the major effects including those affecting cardiovascular disease and cancer and the minor including those affecting dental caries, kidney stones, diarrhea and immune functions (Trevisanato & Kim, 2000:2). The dietary habits of people directly influence the risk of developing certain degenerative diseases, including cardiovascular disease and cancer. This link between dietary habits and disease allows for the use of dietary substances to be encouraged as a practical approach to reduce certain disease (Mukhtar & Ahmed, 2000:S1701). Commonly consumed foods have non-nutritive components which may provide protection against these diseases (Mukhtar & Ahmed, 2000:S1698).

There are many flavonoids, including quercetin, which results in a decrease in ischemia-reperfusion injury by interfering with the nitric-oxide synthase activity. Nitric oxide is produced by various cells, including endothelial cells and macrophages, which reacts with free radicals and produces a highly damaging substance, peroxynitrate. When flavonoids are used as antioxidants, they scavenge the free radicals so the free radicals can no longer react with nitric oxide and in doing so it reduces the damage caused by nitric oxide. The cause of oxidative injury to tissues, especially after ischemia-reperfusion has been linked to the xanthine oxidase pathway. This pathway produces oxygen free radicals and two flavonoids, quercetin and silibinin, can hinder xanthine oxidase with a resultant reduced cellular oxidative damage (Nijveldt *et al.*, 2001:419).

There are flavonoids which chelates iron, removing a causal factor for the development of free radicals. One such flavonoid is quercetin which is particularly known for its iron-chelating and iron-stabilizing properties. Flavonoids also have an effect on enzyme systems through the inhibition of the metabolism of arachidonic acid, the starting point for the general inflammatory response, which provides flavonoids its anti-inflammatory and antithrombogenic properties (Nijveldt *et al.*, 2001:420).

2.3.5.1. Cardiovascular disease

Studies by research groups have provided information regarding the success of the risk of reduction of certain degenerative diseases, such as coronary heart disease, through the consumption of flavonoids (Langley-Evans, 2001:76). The risk of atherosclerosis and coronary heart disease may be decreased through habitual intake of flavonoids, such as tea (Yao *et al.*, 2004:118). Stensvold *et al.* (1992:551) suggested that the consumption of one or more cups of black tea per day could reduce the risk of heart disease death by 36%. In a study in Saudi Arabia whereby the prevalence of coronary heart disease and tea consumption was investigated, results showed the potential protective effect of tea in relation to coronary heart disease. The tea consumed in this study was black tea. The study sample included a total of 3 430 men and women aged between 30 to 70 years. Those subjects who drank more than six cups of tea per day (> 480ml) showed a significantly lower risk of coronary heart disease (Hakim *et al.,* 2003:64). The results of a case-control study by Sesso and colleagues (1999), whereby the relationship between tea and coffee consumption and myocardial infarction was examined, indicated that those who consumed more than a cup of tea per day had a 44% reduced risk of cardiovascular disease.

Cardiovascular disease is dependent on a number of factors which can be influenced by various components of the diet. In the initial stages of the disease when protectors such as tocopherols are depleted, LDL deposits at lesion sites within the arterial walls. As the disease progresses lipid-laden foam cells and atherosclerotic plaques are formed as LDL is subjected to oxidation and causes lipoprotein modifications, which stimulates inflammatory reactions and causes monocytes and monocyte-derived macrophages to accumulate as oxidised LDL (Khan & Mukhtar, 2007:527). Tea flavonoids have the beneficial effects of being antioxidative and anti-inflammatory, as well as having lipid-lowering properties. Arterial compliance and endothelial function also show improvement through the intake of green tea (Khan & Mukhtar, 2007:527). Through the consumption of tea itself and the ingredients of tea such as EGCG, polyphenols and catechins, cholesterol metabolism and cholesterol related events leading to cardiovascular disease can be reduced (Khan & Mukhtar, 2007:528).

2.3.5.2. Cancer

Research has shown that the health related properties of tea include antioxidant as well as antimicrobial effects (Almajano *et al.*, 2008:56). Due to tea containing antioxidants and being effective at protecting cells from free radical damage, it raises the possibility that tea consumption may reduce the incidence of cancer in humans (Wang *et al.*, 2000:154). Flavonoid antioxidants, which have been suggested to play a role in the prevention of certain cancers, are found in tea (Yao *et al.*, 2004:119). These polyphenols are the most important constituents of tea. Green tea is rich in catechins with EGCG being the most abundant (Almajano *et al.*, 2008:560). One third of the dry weight of tea is catechins and other polyphenols such as quercetin, myricetin and kaempferol, which have also been shown to demonstrate very high antioxidant properties (Dufresne & Farnworth, 2001:408). Research has suggested that the polyphenolic compound EGCG, found in green tea, and theaflavin-3,3'-digallate, found in black tea, are two of the most effective anti-cancer factors found in tea, which explains the increased interest in the health benefits of tea (Khan & Mukhtar, 2007:520). The polyphenols found in tea have the ability to decrease the risk factor of specific cancers by inducing phase I and phase II metabolic enzymes which increase the formation and excretion of detoxified metabolites of carcinogens (Sharma *et al.,* 2007:789).

Green tea, which contains high levels of polyphenols, have been shown to have chemopreventative effects against tumor initiation as well as protecting against cancer through cell cycle arrest, including apoptosis (cell suicide) (Yao *et al.*, 2004:119). Promising implications for humans have been shown through studies on mice on the effects of green and black teas in the development of lung cancers (Dufresne & Farnworth, 2001:408). Through the oral administration of tea infusions (green tea, black tea, green tea polyphenols, EGCG and theaflavins) studies on mice models show the reduction in the progression of lung adenomas as well as the inhibition of spontaneous formation of lung tumours (Yang *et al.,* 2009:430). The oral administration of green tea polyphenols to SKH-1 mice has shown a reduction in UVB-induced skin tumour incidence, tumour multiplicity and tumour growth (Khan & Mukhtar, 2007:524). Other studies using oral administration of green tea, black tea or EGCG have shown to inhibit the growth of well established skin tumours as well as tumour regression (Khan & Mukhtar, 2007:524). Animal models have also been used to study the relationship between tea consumption and digestive tract cancers (Dufresne & Farnworth, 2001:408).

Many studies have been conducted on laboratory animals, but only recently on humans regarding the protective effects of tea against cancer. Oolong and black teas, which also contain high levels of polyphenols have also shown strong inhibitory effects in human cancer cells (Yao *et al.*, 2004:119). Through the consumption of green tea, the decreased risk for the development of stomach and oesophageal cancer in both alcoholics and cigarette smokers was seen in a case control study conducted in Taixing. Similarly in Jiangsu, China the consumption of green tea showed a reduction in the development of oesophageal and gastric cancer (Khan & Mukhtar, 2007:526). In the development and the progression of tumors, the immune cells play a very important role in host defence, but their plasma membranes are high in polyunsaturated fatty acids and are vulnerable to oxidation by ROS (Khan & Mukhtar, 2007:526).

2.3.5.3. Dental health

Oral diseases including dental caries, periodontal disease and tooth loss may impact an individual's overall health status (Wu & Wei, 2004:443). Research has suggested that the consumption of tea may reduce dental caries in humans (Wu & Wei, 2004:443). Polyphenols found in oolong tea extract have shown to have antibacterial properties against oral pathogens which are closely associated with dental caries such as *Streptococcus mutans* (Linke & LeGeros, 2003:89). Green tea polyphenols have been reported to have an inhibitory effect on the growth of *Porphyromonas gingivalis,* an oral bacterium causing periodontal disease (Linke & LeGeros, 2003:92). The anti-caries effect of green tea is primarily due to its antibacterial properties of the component polyphenols and tannins rather than the fact that it contains varying amounts of fluoride (Linke & LeGeros, 2003:90). It has also been found that black tea and its polyphenols can inhibit growth and acid production of dental plaque bacteria (Wu & Wei, 2004:443).

2.3.5.4. Obesity

A combination of psychological, environmental and cultural influences as well as physiological regulatory factors cause the complex condition known as obesity (Laquatra, 2004:566). A sedentary lifestyle, such as watching television, has been linked as a major factor for obesity along with poor dietary habits in children. The consumption of "junk" foods will have a strong influence on the potential development of obesity in later life (Ferrari, 2007:332).

Much publicity has been given to the health benefits and weight benefits of tea consumption. Emerging results from studies show that through a regular intake of green tea may increase energy expenditure (EE) and decrease body fatness, showing the beneficial effects of green tea consumption on body weight and composition (Hodgson & Croft, 2010:499). Through the ingestion of oolong, black and green tea leaves by rats their body weight (and plasma triglyceride, cholesterol and LDL-cholesterol levels) were also significantly reduced (Khan & Mukhtar, 2007:528). Studies on animals have shown positive results in weight reduction through tea consumption. Tea catechin supplementation of a high-fat diet reduced body weight gain, visceral and liver fat accumulation in C57BL/6J mice. Similarly EGCG supplementation purified from green tea showed to reduce or prevent an increase in body weight in lean and obese male and female Zucker rats (Khan & Mukhtar, 2007:528).

In an additional study investigating the effects of green tea on weight loss, in which 70 overweight subjects participated using a timeframe of three months, the results showed that body weight decreased by 4.6% and waist circumference by 4.5%. These results were significant as the study had an open uncontrolled design (Westerterp-Plantenga *et al*., 2006:88). A short term human study in Japan have demonstrated a substantial increase in 24-hour EE and in fat oxidation, subjects consumed EGCG plus caffeine (90 mg/50 mg) three times a day on three separate occasions. The results were confirmed through determining 24-hour EE by using respiratory chambers and the subjects consuming different dosages of green tea (Westerterp-Plantenga *et al*., 2006:88). Some studies have shown that green tea has thermogenic properties, promoting fat oxidation and playing a role in the control of body composition which can reduce obesity (Dufresne & Farnworth, 2001:413). Studies have demonstrated that through long term consumption of green tea the incidence of obesity may be decreased as well as the components such as EGCG in green tea may be used in the treatment of obesity (Khan & Mukhtar, 2007:528).

2.3.5.5. Other

Certain tea catechins such as EGCG have also shown to have antidiabetic effects (Khan & Mukhtar, 2007:528). Green tea reduced blood glucose levels in rats by suppressing the activity of glucose transporters in the intestinal epithelium and as a result it is believed to reduce dietary glucose uptake (Dufresne & Farnworth, 2001:414). African black tea has shown to have a suppressive effect on the elevation of blood glucose as well as body weight gain in KK-A(y)TaJc1 diabetic mice (Khan & Mukhtar, 2007:528). Babu *et al.* (2008:283), in a study on diabetic rats showed that green tea significantly reduced elevated blood glucose levels.

Green tea has also shown to have a beneficial effect on viral infections. It is reported that many flavonoids such as EGCG and ECG, can inhibit retrovirus human immunodeficiency virus (HIV) by inhibiting reverse transcriptase, an enzyme which allows the establishment of the virus in host cells (Dufresne & Farnworth, 2001:415). The consumption of tea was shown an independent factor in protecting against the risk of hip fractures in both males and females, during the Mediterranean Osteoporosis Study (Suzuki *et al.,* 1997:462). Reports have shown that tea consumption can improve neurologic and psychologic functions. In a rat model, EGCG reduced focal ischemia/reperfusion-induced brain injury (Khan & Mukhtar, 2007:529).

2.4. Functional foods

Healthy eating, a means of health promotion, is one of the most important actions and should be promoted not only through political programs or strategies, but also in public discussion (Niva, 2007:384). Although eating healthy involves basic principles, eating healthy is an intricate issue. Not only is food nutrition, or fuel for the body, but is deep rooted in culture and societies in which individuals live in. Since eating is so closely linked to cultural practices, it is often found that individuals consume the food which they do not necessarily choose (Niva, 2007:385). Lifestyle factors as well as hereditary, cultural and social conditions and correct eating habits are all interlinked in making a difference to an individual's health status (Niva, 2007:390). Studies have suggested that individuals interpret new information about food and health within the context of personal knowledge, cultural practices and everyday life (Niva, 2007:386).

Cultural beliefs regarding the spiritual and even magical properties of food have been handed down through many generations. A variety of historical documents have recorded the ability of certain foods to prevent or reduce health symptoms, now recognised as nutritional inadequacies.

2.4.1 Explanation of and legislation on functional foods

Incorrect and poor eating habits are often viewed as a major cause contributing to disease and are often associated with additional medical care and costs. In America, dietary factors are viewed as contributing to the leading cause of death, including coronary heart disease and certain types of cancers. As the world's population increases with age, so does the concern regarding how best to reduce the risk of death and/or disability from a number of degenerative diseases (Milner, 2000:1655); one such approach may be to consider the inclusion of functional foods into the diet.

Functional foods are the same as conventional foods in appearance, yet they have health benefits which extend further than satisfying hunger (St-Onge, 2005:7); for example, the consumption of tomatoes provides the beneficial antioxidant lycopene. Conventional foods which are considered to be healthy are usually those foods which are marketed to the consumer as contributing to a healthy diet for example low-fat products or high fiber products; however, the role of any single product is not emphasized, rather the product in its entirety has a beneficial effect in the diet (Ürala & Lähteenmäki, 2004:793). When marketing functional foods, particular components are highlighted as being directly connected with physiological effects and the health benefit of food is linked to a single product. A negative view from consumers who highly value naturalness of food is that functional foods are less natural than conventional foods. This could result from the viewpoint that during manufacturing constituents are often added, removed or modified and the development of these functional foods often require modern food technology. However, functional foods do not differ from conventional foods in sensory characteristics (Ürala & Lähteenmäki, 2004:793).

During the production of functional foods four different approaches are usually used: i) the elimination or removal of a component which may have a detrimental effect on the consumer's health; ii) the "increase" in concentration of a component which is naturally found in the food, for beneficial effects; iii) the addition of components to a food product which is not found naturally in the food product for beneficial effects; and iv) the "replacement" of a component often a macronutrient, the intake which is often in excess, by another component which has shown to have beneficial effects (Kwak & Jukes, 2001:116). Functional foods, in contrast to dietary supplements, are those foods which are part of the normal diet and may have special disease prevention attributes (Halsted, 2003:1003). Dietary supplements are considered foods as they are edible and are not classified as drugs; however they are not regarded as conventional food or as a sole item of a meal or a diet (Kwak & Jukes, 2001:114).

Recently much interest and focus has been placed on the potential role of functional foods and nutraceuticals (Henson *et al.*, 2008:395). Nutraceuticals can be described as any food or parts of a food which provide medical health benefits which includes the prevention and/or treatment of disease. Products included are dietary supplements, genetically engineered "designer" foods, functional foods, herbal products and processed foods for example cereals, soups and beverages. The main difference between a nutraceutial and functional food is that a nutraceutical includes other types of foods; functional foods come in the form of ordinary foods (Kwak & Jukes, 2001:115). A nutraceutical has among others been defined as “a diet supplement that delivers a concentrated form of a biologically active component of food in a non-food matrix to enhance health”; however the United States Food and Drug Administration (FDA) does not recognise the term nutraceutical (Halsted, 2003:1001).

Diet does not only meet nutritional needs but also modulates various functions in the body and may play a beneficial role in the prevention of some diseases. As nutrition has developed over the years, health authorities in some countries, especially Japan and the US justified research in the physiological effects and health benefits of foods and food components. Research on functional foods began in the early 1980’s in Japan when 86 research programs on “systematic analysis and development of food functions” were funded (Roberfroid, 2000:1660S).

Japanese scientists first promoted the concept of functional foods in 1984 when the relationship between nutrition, sensory satisfaction, fortification and the modulation of physiological systems was studied (Siró, 2008:457). Further research led to the establishment in 1991 of Labeling Regulations for Foods for Specified Health Use (FOSHU) (Roberfroid, 2000:1660S). Foods are divided into one of four categories as described in Japan’s Nutrition Improvement Law as “foods for special dietary use”; these include foods which are used to improve an individual’s health and for which claims for specific health effects are allowed (Roberfroid, 2000:1660S). FOSHU includes foods for the ill, milk powder for pregnant or lactating women, formulated milk powder for infants and foods for the aged. FOSHU is the only system, through which government permission for health claims pertaining to food is granted in Japan. FOSHUs can be defined as “foods in the case of which specified effects contributing to maintain health can be expected based on available data concerning the relationship between foods/food's contents and health" (Arai *et al.*, 2001:9). In the European Union (EU) the term "foods for particular nutritional uses" (PARNUTS) is used instead of FOSHU (Kwak & Jules, 2001:110).

Due to the development of new foods, it may be necessary to review the current food regulatory system. At present, options are being considered by the Codex Alimentarius Commission and within various countries, especially in terms of the associated health claims (Kwak & Jules, 2001:109). A health claim as described by the US FDA explains the relationship between the reduction in risk of a disease or health related condition and a food, food component or dietary supplement ingredient (Heller, 2008a:1). Through mandated assessment the FDA considers whether there is "significant scientific agreement" (SSA) amongst qualified experts whether the relationship between diet and disease is supported by publicised scientific evidence, which leads the FDA to the consideration of a qualified health claim that is supported by credible but not yet conclusive evidence (Rowlands & Hoadley, 2006:36). The two major health claims which food and supplements carry and are authorised health claims, are firstly based on significant scientific agreements which demonstrate the relationship between the nutrient and disease, and secondly qualified health claims that include those claims based on emerging research and evidence to show the relationship between food and the reduction in risk of disease (Heller, 2008a:1). Many factors are considered by the US FDA when evaluating health claim use. A few include whether the claims are significant, the vulnerability of the user group, the potential number of users which could be affected and the economic impact of product cost or the amount that could be potentially sold (Heller, 2008b:1). Another category of food which must be noted are those foods which are considered medical foods; these include specific foods which are formulated to be consumed or administered under medical supervision and are intended for specific dietary management of disease or a condition for which specific nutrition is needed (Kwak & Jules, 2001:111).

In the United Kingdom (UK) the growing need for transparency on health claims led to the development of the Joint Health Claims Initiative (JHCI) which was encouraged by not only the consumers but the food industry as well (Ruffell, 2003:125). The JHCI requires that for the acceptability of a health claim, the claim does not just involve a scientifically proven link to a product, the product must deliver the health benefit which it claims to as to prevent consumers being misled as well as to comply with the UK food safety legislation (Ruffell, 2003:126). According to the JHCI health claims should be allowed if the claim has been substantiated by strong scientific principles, follow sound nutritional principles and does not mislead consumers, and that claims should be made and considered as part of the whole diet (Ruffell, 2003:128).

In Japan, in 2001, new legislation was introduced and includes “foods with health claims” (FHC) and “foods with nutrient claims” (FNFC) which allowed for certain health benefits to be included in food labels (Ohama *et al.,* 2006:95). The spectrum for the claims are limited to the contents including (i) indicating benefits for the maintenance or improving a healthy condition that is clearly visible or observed; (ii) by indicating that the food will maintain or improve a healthy physical condition or tissue functioning; (iii) according to the subjects symptoms, the food product may alleviate and improve a physical condition, provided it does not provide long-term effects (Ohama *et al.,* 2006:101).

South African legislation on functional foods is currently being finalised for regulatory control with legislation on a number of allowable reduction of disease risk claims incorporated within the Foodstuffs, Cosmetics and Disinfectant Act, 1972 (Act 54 of 1972). Regulations on nutrient content claims as well as comparative health claims is in addition also well described in the above-mentioned act for regulatory control (South Africa Department of Health, 2010:33-40).

2.4.2. Examples of functional foods

The growth of functional foods have been significantly influenced by what is known as the growing ”self care” movement whereby consumers are taking charge of their own health (Hasler, 2000:500). The self-care movement has evolved from 1994 when one of the leading trends in food industry was the tendency for the consumer to view “the kitchen cabinet as the medicine cabinet” (Hasler, 2002:3775). Consumers have come to realise that not only will lifespan be improved through dietary changes but one can increase one’s healthspan as well (Hasler, 2000:502). The consumption of a varied diet containing safe and healthy foods with a pleasant mouthfeel is the goal for most consumers (Jiménez-Colmenero *et al.*, 2001:5).

2.4.2.1. Unmodified functional and potential functional foods

The rise in interest of functional foods is mainly due to much of the literature showing the health benefits of increased fruit and vegetable consumption (Milner, 2000:1395). A variety of foods have been recognised for their potential functional foods benefits, with research on plant-based foods showing much potential, such as for cranberries, garlic, nuts, grapes and chocolate (Hasler, 2002:3775).

2.4.2.1.1. Fruit and vegetables

A New Zealand survey in 2002 into the food consumed by early Maori settlers found that many of these foods consumed contained high levels of flavonoids, anthocyanins and antioxidants (Cambie & Ferguson, 2003:110). Shoots and leaves from various plants consumed were found to have a high vitamin C content, containing various phenolics as well as antioxidant flavonoids (Cambie & Ferguson, 2003:109). Some of the foods consumed could be considered functional foods and could be related to the decreased incidence of diabetes, cancer and vascular-related diseases in the Maoris. These include many fruits and vegetables particularly the so-called “Maori potato”, officially known as Ureniki. This starch can be characterised by small tubers with purple skin and flesh, the colour due to the content of anthocyanins (Cambie & Ferguson, 2003:110). It was also found that the leaves of the “hens and chickens fern” (*Asplenium bulbiferum*) contain flavonoids such as kaempferol glucosides. These leaves were consumed as greens (Cambie & Ferguson, 2003:114).

Certain botanicals especially the cranberry (*Vaccinium macrocarpon*) are considered to have urinary antiseptic and anti-adhesion properties and show the potential in treating urinary tract infections (Yarnell, 2002:285 & 289). More recent studies have shown the condensed tannins in cranberries, proanthocyanidins, to be the biologically active component in preventing the production of *E. coli* (Hasler, 2002:3775). In the late 1970s research in France showed that avid drinkers of red wine had considerably less heart disease albeit a high level of fat consumed in their diet (Hasler, 2002:3776). Further research on this subject showed that red grape skins contain high concentrations of antioxidant polyphenolics and moderate consumption of red wine has shown to reduce the risk of heart disease in some populations (Hasler, 2002:3776). The most significant source of lycopene, which is a non-provitamin A carotenoid and also an antioxidant, has been found to be tomatoes and tomato products (Sesso *et al.,* 2003:2336). Further research is being done in the area regarding tomatoes and tomato products and their role in cancer chemoprevention (Hasler, 2002:3776).

2.4.2.1.2. Herbs and spices

The Chinese have always integrated food, nutrition and health and have often included herbs and spices in various prepared dishes and beverages for both satiety and the support of health (Tapsell *et al.*, 2006:5S). The term *herbs* as used for medicinal purposes refers to not only the herbaceous part but to the bark, roots, leaves, seeds, flowers and fruits, shrubs, wood vines and the extracts which are valued for the savoury, aromatic and medicinal qualities they possess, whereas *herbs* as the botanical term only refers to the seed producing plants (Craig, 1999:491S). The fact that herbs and spices have such a long history in medical care could implicate them to be considered the first functional foods (Tapsell *et al.*, 2006:5S). For many years garlic has been used for medicinal purposes including its ability to reduce blood pressure and blood cholesterol (Hasler, 2002:3775).

Investigating the use of herbs and spices in the diet may well lead to investigating how they could be regarded as a functional food (Tapsell *et al.*, 2006:6S). Herbs may have the potential to protect against oxidative stress and inflammation. Certain phytochemicals from herbs or herb extracts have shown to inhibit certain stages of cancer (Tapsell *et al.*, 2006:9S). Many herbs and spices are used to flavour foods and drinks without additional calories; it would be validated to consider them as functional agents that could assist in preventing obesity. Examples of such spices used in the latter include capsaicin, black pepper, ginger and herbs which include black and green tea (Westerterp-Plantenga *et al.*, 2006:85).

Herbs used for culinary purposes are grown and used for flavouring of food; the flavour comes from the herbs aromatic components which are the essential oils and olearesins of the plants. Some herbs such as saffron, turmeric and paprika are used for colouring food as well (Craig, 1999:492). The addition of herbs and spices in food preparation may increase the consumption of fruit and vegetables as more flavour and interest is added to meals and so consuming more of a variety of foods; for example the antioxidant capacity of salad dressings may even be increased by adding herbs and spices (Tapsell *et al.*, 2006:19S). Herbs and spices are rich sources of polyphenols and just a few grams of a herb or spice added to food may increase the TAC of a meal. It has as a result already been proposed that specific reference should be made to herbs and spices in dietary guidelines (Tapsell, 2008:132).

2.4.2.2. Modified functional and potential functional foods

As the food industry product selection grows and increases in choice, product development has led to the inclusion of functional ingredients due to consumer demands for healthier foods (Charalampopolous *et al.*, 2002:131). Functional food development has progressed in many areas within the food industry such as dairy, spreads, cereals etc (Siró *et al.,* 2008:461).

2.4.2.2.1. Cereal and bakery products

Cereals have been investigated as potential use for developing functional foods. Cereals provide over 60% of the world food production which provides energy, dietary fibre, minerals and vitamins needed for health (Charalampopolous *et al.*, 2002:132). Based on statements and dietary guidelines which state that a diet rich in wholegrain and other plant foods may reduce the risk of heart disease and some cancers, food manufacturers in the US can use a whole grain heath claim on food products with the claim stating “excellent source” (must contain 16g or more dietary fibre per labeled serving) or “good source” (require 8g to 15g dietary fibre per labeled serving) and “made with” (requires 8g dietary fibre) (Heller (b), 2008:1). However the definition of whole grains as followed by the FDA does not include all studies in the broader sense of whole grain, as some intervention studies use individual grains and do not explicitly state the use of endosperm, bran and germ as in the FDA definition; this excludes much research on the health benefits of consuming cereal and cereal products, such as Kellogg’s products and Cheerios by General Mills Inc. which are both US based food products (Heller (b), 2008:1). Cereal and cereal constituents have shown potential for enrichment, fortification and encapsulation application regarding the development of functional foods (Charalampopolous *et al.*, 2002:132).

However, an area where there is potential for development, is bakery products. Bakery products, as functional foods can be a perfect medium through which functionality can be delivered to the consumer in a product which meets the consumer's needs such as appearance, taste and texture of a baked product (Siró *et al*., 2008:461). If a food has physiological or psychological effects beyond the traditional nutritional effect or if the food contains a component that can benefit one or more functions within the body in a manner which is relevant to a reduction in the risk of disease or the state of well being and health, the food may be regarded as a functional food (Roberfroid, 2000:1661S).

In the 1980s bakery products were more likely to be fortified with vitamins and minerals as well as focus being placed on the health aspects of fiber intake (Hilliam, 1998:352). In late 2003, Unilever introduced a white bread, Blue Band Goede Start, which contained the nutritional elements normally found in brown bread, such as fibers, vitamins B1, B3, B6, iron and zinc (Siró *et al*., 2008:461). In the UK in early 1996, a range of bakery and cereal products were fortified with omega-3 fatty acids and product labels on packages included statements relating omega-3 fatty acid to help maintain normal blood pressure and a healthier heart (Hilliam, 1998:352). A product may also be regarded as demonstrating functional properties by adding a component which is not necessarily a macro- or micronutrient but for which beneficial effects have been shown (Roberfroid, 2000:1661S). Various fluids such as rooibos, honeybush or black teas can be included in the above.

2.4.2.2.2. Other food products

Recent scientific developments have shown that although a food ingredient such as an egg, which previously had negative connotations due to unfavorable effects on blood cholesterol, has functional food potential. An egg is an important source of high quality protein, is inexpensive and contains several nutrients such as riboflavin, selenium and vitamin K (Hasler, 2000:504) with the egg yolk providing high levels of the lutein and zeaxanthin antioxidant carotenoids which are considered important for eye health; thus making this particular dietary staple a potential functional food (Hasler, 2000:504). Another regularly consumed luxury, chocolate, has achieved potential functional status (Hasler, 2000:504); the phenolics contained in chocolate have also shown potential benefits such an antioxidant capacity and immunoregulatory effects for health (Visioli *et al.,* 2000:423).

Highly consumed items such as meat and meat products which are important sources of protein, vitamins and minerals have the potential to be made "healthier" by avoiding undesired substances or reducing these to appropriate levels or by increasing levels of substances with potential beneficial properties (Jiménez-Colmenero *et al.*, 2001:8). A substance found in meat and other animal products such as dairy with potential health properties, is conjugated linoleic acid (CLA). The health properties of CLA include having an anticarcinogenic effect at various stages of cancer as well as the possibility of impacting the immune system positively (Rainer & Heiss, 2004:964). The shelf life of certain products of poultry, pigs and cattle can be prolonged through the addition of a vitamin E supplemented diet whereby the antioxidant activity reduces rancidity and retains the food product's colour (Jiménez-Colmenero *et al.*, 2001:8). Meat products with a higher fat content can be changed to contain less fat and be more beneficial to health by replacing ingredients in animal feeds with healthier vegetable oils such as peanut, canola, etc. Through the process of adding vegetable proteins such as soy, maize or oats to various food products or animal feeds, the food product becomes more acceptable for health (Jiménez-Colmenero *et al.*, 2001:10).

2.4.3. Consumer understanding and acceptance of functional foods

Food choice is influenced by a variety of factors including the food itself, the consumers, the surrounding environment and economic factors (Ürala & Lähteenmäki, 2004:794). A growing awareness began relating to the need for eating to beat the odds, the odds being lifestyle diseases such as diabetes, allergies, osteoporosis, cancer and some types of infectious diseases through changed dietary habits (Arai, 2002:139). From a consumer viewpoint, many inter-relating factors will influence the success of functional foods; these include the level of concern individuals have on general health and various medical conditions, the belief that one can influence one's own health and the awareness and knowledge of those food products and ingredients which are beneficial to health. Consumers currently have a better understanding of the relationship between diet and health and that the three major factors which contribute to healthy living include diet, exercise and genetic factors (Hilliam*,* 1998:350).

The concept of functional foods is directly influenced by consumer acceptance which is recognised as one of the key factors for success for market orientation, consumer-led product development and negotiating market opportunities. The awareness and knowledge of the health benefits of functional foods and functional ingredients is often limited and there is a strong need for good communication from food developers within this area. However, knowledge is not the only factor. Acceptance itself is influenced by various factors such as basic health concerns, familiarity with the concepts and the nature of the carrier product (Siró *et al.*, 2008:465). In the general acceptance of food, taste is one of the major influences; however regarding functional foods the trustworthiness of health claims together with sensory aspects pertaining to the taste of food will influence the acceptance of the food product (Verbeke, 2006:126). However the taste of food should not be influenced (Ürala & Lähteenmäki, 2004) as the functionality of a food increases (Verbeke, 2006:126).

It is evident that more research is needed in the fields of functional foods and nutraceuticals as well as the consumer acceptance thereof. More than often it is important to recognise what attributes towards certain foods, including the functional food concept, may be culture-specific (Henson *et al.*, 2008:396). Not only may the purchasing of functional foods be culture-specific but many socio-demographic aspects influence purchasing behavior. There has been much research and investigation into what type of consumer purchases functional foods.

More than ten years ago the ideal consumer was a well-educated female of a higher income class and in the age group of 35 to 55 years. Since 1997 the consumer included females, with a tertiary level education but a higher proportion of the 55 years and beyond age group. The more recent study (2000) from the International Food Information Council (IFIC) included consumers with a specific health concern. Females have been reported to be the most likely purchasers of functional foods which may be influenced by their involvement in purchasing for a household. Women appear to have more of a philosophical, moral and ecological awareness for food compared to men who have more of a traditional outlook on food (Verbeke, 2005:47).

The acceptance of functional foods should answer some basic questions which include; will the consumer perceive these novel foods as a need and will the personal benefits gained from consuming these novel foods offset the negative thoughts against the novel processing methods. A further factor which will influence the acceptability will be the processing and technology used in the development of these new foods (Frewer *et al.*, 2003:715). A US study, in 1994, investigated the attitudes of consumers towards functional foods (Childs & Poryzees, 1998:422). There was also much interest in purchasing foods which could aid disease prevention. This study found that 55% of the sample group believed that certain diseases can be prevented through substances found naturally in food and that the majority would rather consume foods naturally with food processing manipulation eliminated in order to gain these benefits (Childs & Poryzees, 1998:422). The purchasing behavior of a household is also influenced by the number of small children present, which impacts on the types of food purchased as well as focus being placed on the safety of food preparation, processing and storing (Verbeke, 2005:47).

A prior investigation into the acceptance of products containing lycopene, an antioxidant found in tomatoes which have shown to have protective effects relating to certain cancers, made use of the theoretical model protection motivation theory (PMT). The study involved that the participants had to make a behavioral change, in this study to consume products containing lycopene. The participants had to be convinced that the potential course of action will reduce their risk of prostate cancer and/or severity of effects (response efficacy) and that the participants will be able to continue with these actions (self efficacy) and that the time, monetary costs (response costs) and effort associated with the new behavior will be cost effective (Henson *et al.*, 2008:397). The results suggested that many variables including own health status, relative risk, vulnerability of close others and age influenced willingness to make behavioral change. However although the PMT model provides a framework which can conceptualise the purchasing of functional foods it does not take into account the psychological variables which influences behavior relating to health choices (Henson *et al.,* 2008:401 & 404).

One of the major issues in marketing phytochemicals and functional foods is the name given to the product and product category. The name should be user friendly and easily understood by the consumer (Childs & Poryzees, 1998:425). The marketing of functional foods can be broken into various divisions: (i) products which have been backed by extensive scientific research especially in the areas of health and weight management; (ii) products which benefit on a daily basis and target mental and physical performance; and (iii) products which are generally good for well being and include more general products such as probiotics and antioxidants (Weststrate *et al*., 2002:S234).

For the consumer, clarity needs to made on fortification and enrichment of food products for nutritional purposes as a food can also be regarded as a functional food when a component is added or intensified; enriched or fortified foods are not necessarily regarded as functional foods but rather done for commercial purposes or for the purpose of fulfilling a specific nutritional need (Kwak & Jukes, 2001:112). For example in South Africa legislation on the fortification of various staple food products such as wheat flour has been passed to include micronutrients such as vitamin A, thiamine, riboflavin, niacine, folic acid, iron and zinc (South African Department of Health, 2008:3). The safety of food and especially functional food is not only of importance but also of interest to the consumer. Therefore the concept of novel foods may be applied. These include those foods and food ingredients which have not been used for human consumption significantly within the community and also genetically modified organisms (GMO). These foods use novel processing methods or novel ingredients (Kwak & Jukes, 2001:116). Governmental bodies have opportunities to create a favourable environment to promote functional foods through education on nutrition science, ensuring protection of the consumer through enforcing correct regulatory systems as well as credible scientific claims on nutrition and health (Verschuren, 2002:129). The consumer's choice to purchase a functional food product is not necessarily determined by the "functional" component itself but rather should be based on the positive health image it can create and avoid medical or clinical distinctions (Menrad, 2003:187).

CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

3.1. Type of study

A comparative experimental study design was utilised with the ultimate goal to increase the TAC of a brown bread recipe formulation through fluid manipulation utilising black tea and two South African herbal teas. Experimental design allows for the consideration of factors which may cause or influence a particular condition or situation (Leedy & Ormrod, 2010:223). In doing so, experimental design shows to what extent one variable will influence another variable (Leedy & Ormrod, 2010:224). This experimental study investigated to what degree the TAC of brown bread, the dependent variable as the condition or situation, is influenced by fluid manipulation in the form of differing tea and herbal tea beverages and concentrations, the independent variables. The degree to which the dependent variable is influenced depends on factors such as the concentrations or amounts of the independent variable (Leedy & Ormrod, 2010:224); in this study the types and concentrations of black tea and two proudly South African herbal teas.

A comparison of the characteristics of a new material against the characteristics of a standard (Greenfield, 2002:152) was also observed in this study with the TAC as the main characteristic comparison between the experimental breads (new material) and the control bread (standard). New experimental bread recipe formulations, comparable to the control bread recipe formulation, was used to produce the control and experimental breads and a commercial bread used as the reference bread or industry standard. The difference between the TAC of the new material (experimental breads on fluid manipulations) and the control and industry standard (commercial brown bread) was examined. Several samples of the new material (i.e. triplicate samples of the control and experimental breads providing a total of 21 samples) were taken which were analysed to examine the difference in TAC compared to the industry standard (Greenfield, 2002:151).

The reference industry standard bread was a commercial brown bread of a high selling retail brand. It's high sales figure was confirmed by the head office of one of the largest South African retail food store chains (Fourie, 2007). The control bread was produced using a standardised recipe formulation with no fluid manipulation but the ingredients, methods, and equipment used in the recipe formulation simulated those used during commercial bread baking. The experimental breads was produced using the control recipe formulation, but the fluid replaced by rooibos, honeybush and black tea respectively at two different concentrations. The TAC, being the dependent variable, was determined of all 21 samples of the control and experimental baked products. The study design depicting its major methodological steps with the accompanying influencing factors and decision-making process as supportive theoretical and practical information to the methodological steps is outlined in Figure 3.1.

Figure 3.1. Flow diagram of study design depicting the major methodological steps

A: Pre-experimental recipe formulation stage

-Selection of bread as vehicle and tea for delivery of antioxidant content
- Development of base bread recipe formulation with literature support in the selection of the recipe ingredients and the preparation and baking process to ensure a well formulated base recipe:
  -Recipe ingredients: flour and gluten, biological leaving agents, liquid, salt, sugar and fat
  - Bread manipulation process: autolyse and kneading, fermentation, dough division, proofing and baking process

↓

B: Control and experimental recipe development formulation stage

- Formulation of control recipe based on base recipe formulation (as A above)
- Development and formulation of experimental recipes based on the control recipe formulation using a 2% weight per volume (w/v) concentration making use of honeybush, rooibos and black tea as the fluid manipulations (considering the effects of the fluid manipulations on the bread sensory attributes to provide for further recipe developmental work to ensure a well-formulated 2% w/v experimental bread recipe formulation)*
- Development and formulation of experimental recipes based on the control recipe formulation using a 5% w/v concentration making use of honyebush, rooibos and black tea as the fluid manipulations (considering the effects of the fluid manipulations on the bread sensory attributes to provide for further recipe developmental work to enure a well-formulated 5% w/v experimental bread recipe formulation)*
- Consideration of control and experimental bread weights and heights and cost (using the rooibos ingredient inclusion as an intermediary cost between honeybush and black tea incorporation)* as support measures for the recipe development work

↓

C: Analytical testing

- Total antioxidant capacity (TAC) - Hydrophilic components
- Shelf-life testing of selected experimental bread - Weight and height per slice (1cm thickness), crumb firmness and elasticity (time taken for the sample to recover after being compressed within ten seconds) and microbial growth

↓

D: Consumer acceptance testing of selected experimental bread

- Selection of participants
- Development and pretesting of questionnaire
- Consumer acceptance testing considering participant liking of sensory attributes (taste/flavour, colour and texture) of selected experimental bread

↓

E: Data analysis (and study results)

- Effect of fluid manipulation (water as ingredient in control recipe formulation versus honeybush rooibos and black tea as in experimental recipe formulation) on TAC of formulated breads
- Effects of fluid manipulation of shelf-life characteristics (weight and height per slice (1cm thickness), crumb firmness and elasticity (time taken for the sample to recover after being compressed within ten seconds) and microbial growth) of selected experimental breads
- Effects of consumer acceptance testing (sensory attribute acceptance of taste/flavour, colour and texture with consideration of the participant demographic and biographic characteristics) of selected experimental bread

*As a result included in the methodology of the study

3.2. Selection of bread as a vehicle and tea for the delivery of the antioxidant content

The potentially large impact that a reduced intake of fruit and vegetables has on the global burden of diseases, such as heart disease and cancer, has been widely recognised (Lock *et al.,* 2005:100). Much evidence suggests that a change in dietary eating habits such as adding phytochemical rich fruit and vegetables, as well as wholegrains, can significantly reduce the incidence of age related and degenerative diseases (Liu, 2003:517). Research has indicated that the South African population does not consume sufficient fruits and vegetables (Labadarios *et al*., 2005:533) and wholegrains (Vorster & Nell, 2001:S23) which contain a selection of antioxidants which aids in better health (Parnes, 2007:1). The National Food Consumption Survey (NFCS), in South Africa in 1999 indicated that the micronutrient intake of children between the ages of one to nine years old was below two thirds the recommended dietary allowances (RDA), including that of the antioxidant micronutrients such as vitamin C, selenium and the carotenoids (Labadarios *et al.,* 2005:534). Research has shown that an increase in antioxidant intake from a young age, i.e. below five years, may prevent degenerative lifestyle diseases such as heart disease, certain cancers and diabetes in later life (Parnes, 2007:1). It was further found that 15% of the energy contribution came from protein, while 60% came from carbohydrates (Labadarios *et al.,* 2005:539) with maize, sugar, tea, whole milk and brown bread being the most commonly consumed foods (Labadarios *et al.,* 2005:533). Carbohydrate containing foods, including bread are widely consumed by the South African population with brown bread being the most commonly consumed bread (Nel & Steyn, 2002:75-92).

The influence of lifestyle on disease incidence, including the dietary intake, has been well publicised, with many consumers looking at food manufacturers to assist with the growing need of improved healthier foods. The consumers are the driving force for food manufacturers to develop affordable, healthier food items which does not entail the consumer having to change their lifestyle and eating patterns radically. The consideration of a staple food item such as brown bread, which is already commonly consumed by the South African market, as the food vehicle to increase the antioxidant intake seemed a viable undertaking.

In order to increase the levels of antioxidants within the bread, various plant ingredients were considered as to which ingredients would be best to use in the manipulation. Consumers, although requesting healthier food products, still require that bread remains bread and that it should still have good taste qualities, aroma with uniform porosity and good volume (Iancu & Jâşcanu, 2003:3). Bread has previously been manipulated, such as bread manufacturers being able to add or increase various ingredients in bread. The addition of milk proteins to increase the vitamin content is one such example. By increasing the micronutrient content, such as that of calcium or iron, bread may become more beneficial to health (Iancu & Jâşcanu, 2003:16) which has also been explored through food product development of health breads. The various ingredients that can be used in bread making to manipulate the bread may influence the final product. It was considered that the manipulation of the fluid as the ingredient would be most viable to include antioxidants without changing the final product characteristics greatly, as well as having minimal influence on the other ingredients used in bread making (see 3.3.1.). The use of both rooibos and honeybush is particularly viable as they are unique products indigenous to South Africa (McKay & Blumberg, 2007:2, 7). These herbals are respectively found in the Cedarburg Mountains and Langkloof district, and has health related properties linked to the levels of antioxidants, especially the flavonoid content (McKay & Blumberg, 2007:10). Black tea, which also has high flavonoid content (Cheng, 2006:34), was used to form a comparison to ascertain which beverage as fluid manipulation would increase the TAC of the final baked product the most as well as black tea being the most commonly consumed of the tea beverages by the South African population (Nel & Steyn, 2002:75-92).

3.3. Selection of base bread recipe formulation

A bread recipe formulation had to be selected as a base recipe formulation for the standardised control and experimental bread recipe formulation to be developed. The bread recipe formulation used which combines both brown bread and white bread flours is a tested bread recipe used by the program Consumer Science: Food and Nutrition in the practical application of the first year food and food science theory level (Addendum A) in the Faculty of Applied Sciences, Department of Agricultural and Food Sciences, Cape Peninsula University of Technology. The bread recipe formulation included all the required ingredients, such as flour, yeast, liquids, salt and sugar and the most suitable dough manipulation process, the straight-dough method, to provide for a base recipe formulation for a final baked product which had sensory attributes similar to that of the commercial bread currently available on the market.

3.3.1. Selection and influence of ingredients on bread making process

The ingredients used in bread baking each have a particular purpose in all stages of bread making from the development of the bread dough, the baking process to the shelf life of the final product and therefore had to be ingredients in the base recipe formulation selected. The most basic of breads contain the ingredients flour, water, yeast and salt (Charley, 1982:199). Such breads are usually consumed within three days of being baked as the shelf life is limited (Giménez *et al.*, 2007:196).

3.3.1.1. Flour and gluten

The basic structural component of most baked products is dependent on the flour included as it can perform the textural function, which allows the expansion of cells and provides the rigid structure post baking (McWilliams, 1997:470). The protein complex formed when flour is manipulated with water consists of the two fractions, gliadin and glutenin, usually in equal amounts. When manipulated with water flour forms an elastic and cohesive complex. The glutenin contributes to the elasticity of the complex, while the gliadin contributes to the cohesiveness (McWilliams, 1997:460). When flour is not only mixed with water but also kneaded the glutenin and gliadin combines with the water and also links and crosslinks with each other forming sheets of flexible, yet resilient film which is known as gluten (Amendola & Rees, 2003:10). The formation of the gluten complex is the key to the quality success of a baked product (McWilliams, 1997: 462). Gluten is the one ingredient which bread relies onto for its unique texture and structure. The gluten complex traps air and the gases formed by the yeast addition causes the bread to rise (Amendola & Rees, 2003:10).

The rate at which the gluten complex develops depends on various factors such as time; this includes both the initial autolyse whereby the bread dough is left for approximately 30 to 40 minutes after ingredients are combined, where the flour hydrates to its fullest potential and improves dough-handling qualities (Amendola & Rees, 2003:19) as well as the 'first rise' also known as fermentation where the dough rises as a single mass and allows the yeast to feed and multiply (Amendola & Rees, 2003:22) and proofing where the shaped bread masses are allowed to double in size (Amendola & Rees, 2003:23), temperature of dough and other ingredients incorporated, such as sugar and liquid. Excess liquid, i.e. a high ratio of water to flour, will influence the viscosity of the dough as the protein molecules are diluted in excess and cannot cling to each other to form the gluten network (McWilliams, 1997:465).

Starch is another important component in flour; the starch gelatinises during baking which assists with the structural component of the baked product. Flour can also provide some food to the yeast during fermentation as flour contains sugar, in the form of simple sugars, such as glucose. Glucose is the most common sugar used within the food industry. The combinations of proteins within the flour with the sugars within the flour furthermore influence the browning of the crust during baking (McWilliams, 1997:470).

3.3.1.2. Biological leavening agents

Carbon dioxide, which may either be from a biological or chemical source, is a gas that provides effective leavening in baked products (McWilliams, 1997:474). The ingredient yeast is included in bread dough because the yeast cells metabolise the fermented sugars giving off carbon dioxide and alcohol as waste products. The waste product of carbon dioxide is used as the leavening agent in dough making (Charley, 1982:199). The strain of yeast which is normally used in bread making is *Saccharomyces cerevisiae*. Compressed yeast is dispersed in a small amount of liquid, usually lukewarm water, at a temperature of 32˚C to 38˚C, together with sugar which provides the food for the yeast to begin fermenting (McWilliams, 1997:474). Temperature control is very important even after the yeast has combined with the other dry ingredients as good temperature control will ensure the yeast remains viable and continues to actively produce carbon dioxide (McWilliams, 1997:476). During the proving (rising) of the bread the yeast metabolises the flour sugars into carbon dioxide gas which disperses into bubbles. The bubbles inflate and cause the dough to rise (Chiotellis & Campbell, 2003:194).

3.3.1.3. Liquid, salt, sugar and fat

Water, or any other liquids, used in bread making serves as a solvent which dissolves the sugar, leavening agents and dry ingredients, hydrates the yeast (McWilliams, 1997:470), assists in distributing the yeast cells throughout the flour and transports food to the yeast cells through cell membranes (Charley, 1982:200). For the gluten network to develop, liquid must be present (McWilliams, 1997:470). The liquid used in bread making is usually water (Charley, 1982:200), as in the case of this study. Milk can be used as well due to its high water content, ability to increase food value and to decrease staling time (Charley, 1982: 200).

The liquid added during the dough making process dissolves the salt and sugars. If too much liquid is added the resultant dough is sticky and too soft and if insufficient liquid is added the dough resists stretching and is stiff. The consistency of the dough will affect the extent to which the films of gluten around the gas bubbles resist the pressure of the accumulating carbon dioxide, which occurs during fermentation, as well as the pressure of the gas expansion, which occurs during the baking process. This will influence the volume and texture of the bread crumb once the bread is baked (Charley, 1982:200). The liquid added during mixing aids in the gelatinisation of starch during baking. The liquid being a source of steam, is furthermore one of the primary sources of rising in baked products (McWilliams, 1997:471).

The control of the liquid temperature is important as this will influence the dough development (Amendola & Rees, 2003:13). The ideal temperature being between 25˚C to 27.7˚C. However, this is used when the dough is being manipulated for a relatively long time period and the temperature increases through friction during manipulation. The temperature usually used is between 35˚C to 40˚C when bread is manipulated for shorter time periods (McWilliams, 1997:477).

Salt and sugar serve as humectants during the bread making process. Humectants are used to retain moisture during the baking process. Salt also not only improves the flavour of bread (McWilliams, 1997:472) but also inhibits the action of proteases (protein splitting enzymes) in flour. Yeast dough without salt results in a sticky hard to handle dough. The dough will have weakened gluten strands and gas cells will over expand during the fermentation process (Charley, 1982:200). Salt however has a negative affect on the production of carbon dioxide by yeast; it is for this reason that a lower proportion of salt is used during dough making. Salt is added to decrease the rate of fermentation time during the proofing stages of bread. This allows for more control over the rising of the bread dough as well as ensuring even cooking and improving the texture of the bread (Charley, 1982:201). Salt has the ability to tighten the gluten network and so a fast dissolving salt is preferred for machine-mixed bread doughs (Amendola & Rees, 2003:16).

Sugar is included in the dough as a source of flavour and it aids in browning the crust through the process of caramelisation brought about by the Maillard reaction (McWilliams, 1997:472). The chemical reaction, known as the Maillard reaction, takes place between an amino acid and a reducing sugar which depends on temperature, PH and water activity (Sivam *et al.,* 2010:R169). The addition of sugar also serves as a tenderiser as it firstly retards gluten development during mixing and then by increasing the coagulation temperature of the structural proteins so that cell walls have more time to stretch. This also increases the volume of the baked product (McWilliams, 1997:472). In the absence of sugar, the fermentation process is limited and delayed as sugar provides food for the yeast (Bennion & Scheule, 2000:614).

The addition of fat to bread dough acts as an emulsifier and allows the crust of the bread to colour better. The increase in bread volume when fat is included is due to the ability of fat to plug holes in the walls of the dough around the gas cells. This allows the gas cells to expand more before rupturing and releasing carbon dioxide (Charley, 1982:201). Sunflower oil was included as fat ingredient in the base recipe formulation selected (Addendum A).

3.3.2. Selection and importance of bread manipulation process

There are two basic methods of manipulating yeast dough, namely the sponge method and the straight dough method (Labensky & Hause, 2007:1117). During this experiment it was aimed to achieve the method most closely used by the general bread baking industry. The method chosen was the straight dough method which is the simplest and most commonly used method for bread making. In this method all ingredients are simply combined and then mixed, once combined the dough is kneaded until it is smooth and elastic, then rising occurs, followed by baking (Labensky & Hause, 2007:1117).

3.3.2.1. Autolyse and kneading

Prior to mixing the yeast into the ingredients, the yeast is fermented. This is done by combining the fresh crumbled yeast, sugar and lukewarm water. The liquid used is between the temperature ranges of 40˚ to 60˚C. Yeast placed in liquid at a hotter temperature will die, while yeast placed in a cooler liquid will remain dormant while also releasing a substance, glutathione which will influence the quality of the dough (Labensky & Hause, 2007:1113).

After the suspension of yeast cells is distributed in the liquid the flour is added, to form a soft, pliable dough which handles easily. The addition of too much flour results in a stiff, hard dough. The development of gluten in bread dough is essential for a high quality bread. Gluten can be developed by manipulating or kneading the dough by hand, in the case of homemade bread recipes, or by using an electrical beater (Charley, 1982:206). The bread dough needs to be kneaded so that numerous gas cell nuclei by the inclusion of air are formed, and to give the dough elasticity and gas-holding capacity. It is possible to overwork the dough which results in the gluten loosing its cohesiveness and springiness as well as the cells leaking gas (Charley, 1982:207). After the dough has been kneaded it is ready to begin fermentation.

3.3.2.2. Fermentation, dividing and proofing

The temperature of the dough as it ferments will influence the speed at which the dough ferments and the quality of the final product. The optimum fermentation temperature range is 24˚C to 35˚C. Dough which is too warm is soft and more likely to be sticky making the dough difficult to handle (McWilliams, 1997:465).

During the fermentation process many changes occur in the bread dough. These changes include the production of acids, as well as carbon dioxide. The production of acids during fermentation contributes in making a less sticky dough. During the initial stages of fermentation the gluten is tight and resists stretching. The carbon dioxide released by the yeast collects in bubbles which stretch the films of gluten surrounding them; this stretching is essential if the dough is to expand during the baking process. Yeast dough should not be allowed to over stretch as once the gluten strands are over stretched they can never regain their elasticity. Dough is sufficiently light when it has approximately doubled in size volume. A second criterion for lightness is that the dough barely springs back when punched lightly with a finger. The time needed for dough to rise depends on the proportion of yeast in the dough and on the fermentation temperature (Charley, 1982:209).

Once dough is sufficiently light, it is ready to be punched down. This is done to firstly prevent the films of gluten surrounding the gas cells from being over stretched and secondly to subdivide the gas cells which have enlarged during the fermentation period. Manipulating the dough at this stage both divides and increases the number of gas cells. An increased number of gas cells allows for better distribution of carbon dioxide within the dough and results in a finer textured baked product. During fermentation heat is developed and punching down of the bread dough allows the temperature to be equalised. Once the dough has been punched down it can be shaped. After the dough is shaped and in baking pans, it is proofed and allowed to rise again, which results in a lighter baked product. The proofing stage is complete once the dough has approximately doubled in size and holds a slight depression when pressed gently with a finger (Labensky & Hause, 2007:1117).

3.3.2.3. Baking

Many changes occur once the bread starts to bake. The volume of the bread dough rapidly increases in the initial stages of baking, which is known as “oven spring”. This can be up to a 80% increase in volume if the bread dough is of a high quality. Many factors will influence oven spring including the quality and the temperature of the dough. Oven spring is most rapid until the interior of the bread loaf reaches 60˚C, thereafter expansion reduces. At the end of the baking period the temperature of the interior of the bread is approximately that of boiling water (Labensky & Hause, 2007:1118). During the baking process as the surface of the bread dries the temperature of the bread can reach up to 150˚C. The doneness of bread can often be difficult to assess as colour and browning is not always a criterion; a loaf may sound hollow when thumped even though it is under baked. The time baked is the most reliable method for testing doneness, but the size of the loaf will influence the baking time. The shape of the bread pan can influence the final baked product, as to the amount of space given for rising during baking compared to the amount of dough used (Labensky & Hause, 2007:1119).

3.4. Development of standardised control and experimental recipe formulations

3.4.1. Base recipe formulation

The base bread recipe formulation selected (see 3.3) uses a combination of both white bread flour and brown bread flour (Addendum A). The white bread flour aids in the end baked product having a finer texture, while the brown bread flour adds to the fiber and whole grain content of the bread. During the experimental bread baking stage it was also noted that the use of brown bread flour aids in minimising the colour change of the experimental breads due to the inclusion of rooibos and honeybush herbal teas on the fluid manipulation. The other bread ingredients including sugar, which aids yeast fermentation, vinegar which acts as a preservative, yeast which aids rising and water which assists with dough formation where in correct proportions (Addendum A) to result in a baked product. This was confirmed in the baking of the recipe formulation.

A straight dough method was selected as the base recipe formulation for the control and experimental bread recipe formulations, which involves an initial fermentation of the yeast, sugar and part of the liquid which is added to the remainder of both the wet and dry ingredients after which the mixture is mechanically kneaded for a length of time. In this study a stand alone spiral dough mixer with flour capacity of 8 to 15 kilogram (kg) of finished dough was used. The dough was kneaded with the dough hook attachment on speed number one for a total of five minutes. Thereafter the first proofing takes place of the mixture as a whole, after which the mixture is shaped and a second proofing takes place prior to baking the product (Addendum A). In this study the dough was placed covered, to prevent drying out, in a dough prover with 220 volt (V) manual steam function, set on mark four. The bread was baked in an 18x8x5 centimeter (cm) loaf tin, yielding a baked bread of approximately 380 gram (g) and dough baked for 26 minutes at 180˚C in a preheated convection oven (Fagor Combination oven, Western Cape Catering and Refrigeration Equipment).

3.4.2. Control recipe formulation

In ensuring that the control bread and the various experimental breads were all made in the same environment, the same utensils and equipment such as baking provers and ovens and following the same time schedule were used. The control bread recipe formulation, based on the base recipe formulation was used as the guide to set the parameters which included the same measurements for ingredients, the same baking methodology and the same baking environment, for the control bread and the experimental breads. The control bread resulted in a well textured, soft but not dry bread.

Both the control bread, and the experimental breads, were made using the straight dough method, which entailed that all ingredients were combined and the dough kneaded prior to the rising process. The fresh yeast, water with a temperature of 40˚C and sugar was combined and placed in a baking prover for 23.5 minutes to allow fermentation. It is during this process that the yeast feeds off the sugar and releases carbon dioxide and alcohol as waste products. The remaining ingredients of white bread flour, brown bread flour, salt and sugar were placed in a stand alone spiral dough mixer with flour capacity of eight to 15 kg of finished dough. The remaining liquid, water, with a temperature of 40˚C, the vinegar and the oil were then added. The dough was kneaded at speed number one for five minutes. It is during this period that the elasticity of gluten is developed. The dough was then removed and placed in an oil rubbed bowl and placed in a dough 220V prover with manual steam function, set on mark four for a time period of 45 minutes. The dough, with weight of 1.241 kg, was removed from the prover and knocked down for one minute resulting in a weight of 1.246 kg. The dough was then divided into three loaves at 415 g per loaf. The individual shaped loaves were placed back into the prover for an additional 15 minutes for a second proving. The loaves were baked in a preheated convection oven at a temperature of 180˚C for 26 minutes. The final baked product weighed 370 g per individual loaf with a height of 7.5 cm. The final baked product was of good texture, soft but not dry. The control bread recipe formulation with its methodology described is included as Addendum B.

3.4.3. Experimental recipe formulation

The six experimental breads (Addendum C) were prepared in the same manner as the control bread using the control bread recipe formulation (Addendum B). Each fluid used in the experimental breads was at two different concentrations, providing for 18 baked samples to be analysed for the TAC as each bread was prepared and baked three times for analysis. The initial fluid use was a 2% (w/v) concentration level and thereafter a 5% (w/v) concentration level.

3.4.3.1. Experimental recipe formulation at 2% (w/v) concentration

During the ≈2% (w/v) rooibos infusion experiment, a total of 9 g of rooibos tea leaves was infused in 400 millilitre (ml) of just boiled water for ten minutes until a temperature of 40˚C was reached; the liquid was then used as required by the recipe. During the 2% (w/v) rooibos infusion the resultant unbaked dough was much drier and the elasticity of the dough had decreased compared to that of the control bread. As a result more liquid had to be used. The dough was more golden in colour as the addition of rooibos had affected the colour compared to that of water used in the control bread. During the fermentation of the yeast, which took place in a rooibos solution, the yeast fermentation process took place quicker within the specified time frame, which could be due to more "food" being available to the yeast. As the dough was much drier and slightly less elastic during the knock down process the dough was denser and compact and handling was tougher with no taste changes. The total dough weight prior to knock down was 1.176 kg, and post knock down 1.175 kg; each loaf weighed 391.7 g prior to baking and 360 g post baking with a height of 6.5 cm.

The 2% (w/v) concentration of honeybush used in the bread making followed the same process as the 2% (w/v) rooibos experimental bread recipe formulation. As with the rooibos experimental bread the honeybush experimental bread was also drier and needed additional liquid. During the mixing process the mixture took longer to come together as a homogenous mixture, compared to the other doughs, and the dough did not form a round ball prior to proofing. Similarly to the rooibos experimental bread the yeast fermentation process was quicker within the specified time parameters as fermented in the honeybush solution. There was only a slight difference in dough colour prior to baking and no noticeable taste changes post baking. The total dough weight prior to knock down was 1.146 kg and post knock down 1.145 kg; each loaf weighed 381.7 g prior to baking and 353 g post baking with a height of 5.5 cm.

The use of the 2% (w/v) concentration of black tea in the bread making resulted in a very dry bread which had to be brought together by hand as the dough struggled to come together as a homogenous mixture. The colour was slightly darker, but still visually acceptable, and no taste changes were identified in the bread. The total dough weight prior to knock down was 1.161 kg and post knock down 1.160 kg; each loaf weighed 386 g prior to baking and 355 g post baking with a height of 5.9 cm.

Due to the dryness of the experimental doughs additional liquid was added to improve handling and the texture of the breads. The dryness of the experimental breads could be attributed to the dry tea leaves absorbing fluid during the infusing time and resulting in less fluid being available for use. Excess fluid was infused and fluid needed for the recipe was measured as required. Initially a 100 ml additional liquid was added to the recipe formulation, but the resultant dough had glue-like consistency and was sticky and soft and almost batter-like which inhibited handling. The addition of 50 ml rooibos/honeybush extract to the recipe formulation was a viable option, as the dough required an improved texture which could be achieved through the addition of more fluid. An increase of other ingredients would have interfered with the sensory qualities of bread. The additional liquid made positive improvements to the final baked product. The bread dough could form a ball during mixing and prior to fermentation and post fermentation the bread could be kneaded more easily than before and the additional liquid allowed for characteristics similar to that of the control bread. The unbaked rooibos bread dough was sticky to handle and there was also an increase in the proofing time which was visible in the final baked product as a slightly more aerated texture, which resulted in the bread having a slightly softer texture. The additional liquid also resulted in bread with a similar height (control: 7.5 cm; rooibos: 7.5 cm; honeybush: 8.5 cm) and weight (control: 370 g; rooibos: 385 g; honeybush: 380 g) as that of the control bread.

The additional 50 ml liquid added to the honeybush bread resulted in a dough which was very sticky and soft in texture prior to baking. The increase in liquid also aided in increasing the size of the dough during proofing and resulted in a bread with a soft, aerated texture and similar weight, 380 g to that of the control bread, 370 g. The additional liquid added to the black tea bread allowed for an increase in size during proofing with a similar final weight (control: 370 g; black tea: 384 g) and size (control: 7.5 cm; black tea: 7.5 cm) to that of the control bread. The additional liquid improved the final experimental bread formulation to result in a baked product similar to that of the control bread in weight, height and texture.

3.4.3.2. Experimental recipe formulation at 5% (w/v) concentration

The major reason for increasing the concentration was to investigate the difference in TAC at the various concentration levels and what sensory changes these concentrations made on the breads itself. The increase in fluid concentration had a considerable influence on the doughs and baked products.

The ≈5% (w/v) (using the same amount of liquid/extract as per the 2% (w/v) experimental recipes) rooibos bread colour was very “golden-orange” during the dough making and the dough had a pungent smell. The dough itself had a good texture to work with and during the proofing time, the dough rising was stimulated which could be attributed to the increase in the rooibos concentration and the availability of food for the yeast. The total dough mass was slightly heavier in weight compared to that of the total dough mass of the control bread (1.241 kg) and had a total weight of 1.268 kg prior to knock down and a total weight of 1.271 kg post knock down with each individual loaf weighing 423 g prior to baking. The texture of the final baked bread dough was light and springy, similar sensory properties to that of the control bread. However due to the increased rooibos concentration the smell of the bread was very strong and could possibly be considered to some consumers as unpleasant. The final baked loaf was bigger than the control bread and weighed 380 g with a height of 8 cm. On experimental tasting of the dough it was found to be bitter and had an increased “tannin”/bitter taste.

The 5% (w/v) honeybush bread formed a very sticky dough difficult to handle which had a pungent smell with the undertones of honey from the honeybush herbal tea. The colour of the dough itself was “pink” in comparison to that of traditional brown bread which is light brown in colour. The dough had a total weight of 1.177 kg prior to knock down and 1.285 kg post knock down with each individual loaf weighing 428 g prior to baking. The final baked product resulted in a bigger loaf compared to that of the control bread and was holey in texture and very fragrant in taste and smell. The final baked product weighed 377 g with a height of 8 cm.

The use of the 5% (w/v) concentration black tea had a slightly negative effect on the bread regarding the sensory factors. The dough was a very dark brown colour and the texture was sticky making handling difficult. During the dough making and in the final baked product the dough and the bread had an increased “tannin”/tea smell. The dough had a total weight of 1.294 kg prior to knock down, heavier than the total dough mass of the control (1.241 kg) and a total weight of 1.297 kg post knock down and each individual loaf weighed 423 g prior to baking. The final product weighed 393 g with a height of 7.6 cm. The texture of the final baked product comparable to the control bread was dense, yet fine, but not heavy. The product was very dark in colour, almost similar to the colour of dark rye bread. On experimental taste the increased concentration of black tea resulted in the flavour of traditional brown bread being obscured due to the overpowering taste of black tea with undertones of tannins.

In summary the following table (Table 3.1.) shows a comparison of the experimental breads against the control bread, for the various weights and heights to the concentration levels of the fluid manipulations used. Prior to knock down the weight of the 450 ml liquid experimental breads are approximately 20 g to 30 g more than the control bread with the exception of the 5% (w/v) honeybush bread which is 5 g less in weight for the 2% (w/v) liquid and 64 g less in weight for the 5% (w/v) liquid than the control bread. There is an average weight difference of 17 g between the control and the 450 ml liquid experimental breads post knock down with the 5% (w/v) black tea bread showing the largest increase in weight of 51 g. An average weight difference of 8 g was found between the individual unbaked loaf weights of the control and experimental breads with the 5% (w/v) honeybush bread having an increased weight difference of 13 g compared to that of the control. The experimental breads had an average individual loaf weight increase of 13 g after baking, with the 5% (w/v) black tea showing the largest increase in weight of 23 g compared to the control. The average height increase of the experimental breads compared to that of the control breads was negligible, 0.35 cm. The majority of breads were of the same height or half a centimeter different in height. The 2% (w/v) honeybush experimental bread showed the highest increase that of 1 cm.

Table 3.1: Comparison of control and experimental bread weight and height

Bread weight and height characteristics	**Fluid Manipulation**									
	Control	**2% (w/v) 400ml liquid**			**2% (w/v) 450ml liquid**			**5% (w/v) 450ml liquid**		
	Water	Rooibos	Honeybush	Black	Rooibos	Honeybush	Black	Rooibos	Honeybush	Black
Weight (kg) Prior knock down	1.241	1.176	1.146	1.161	1.260	1.246	1.268	1.268	1.177	1.294
Weight (kg) Post knock down	1.246	1.175	1.145	1.160	1.264	1.246	1.270	1.271	1.285	1.297
Unbaked weight (kg) Individual loaf	0.415	0.392	0.381	0.386	0.423	0.421	0.423	0.423	0.428	0.423
Baked weight (kg) Individual loaf	0.370	0.360	0.353	0.355	0.385	0.380	0.384	0.380	0.377	0.393
Height of bread (cm) Per slice	7.5	6.5	5.5	5.9	7.5	8.5	7.5	8.0	8.0	7.6

3.4.3.3. Cost analysis

Although not being an objective of this study a cost analysis of the rooibos experimental recipe formulation was done (Table 3.2) to compare the selling price of the reference commercial bread and the proposed selling price of the experimental breads, as using herbal tea in place of water will increase the cost of the bread recipe formulation in its entirety. Rooibos was used as the example due to it being an intermediate cost between black and honeybush teas respectively. The general aim of the research is to provide bread with an increased TAC using various herbal teas/teas to increase the TAC, but with the final experimental product being considered a viable option for commercialisation. An average price of the top selling brown breads was R5.97, at the time (June 2009) of this research, and is based on the selling price of the four top selling brown breads as obtained from the sales figures from one of South Africa's largest food store retailers (Fourie, 2007). When the ingredient costs, with no inclusion of overheads such as profit margin, production or labour costs, the experimental breads was cheaper by 41% for the 2% (w/v) rooibos experimental breads and 45% for the 5% (w/v) rooibos experimental breads than the average price of a retail brown bread. A cost comparison of the control bread against the cost of the experimental bread indicates a similar cost to that of the experimental bread.

Table 3.2.: Cost analysis of rooibos experimental bread

	2% (w/v) experimental bread			5% (w/v) experimental bread		
Ingredient	**Cost/kg** *R/c*	**Amount used/kg** *(kg)*	**Total cost** *R/c*	**Cost/kg** *R/c*	**Amount used/kg** *(kg)*	**Total cost** *R/c*
Brown bread flour	7.39	0.300	2.22	7.39	0.300	2.22
White bread flour	6.39	0.450	2.87	6.39	0.450	2.87
White sugar	7.49	0.025	0.18	7.49	0.025	0.18
Salt	11.98	0.010	0.11	11.98	0.010	0.11
Yeast	27.00	0.025	0.68	27.00	0.025	0.68
Vegetable oil	16.85	0.025	0.42	16.85	0.025	0.42
White vinegar	39.98	0.010	0.40	39.98	0.010	0.40
Rooibos tea leaves	50.40	0.009	0.45	50.40	0.023	1.16
Total cost (yields 3 breads)			7.32	Total cost (yields 3 breads)		8.03
Cost per loaf (380g)			2.44	Cost per loaf (380g)		2.68
Total cost of control bread[1] (yields 3 breads)			6.87			
Cost per loaf (380g)			2.29			

[1] Excluding cost of rooibos tea leaves

3.5. Total antioxidant capacity analysis and sampling procedure

There are many antioxidant compounds in foods and the TAC of any given food will represent an integrated action from the various compounds found in foods instead of from one compound (Wu *et al.,* 2004:408). Therefore the possible interaction between the various antioxidant compounds in the breads was impacting the TAC of the different breads. The oxygen radical absorption capacity (ORAC) method as used by Wu and co-workers (2004:412), who determined the TAC of commonly used foods in the US, was used in this study. This method allows both the hydrophilic (H-ORAC) and lipophilic (L-ORAC) capacities to be analysed separately and then the values are added together to obtain a TAC.

There are two major classes of antioxidants, namely endogenous, those that the body supplies itself and exogenous, those that come from external sources like the diet. To obtain the TAC of exogenous antioxidants in food, the subclasses of the antioxidants are measured separately. The exogenous antioxidants are subclassified as lipophilic antioxidants, those that favour fat environments such as vitamin E and carotenoids and the hydrophilic antioxidants, those which favour a water environment and these include vitamin C and the polyphenols. To ascertain the TAC of a food product the ORAC method is used; either a L-ORAC, which measures the lipophilic antioxidants or a H-ORAC which measures the hydrophilic antioxidants is used. In the case of this experimental study, the H-ORAC test was used as rooibos contains polyphenols, which favour a water environment. From a previous study, the lipophilic antioxidant contribution to the TAC of bread and other starchy foods was determined to be only approximately 5% (Louwrens *et al.,* 2009:198).

3.5.1. Oxygen radical absorption capacity assay

The TAC of a number of products such as whole fruits and vegetables, beverages including fruit juices, wines and tea can be measured through this simple but, sensitive method, which is suitable for quantifying the antioxidant capacity of the products. The majority of methods used as a base to quantifying the antioxidant capacity use either the inhibition time at a fixed degree of inhibition or the range of inhibition at a fixed time. The ORAC method has the ability to measure both: i) the degree to which the sample inhibits the action of an oxidising agent; and ii) in what time period this happens. The measurements are then incorporated into a single measurement known as the ORAC value (Cao *et al.,* 1996:3426).

The standard, Trolox, a non-commercial water soluble derivative of tocopherol, is used for measuring antioxidant capacity and micromoles Trolox equivalents per gram of a substance (µmole TE/g) are used to express the ORAC. The chemical assay is a combination of the test sample, a fluorescent probe and an oxidising agent such as peroxyl radical, hydroxyl radical or oxidising-catalysing metal ions.

As the free radicals damage the fluorescent probe, so the fluorescence decreases. However, in the presence of an antioxidant, the fluorescence decreases more slowly as the antioxidant surrenders itself to the free radicals, which protects the probe. The ORAC method combines both inhibition time and inhibition percentage of the free radical damage by the antioxidant into a single quantity when the reaction is allowed to go to completion and the area under the curve (relative fluorescence intensity versus time) is measured (Cao *et al.,* 1996:3427).

3.5.2. Chemicals and apparatus used

The hydrophilic antioxidant solvent used was a combination of acetone (Merck Chemicals), de-ionised water and acetic acid (Merck SA) (AWA) in a ratio of 70:29.9:0.1 (v:v:v), respectively. The buffer (75mM) used to maintain the pH at 7.4 was a mixture of two phosphates, di-sodium hydrogen orthophosphate dihydrate and sodium di-hydrogen ortophosphate dihydrate (Merck SA). 2,2'-Azobis(2-amidino propane) dihydrochloride (25mg/ml) (AAPH) (Sigma-Aldrich SA), 6-Hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (0,5,10,15,20,25 µm) (Trolox) (Sigma-Aldrich SA) and fluorescein (Na salt) (14µm) (FL) (Sigma-Aldrich SA) were used. Antioxidants were extracted from bread for 30 seconds in a Polytron homogeniser (Merck SA) set at 9500 revolutions per minute (rpm) with a S25N blade (Merck SA) (Prior *et al.,* 2003:3274). Antioxidants were further extracted on a tube rotator (Stuart SB3) for 30 minutes set at 40 rpm. The ORAC analyses were carried out using a Fluoroskan Ascent plate reader (Thermo Electron Corporation). Fluorescein filters (Thermo Electron Corporation) with an excitation wavelength of 485 nm and an emission wavelength of 538 nm was used. A 96 well black microplate (Sigma-Aldrich SA) was used for the measurement of samples and standards (Wu *et al.,* 2004:410).

3.5.3. Sampling and sampling procedure

Three slices per baked bread was taken (two slices of bread from each side of the baked loaf and one from the centre of the baked loaf) and accurately weighed off into 2 g pieces per composite sample. Each 2 g composite sample was combined with 30 ml AWA together with a pipetting aid and antioxidants extracted with the polytron homogeniser and tube rotator. After centrifugation AWA extracts were diluted with the phosphate buffer and these solutions used to measure the H-ORAC.

The H-ORAC assay was carried out using the Fluoroskan Ascent plate reader, the temperature set at 37˚C. AAPH (50µl) was used as the peroxyl generator and Trolox as the standard. The sample (12 µl), fluorescein (138 µl) and trolox standards (12 µl) were placed in the 96-well microplate based upon a set layout. The plate reader was programmed to record the fluorescence decay of FL every five minutes over a time period of two hours (Wu *et al.,* 2004:410). The final ORAC values were calculated using a standard curve where $y = aX^2 + bX + c$ between the sample concentrations and the trolox concentration and the net area under the FL decay curve. The H-ORAC assay of each sample was conducted in triplicate with each bread baked three times that provided for an average H-ORAC of nine samples per bread (with 21 samples in total of the seven different breads).

3.6. Shelf life testing of the experimental bread selected for the consumer acceptance testing

The shelf life of food products is mostly dependent on the interaction between the food and the consumer, rather than the food product having a sensory shelf life of its own (Giménez *et al.,* 2007:197). It is necessary to determine the shelf life of the experimental bread for future reference. The average shelf-life, without the addition of enzymes, of freshly baked bread is between three to five days before staling develops. Staling is a general term which is given to the time-dependent loss in quality of flavour and texture of bread. The baking industry prevents and reduces staling through the addition of enzymes which retards staling by acting on certain flour components (Giménez *et al.,* 2007:196).

Shelf life is judged as the time when an initial significant change in overall acceptability by the consumer is noted (Giménez *et al.,* 2007:197). The majority of shelf life estimates are based on consumer rejection use survival analysis, which is often related to the number of complaints which suppliers or retail outlets receive regarding that particular product (Giménez *et al.,* 2007:202). The shelf life of the experimental bread will not be tested in conjunction with the consumer acceptance study but rather the changes in the sensory attributes such as the development of mould and the changes of the texture and crumbs and shrinkage or hardening of the crust noted (Bennion & Scheule, 2000:626) by the researcher on such visual cues of the fresh product over a four day time span. Slices of each experimental bread, 1cm in thickness, the average slice thickness of commercial bread, was taken from the middle of the loaf and stored individually in sealed plastic packets which were closed with a plastic tie. The plastic packets and ties were similar to those used for the sale of commercially packaged sliced bread. This allowed the experimental breads to be in a similar environment to commercially sliced and packaged breads. The bread was stored at room temperature but not in a sealed container. This was done as the majority of households may not make use of breadbins or containers to store packaged sliced bread. This method of storing allowed the bread to have contact with air exposure, which does occur when consumers open the packaged sliced bread for use, exposing these slices to the air. On a daily basis for four days, each packaged slice was visually examined by the researcher on food practical experience and changes, if any, were noted.

3.7. Consumer acceptance testing of selected experimental bread

A further objective of the research was to determine whether the bread with the highest TAC will be sensorically acceptable to consumers. A consumer-based acceptance study was conducted to determine whether the selected experimental bread(s) with the highest TAC was sensory acceptable to the participants, particularly with regards to the taste. Many factors influence consumer's choice to purchase and to eat a food. Taste is the factor known to have the greatest influence on consumer food choices (Bennion, 1995:8).

3.7.1. Acceptance testing

Research demonstrates that the success of new products rests with the consumers who determine whether a product is acceptable or not. The individuals' relationship with food is constantly changing and is also dependent on the situation in which the food is consumed. Many factors will contribute to the acceptability of food products such as the sensory attributes of the food, the physiological state of the consumer, the socio-psychological context of consumption and the effects of learning on all these aspects (Bosman *et al*., 1997:90).

Consumer acceptance testing is made use of to determine whether consumers like or accept a product, whether there are preferences to other products or for the product being tested and whether the consumers intend to purchase and consume the product on a regular basis (Bosman *et al*., 1997:90). Acceptance testing is a much needed component of every sensory program. Acceptance testing refers to the measuring of liking or preference for a product (Stone & Sidel, 2004:247-248). Although acceptance testing is a major part of the process, the success of a product is also influenced by factors such as packaging, price, advertising and market segmentation. Acceptance testing must be used in conjunction with market research which focuses on populations, identifying consumers to whom the product will have the most appeal and developing methods to influence those consumers. Acceptance testing usually consists of a small panel test of between 50 and 75 participants. The acceptance test focuses on the product and the products attributes and will assist to determine the best suitable product for the consumer (Stone & Sidel, 2004:249).

When measuring product liking and preference, the hedonic scale is more likely to be the most useful sensory method. The scale has been used extensively on a number of products with considerable success (Stone & Sidel, 2004:255). The scale has gained consideration because of its suitability in measurement of product acceptance and preference (Resurreccion, 1998:36). Naive consumers with minimal instruction can easily understand the scale, with the results being proven to be stable (Stone & Sidel, 2004:255). The scale as well as being easily understood is also easy to use by participants. Unlabelled check boxes can be used in place of integer numbers to avoid bias. These scales carry verbal end labels as to anchor the scale to a common frame of reference. The scale has a neutral middle; “neither like nor dislike” and on either side further scales until “like extremely” or “dislike extremely”. All verbal labels are the same for each individual question. The scale should be valid and measure the attribute, property or performance characteristic which is applicable to the study (Resurreccion, 1998:37); in this case the colour, flavour and texture for the experimental breads was considered for acceptance by measuring the participant(s) liking for the products.

Baked goods categorised as breads, quick breads, biscuits and muffins, cookies, crackers and cakes should follow set criteria for acceptance testing sampling. It is most important to minimise variability between the samples used. Ideally, in the case of bread to only use samples from the centre part of the baked loaf, exclude all edges and crusted ends or browned edges. In the case of appearance being evaluated it is important that there is a sufficient sized sample given (Resurreccion, 1998:58). In this study a sample size with no edges of 2 cm x 4 cm was used. These bread slices from which the sample sizes were obtained were taken from the whole loaf of baked bread (besides the crusted edges) similarly to what the consumer would expect from a commercial baked bread. The study focus was on the acceptance of the colour, flavour/taste and texture of the experimental breads. Smell was not a vital focus of this study as consumers would purchase commercial bread in plastic packets which are sealed, which would prevent smell from reaching the consumer prior to purchasing the bread. Although smell has an impact over the acceptance of the taste of a food item (Bennion & Scheule, 2000:10) the study focused on the flavour/taste, colour and textural acceptance of the experimental breads. As the smell/fragrance of rooibos, a herbal tea commonly consumed by South Africans, as well as being the extract used as the fluid in the experimental breads, may be a smell/fragrance easily recognised by the participants, smell/fragrance was not considered as on of the criteria for consumer acceptance. The possibility of the smell/fragrance of the rooibos used would be recognised by the participants. This may influence the acceptance of the experimental breads either through prejudice of liking or disliking the smell/fragrance of rooibos which means consumers may have the possibility of being prejudiced towards the product, prior to tasting or consuming the sample and therefore not provide an objective indication of acceptance/liking of the product.

The breads were served as the participants will consume it, i.e. with spread butter. Baked goods should also be served the right way up and samples such as bread held in sealed packaging until needed to prevent drying out of the samples. The samples are to be served at ambient temperature, which ranges from 18˚C to 24˚C (Resurreccion, 1998:58). In this study the experimental bread formulations were baked, cooled uncovered and placed in airtight containers. Slicing of the bread only took place one hour prior to the participant acceptance testing eating, during this time period the bread slices were also buttered and kept in airtight containers to prevent drying out. The bread was served without crusts and with butter spread and at room temperature.

3.7.2. Selection of participants

Ethical clearance was obtained on 23 April 2008 by the Research Ethics Committee of the Faculty of Applied Sciences, Cape Peninsula University of Technology (CPUT), in order to conduct the consumer acceptability study. The consumers were not to be requested to provide descriptive sensory characteristics, as they were not trained sensory evaluation panelists, but to indicate the acceptability (as the liking for the product) and purchase intent of the selected experimental breads in a constructed questionnaire (see 3.7.3).

The overall objective when selecting participants for the acceptance study is to select a homogenous group, all of whom are within the norm of likers of the product being tested and to be able to successfully exclude those individuals who may exhibit extreme response patterns on the questionnaire (Stone & Sidel, 2004:259). Because sensory acceptance studies usually make use of smaller numbers of participants, it is important to select those individuals who have a general likeness for the product; in this study those participants who consumed bread on a daily basis was asked to participate. Individuals with food allergies, food intolerances or dislike towards bread, wheat or tea were excluded from the study. The bread was also prepared in a facility that did not cater for religious or cultural requirements. Individuals who followed strict dietary and religious cooking preparations were not obliged to participate in the study. In marketing a basic concept often used is that all people and all consumers are not the same, but rather diverse. Not only will demographics such as age or gender influence food choice but also past experiences which could influence as opinion on sensory evaluating a food product (Wansink, 2003:23). Within this sample, participants would be expected to be heterogeneous regarding some demographic and biographic characteristics and homogenous regarding other demographic and biographic characteristics.

Participants were selected based on their individual willingness to participate, availability and their general consumption of baked products such as bread. Participants used formed part of the students attending CPUT evening class programs. These participants were selected as a convenient sample regarding their availability, but also being employed individuals earning an income and possibly being involved in food purchasing to a certain degree besides being available at a time convenient to the researcher to conduct the acceptance testing. The participation in this study was not only voluntary but also anonymous as no identification of the participants was required for the cross-sectional acceptance testing.

3.7.3. Questionnaire

The questionnaire (Addendum D) used consisted of two sections and was pre-screened by two persons qualified within the related field and experienced in consumer survey research for content-related evidence of validity. This was done to ensure the questioning domain reflected relevant information on the consumer demographic and biographic characteristics and the consumer acceptance testing regarding the experimental breads. The questionnaire was also pre-screened by these persons for face-related evidence of validity to ensure clarity of understanding of the questionnaire (Leedy & Ormrod, 2010:92) especially of the hedonic scale used for the consumer acceptance. The questionnaire was then pre-tested by ten persons representing the participant group to determine the participant understanding of questions within the questionnaire as well as if the time period of 15 to 20 minutes allocated to the participant involvement could be adhered to with ease. No major changes were made to the questionnaire.

The questions comprised of close-ended selection-type items and followed the general rules of constructing multiple-choice questions. This included giving the participant a set of possible responses from which they had to select the most appropriate answer (Gronlund, 1993:27, 47). The first section (Addendum D, Section A) consisted of general demographical, health status and health perception and awareness questions. The consumer acceptance was not only tested on whether the experimental bread was sensorically acceptable but also whether the experimental bread, or other food products which are found to be beneficial to health, would be purchased even if a higher price was attached.

The second and final section of the questionnaire made use of the 5-point hedonic scale to ascertain the sensory acceptance of the bread. Hedonic tests are related to an individual's preference rather than individuals evaluating differences within the food product. Participants of such tests are provided with a form/questionnaire which records their likes and dislikes according to a rank or rating relative to the sensory attribute being tested. The participants then rank/rate food products as follows: very poor/dislike very much, poor/dislike, fair/neither like nor dislike (neutral response), good/like and very good/like very much according to their preference (Murano, 2003:432). The response categories used was a 5-point combination of the traditional hedonic scale to provide for direct correspondence to the five category rating used for rating food product development (Murano:2003:432). All samples were evaluated as indicated according to colour, flavour, texture and overall purchasing probability (Addendum D, Section B). The buttered bread samples were served on white paper plates. Two experimental bread samples were selected for the sensory testing (the selection is explained in the results and discussion chapter which follows). Between each new sample, participants refreshed their mouths with water at room temperature. In the fields of nutritional science, dietetics, human nutrition and sensory studies, research is often focused on scaled questions which rate certain attributes such as sweetness, dryness and so forth. Although this data can easily be analysed another two types of measures can be used to increase the validity of the collected data, such as open ended responses and consumption intentions (Wansink, 2003:24). This questionnaire made use of close-ended questions including that of consumption intent.

3.7.4. Consumer acceptance testing sequence

Each participant was given an individual plate divided into sections marked A and B. Each section contained a bread sample, each bread sample representing the two experimental bread formulations selected on the attained TAC. The samples were served with crust removed and approximately 1 cm in thickness and 2 cm x 4 cm in size. Each sample was buttered (Butro butter spread). The sample was tested with butter as this is closely linked as the method in which a consumer would consume the product in their household environment on a daily basis. The participants all received an accompanying questionnaire to complete within the given amount of time of 15 minutes, including the acceptance testing as section B of the questionnaire (Addendum D).

3.8. Data analysis

The data was captured using Microsoft Excel. Descriptive statistics are used to indicate the TAC of the reference brown bread, the control bread and the experimental breads prepared through fluid manipulations using rooibos, honeybush and black tea at a 2% (w/v) and a 5% (w/v) concentration. The H-ORAC was expressed as µmol TE/g. The coded response data obtained through the completed questionnaires captured was cleaned after initial response frequency analysis. The data was imported into the MedCalcR Version 9.4.2.0. statistical analysis program. The independent students t-test with significance level 5% ($p < 0.05$) was used to compare the TAC of the different experimental bread formulation samples to that of the control bread formulation sample. The Pearson chi-square test was used to determine any associations/differences within the data categories indicated as response frequencies; i.e. between the participant sensory attribute acceptance of the experimental breads selected for the participant accepting testing (i.e. the bread appearance (colour), the bread flavour/taste and the bread texture) and the participant characteristics (as their demographic characteristics, their biographic characteristics and their functional food awareness, willingness to purchase foods with added health benefits and tea consumption). A significance level of $p < 0.05$ was used.

CHAPTER 4
RESULTS

4.1. Total antioxidant capacity of experimental breads and bread selection for consumer acceptance testing

The H-ORAC$_{FL}$ of the control bread formulation, which made use of water as the liquid, was significantly lower ($p < 0.05$ for each) to that of the experimental bread formulations containing rooibos and black tea at the 2% (w/v) concentrations. The H-ORAC$_{FL}$ of the control bread formulation was also significantly lower ($p < 0.05$ for each) to that of the experimental bread formulations containing rooibos, black tea and honeybush at the 5% (w/v) concentrations. The H-ORAC$_{FL}$ of all these experimental bread formulations was higher than that of the control bread formulation and in the range of approximately 47% [46.8% for the experimental rooibos bread formulation at 2% (w/v)] up to 173% [for the experimental black tea bread formulation at 5% (w/v)]. There was, however, no significant difference ($p > 0.05$) between the H-ORAC$_{FL}$ of the control bread formulation using water as the liquid and the experimental bread formulation using honeybush as the liquid at the 2% (w/v) concentration. The H-ORAC$_{FL}$ of the experimental honeybush formulation at 2% (w/v) was approximately 9% (8.8%) higher than the H-ORAC$_{FL}$ of the control bread formulation. The H-ORAC$_{FL}$ of the control bread formulation and that of the experimental bread formulations are indicated in Table 4.1. Similarly there was a significant difference ($p < 0.05$ for each) between the TAC of the commercial reference brown bread and both the experimental breads using black tea and rooibos at both the 2% (w/v) and 5% (w/v) concentration, as well as a significant difference ($p < 0.05$) between the TAC of the commercial reference brown bread and the experimental bread using honeybush at the 5% (w/v) concentration. No significant difference ($p > 0.05$) was found between the TAC of the commercial reference brown bread and the experimental bread using honeybush at the 2% (w/v) concentration.

Table 4.1: Total antioxidant capacity of the control and experimental bread formulations

Bread	Fluid	Fluid volume (ml)	Black/herbal tea concentration (%)[1]	H-ORAC$_{FL}$ (µmol TE/g)[2]
Reference/commercial bread	Water	Not known	0	9.22 ± 2.60[a]
Control	Water	400	0	7.70 ± 0.08[a]
Experimental	Rooibos	450	2	11.3 ± 1.03[b]
Experimental	Honeybush	450	2	8.38 ± 0.25[a]
Experimental	Black tea	450	2	11.77 ± 0.84[b]
Experimental	Rooibos	450	5	17.93 ± 0.87[b]
Experimental	Honeybush	450	5	13.79 ± 0.41[b]
Experimental	Black tea	450	5	21.02 ± 1.11[b]

[1] Volume per weight
[2] Total antioxidant capacity (TAC) indicated as average ± standard deviation and repersented by the hydrophilic (H) oxygen radical absorbance capacity (ORAC) expressed as micromole (µmol) Trolox Equivalents (TE) per gram (g)
[a] No significant difference ($p > 0.05$)
[ab] Significant difference ($p < 0.05$)

The breads selected for use in the consumer acceptance testing was chosen from the 2% (w/v) and 5% (w/v) experimental bread formulations. Although the H-ORAC$_{FL}$ of the experimental bread formulation using black tea at the 2% (w/v) concentration as the experimental liquid was slightly higher than that of the experimental bread formulation using rooibos at the 2% (w/v) concentration as the experimental liquid (11.77 ± 0.84 ɥmol TE/g versus 11.30 ± 1.03 ɥmol TE/g with a 4% difference) as well as the black tea experimental bread at a 5% (w/v) concentration having the highest H-ORAC$_{FL}$ (21.02 ± 1.11ɥmol TE/g) the experimental bread formulations using rooibos was selected for the consumer acceptability testing at both the 2% (w/v) and the 5% (w/v) concentrations. There was no significant difference ($p > 0.05$) between the experimental bread using black tea at a 2% (w/v) concentration and the experimental bread using rooibos at a 2% (w/v) concentration. There was however a significant difference ($p < 0.05$) between the experimental bread using black tea at a 5% (w/v) concentration with the latter having an approximately 15% lower TAC. This particular experimental bread formulation had a ‘golden-orange’ colour with a pungent smell due to the increase in rooibos concentration. The 5% (w/v) black tea experimental bread formulation, however, had noted negative sensory attributes of being densely textured with a very dark colour and a pungent and over powering taste of black tea (refer to 3.4.3.2). These sensory attribute and TAC results lead to the rooibos experimental breads containing rooibos at 5% (w/v) (as bread A) and 2% (w/v) (as bread B) chosen for the consumer acceptance testing and rooibos also being a proudly South African product.

4.2. Shelf life testing of the selected experimental breads.

Shelf life testing of the two selected experimental breads (bread A and bread B) was conducted over a period of four days, the approximate lifespan of fresh bread. The bread was visually assessed by the researcher over the four day period. The bread was sliced, approximately 1cm in thickness (the average thickness of commercially bought sliced bread) and stored in a plastic bag at room temperature, as available to consumers in retail outlets. Through this method of storage the bread slices was exposed to air, however consumers purchase sliced bread in plastic bags and once opened the sliced bread is often exposed to air during storage and usage. The bread was evaluated for the following characteristics: weight and height of bread per slice, textural properties as the crumb firmness and elasticity (the time taken for the sample to recover after being compressed, between thumb and forefinger, within ten seconds) and microbial growth, which visually assessed the degree at which mould developed on the individual slices (Giménez *et al.,* 2007:196).

The height (8cm) and weight (25g) of both bread slices remained unchanged for the time period of four days. The deterioration in the textural characteristics of both experimental breads was similar to each other. The crumb firmness of both bread A and B showed signs of becoming slightly hard from day three and on day four was firm to the touch with hardness around the crust with the edges of the bread breaking slightly. The elasticity of both breads, determined by the time taken for the bread to recover after being compressed for ten seconds, decreased slightly. When the breads were evaluated for this characteristic (taken from the center of the breads) both breads recovered moderately when pressed on day four. There was no mould development on both the bread slices within the specified four day lifespan. These shelf life testing results of the two experimental breads selected are indicated in Table 4.2

Table 4.2: Shelf life testing results of the experimental breads selected for the consumer acceptance testing

	Bread A[1]				Bread B[2]			
Shelf life testing criteria	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 1**	**Day 2**	**Day 3**	**Day 4**
Weight of bread per slice(g)	25	25	25	25	25	25	25	25
Height of breads per slice(cm)	8	8	8	8	9	9	9	9
Crumb firmness	Soft	Moderately firm	Moderately firm	Firm	Soft	Moderately firm	Moderately firm	Firm
Elasticity of bread [3]	Fully recover	Fully recover	Fully recover	Recover moderately	Fully recover	Fully recover	Recover moderately	Recover moderately
Bacterial growth[4]	None detected	None detected	None detected	None detected	None detected	None detected	None detected	None detected

[1] Experimental bread containing 5% (w/v) rooibos extract
[2] Experimental bread containing 2% (w/v) rooibos extract
[3] Time taken for the sample to recover after being compressed within ten seconds
[4] Determined as mould occurrence/growth on bread slice

4.3. Participant acceptance testing of the selected experimental bread formulations

4.3.1. Participant sample

All the invited volunteers who also consumed bread regularly (i.e. most days of the week) participated in the study. The participant sample comprised of 87 volunteers of which the questionnaires of 85 participants were fully completed and utilised in the study.

4.3.2. Participant demographic and biographic characteristics

Nearly 60% of the participants were female (57.6%). The majority of the participants were from the age groups 18 to 24 years (54.1%) and 25 to 34 years (31.7%). Only five of the participants were 45 years and older. The majority of the participants furthermore had an education level of between three and four years post-school education (71.7%) and were single and living on their own without children (76.4%) (see Table 4.3).

Table 4.3. Participant demographic characteristics

Participant demographic characteristics		n (n = 85)	%
Gender	Female	49	58
	Male	36	42
Age	18-24 years	46	54
	25-34 years	27	32
	35-44 years	7	8
	45-54 years	3	4
	55-60 years	2	2
	61 years and older	0	0
Post school education	1-2 years	6	7
	3-4 years	61	72
	5 and more years	18	21
Marital status	Married/living together without children	5	6
	Married/living together with children	10	12
	Single/living on own	65	76
	Single/living with children	5	6

The participants had to indicate their perception of their own health status and general health awareness (health consciousness perception) in relation to other adults of similar age. Most of the participants (55.2%) perceived themselves as having an optimal or normal body weight status, while somewhat less of the participants (37.6%) perceived themselves to be slightly overweight or overweight. Approximately 62% of the participants (62.3%) perceived themselves as having a similar health status as adults of the same age, while a similar number of participants perceived themselves as being as health conscious as other adults in their age group (40%) or perceived themselves as being more health conscious than adults of similar age (36.4%). The majority of the participants did not smoke (74.1%), were physically active (63.5%), did not have a family history of chronic disease (69.4%) and did not consume dietary supplements including vitamins, minerals, herbs, botanicals and amino acids (70.5%) (see Table 4.4).

Table 4.4: Participants biographic characteristics

Participant biographic characteristics		n (n = 85)	%
Perceived body weight status	Underweight	6	7
	Optimal/normal weight	47	55
	Slightly overweight/overweight	32	38
	Obese	0	0
Smoking[1]	Yes	22	26
	No	63	74
Physically active[2]	Yes	54	64
	No	31	36
Family history of chronic disease	Yes	26	31
	No	59	69
Dietary supplement user[3]	Yes	25	29
	No	60	71
Own perception of health status relative to other adults of similar age	Worse than most	3	4
	About similar to most	53	62
	Better than most	29	34
Health conciousness perception in relation to other adults of similar age	Much less than most	5	6
	Somewhat less than most	12	14
	About similar to most	34	40
	Somewhat more than most	31	36
	Much more than most	3	4

[1] Current smokers include those persons who smoked tabacco in the past 12 months and those who quit within the past year (Yusuf *et al.,* 2004:939)
[2] 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 (Yusuf *et al*., 2004:939)
[3] Dietary supplements include vitamins, minerals, herbs or botanicals, and amino acids intended to supplement the diet

Approximately 60% of the participants (63.5%) had not heard of the term ‘functional foods’. However, nearly all the participants (92.9%) indicated a willingness to purchase food with added health benefits and the majority (72.9%) of the participants was willing to pay more for food products with added health benefits (see Table 4.5). The majority of the participants consumed rooibos (75.3%), while the consumers of honeybush (18.8%) and black tea (21.2%) were in the minority compared to the green tea consumers (35.3%) (see Table 4.5).

Table 4.5: Participant functional food awareness, purchase willingness of foods with added health benefits and tea consumption

Participant functional food awareness and purchase willingness of foods with added health benefits		n (n= 85)	%
Awareness of functional foods	Yes	31	36
	No	54	64
Purchase willingness of foods with added health benefits	Yes	79	93
	No	6	7
Willingness to pay more for foods with added health benefits	Yes	62	73
	No	23	27
Participant tea consumption			
Black tea	Yes	18	21
	No	67	79
Honeybush	Yes	16	19
	No	69	81
Rooibos	Yes	64	75
	No	21	25
Green tea	Yes	30	35
	No	55	65
Other herbal teas	Yes	15	18
	No	70	82

4.3.3. Participant acceptance of the selected bread sensory attributes

The sensory attributes such as the colour, flavour/taste and texture of the selected breads were assessed according to the degree of liking by the participants. As indicated previously bread A was the experimental bread formulation containing rooibos at 5% (w/v) and bread B the experimental bread formulation containing rooibos at 2% (w/v).

4.3.3.1. Colour acceptance

No significant association/difference ($p > 0.05$) was found between the participant appearance/colour acceptance of breads A and B (see Table 4.6.). Approximately two thirds (67.1%) of the participants indicated that they liked (56.5%) the colour of bread A or liked the colour very much (10.6%) which was followed by the participants (23.5%) neither liking nor disliking (neutral response category) the colour of bread A. Although slightly more participants indicated that they liked the colour of bread B very much (15.3%) just more than half (56.5%) of the participants indicated that they either liked or liked the colour of bread B very much (41.2% and 15.3% respectively). This appearance/colour rating of ‘like’ and ‘neither like nor dislike’ by most of the participants for both breads A (80%) and B (72.9%) indicates the development of the breads as fair to good. Very few participants indicated that they disliked or disliked the colour of bread A and bread B very much (7.1% and 2.3% respectively for bread A and 8.2% and 3.5% for bread B) that would have represented poorly to very poorly developed breads. There was also no significant difference ($p > 0.05$) in the participant score for the appearance/colour of breads A and B. The participant appearance/color score for both breads A (3.66 ± 0.85) and B (3.56 ± 0.97) also represented fair to good developed breads considering the liking score rating of three as neither like nor dislike (or fair development) and four as like (or good development) (see Table 4.6).

Table 4.6. Participant acceptance rating of selected experimental breads

	Acceptance rating[a]										Bread score[b]	
Participant acceptance testing	Dislike very much[1]		Dislike[1]		Neither like nor dislike[1]		Like[1]		Like very much[1]		Average ± standard deviation	
Food product development	Very Poor		Poor		Fair		Good		Very Good			
Bread sensory attributes	Bread A	Bread B	Bread A	Bread B	Bread A	Bread B	Bread A	Bread B	Bread A	Bread B	Bread A	Bread B
Appearance/ Colour[c]	2.3% (n=2)	3.5% (n=3)	7.1% (n=6)	8.2% (n=7)	23.5% (n=20)	31.8% (n=27)	56.5% (n=48)	41.2% (n=35)	10.6% (n=9)	15.3% (n=13)	3.659 ± 0.853	3.565 ± 0.969
Flavour/ Taste[d]	2.3% (n=2)	0.0% (n=0)	10.5% (n=9)	9.4% (n=8)	7.1% (n=6)	21.2% (n=18)	55.3% (n=47)	41.2% (n=35)	24.7% (n=21)	28.2% (n=24)	3.894 ± 0.953	3.882 ± 0.867
Texture/ Mouthfeel[e]	1.2% (n=1)	1.2% (n=1)	3.5% (n=3)	4.7% (n=4)	16.5% (n=14)	15.3% (n=13)	50.6% (n=43)	44.7% (n=38)	28.2% (n=24)	34.1% (n=29)	4.012 ± 0.838	4.059 ± 0.891

[1] Acceptance rating scores: Dislike very much=1; Dislike=2; Neither like nor dislike=3; Like=4; Like very much=5

[ac, ae, bc, bd, be] No significant association/difference ($p > 0.05$)between the participant acceptance rating of the breads (a) and the bread scores (b) and the bread sensory attributes (c,d,e)

[ad] Significant association ($p < 0.05$) between the participant acceptance rating of the breads (a) and the flavour/taste sensory attribute (d)

4.3.3.2. Flavour/taste acceptance

There was a significant association ($p < 0.05$) between the participants' flavour/taste acceptance of breads A and B (see Table 4.6). About three-quarters of the participants indicated liking (response category 'like' or 'like very much') the flavour/taste of bread A (55.3% and 24.7%, respectively or 80% in total) as well as liking (response category 'like' and 'like very much' or 69.4%) the flavour/taste of bread B (41.2% and 28.2%, respectively), which indicates the development of the breads as good to very good. A number of the participants indicated to neither like nor dislike (neutral response category) the flavour/taste both bread A (7%) and B (21.2%) which indicates the development of the breads as being fair. Very few participants indicated to dislike the flavour/taste of both bread A and B (10.5% and 9.4%, respectively) which would have represented the developed breads as poor. The participants' flavour/taste score for both breads A (3.89 ± 0.87) and B (3.88 ± 0.87) indicates the developed breads as approaching good considering the liking score with no significant difference ($p > 0.05$) between these scores (see Table 4.6.).

4.3.3.3. Texture/mouthfeel acceptance

There was no significant association/difference ($p > 0.05$) between the participants' texture/mouthfeel acceptance of bread A and B (see Table 4.6.). The majority of participants (78.8%) indicated liking (response category 'like' and 'like very much') the texture/mouthfeel of bread A (50.5% and 28.2% respectively) with the same percentage of them (78.8%) indicating liking (response category 'like' and 'like very much') the texture/mouthfeel of bread B (44.7% and 34.1% respectively) showing the developed breads as being rated as being good to very good. A near equal percentage of participants indicated a neutral response (response category 'neither like nor dislike') for both bread A and B (15.6% and 15.3% respectively) which rated the developed breads as being fair. Very few participants (10.6%) indicated as disliking (response category 'dislike' and 'dislike very much') the texture/mouthfeel of bread A (3.5% and 1.2% respectively) and bread B (4.7% and 1.2% respectively) which would rate the developed breads score as poor to very poor (see Table 4.6.). There was also no significant difference ($p > 0.05$) in the participants' score for the texture/mouthfeel acceptance of bread A (4.01 ± 0.84) and bread B (4.06 ± 0.89) with the liking score ratings representing good developed breads based on their texture/mouthfeel (see Table 4.6.).

4.3.3.4. Overall acceptance

The overall acceptance of both the experimental bread formulations can be seen through the favourable acceptance of the sensory attributes by the participants. The three liking acceptance categories, including 'neither like nor dislike' (neutral response), 'like' and 'like very much' were the most common participant responses which scored the developed breads as fair, good and very good.

Although both experimental breads are rated very closely, bread A was rated higher in the response category ‘like’ with regards to the sensory attributes of appearance/colour, flavour/taste and texture/mouthfeel (56.5%, 55.3% and 50.5%, respectively) compared to the rating of bread B within the same category (41.2%, 41.2% and 44.7%, respectively) which indicated bread A to be scored as good for the food product. This was followed closely with bread B actually being rated higher within the response category ‘like very much’ regarding the sensory attributes of appearance/colour, flavour/taste and texture/mouthfeel (15.3%, 28.2% and 34.1%, respectively) compared to the rating of bread A within the same response category (10.6%, 24.7% and 28.2%, respectively) which scored both developed breads as very good. There was an overall willingness to purchase the experimental breads, with bread A being rated slightly higher than bread B regarding willingness to purchase and participants demographic, biographic and tea consumption respectively.

4.3.4. Associations between the participant acceptance of the experimental breads and their demographic characteristics

The demographic characteristics of the participants were associated with their sensory acceptance of the experimental breads to determine whether any participant demographic characteristic influenced the sensory liking of the experimental breads.

4.3.4.1. Colour acceptance

Most of the female and the male participants indicated liking (response categories of ‘like’ and ‘like very much’) the colour of bread A (65.3% and 69.4%, respectively) which was followed by them indicating to neither like nor dislike (neutral response category) the colour of bread A (22.4% and 25%, respectively of the female and the male participants) ($p > 0.05$). Gender also did not impact the colour acceptance of bread B ($p > 0.05$). Most of the female and male participants (59.2% and 52.8%) again indicated liking (response categories 'like' and 'like very much') the colour of bread B, which was followed by them indicating to neither like not dislike its colour (32.7% and 30.6%, respectively of the female and male participants).

The participant age groups also did not impact the colour acceptance of bread A nor bread B ($p > 0.05$ for each). Considering the two predominant age groups (18 to 24 years and 25 to 34 years) most of the participants in each of these age groups indicated liking (response categories 'like' and 'like very much') the colour of bread A (60.9% and 74.1%, respectively) and bread B (50% and 74.1%, respectively). This indication was again followed by a neutral response in each of these age groups (26.1% and 22.2%, respectively for bread A and 37.4% and 18.5%, respectively for bread B). The participant post-matric/-grade 12 educational level and their marital status also did not impact the colour acceptance of either of the breads ($p > 0.05$ for each). In each of the post-matric/-grade 12 educational levels (one to two years, three to four years, five or more years) most participants indicated liking (response categories of 'like' and 'like very much') the colour of both bread A (100%, 65.6% and 61.1%, respectively) and bread B (66.7%, 55.7% and 55.6%, respectively). Considering the two predominant marital status groups (married/living together with children and single living on own) most participants again indicated liking (response categories of 'like' and 'like very much') the colour of both bread A (80% and 67.7%, respectively) and bread B (50% and 60%, respectively) ($p > 0.05$ for each).

Table 4.7: Associations between the participant colour acceptance of the experimental breads and their demographic characteristics

Participant demographic charcateristics		n[1]	Degree of colour acceptance of bread (n = 85)									
			Bread A[a]					Bread B[b]				
			Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Gender[c]	Female	49	4% (n=2)	8% (n=4)	22% (n=11)	59% (n=29)	6% (n=3)	4% (n=2)	4% (n=2)	33% (n=16)	47% (n=23)	12% (n=6)
	Male	36	0% (n=0)	6% (n=2)	25% (n=9)	53% (n=19)	17% (n=6)	3% (n=1)	14% (n=5)	31% (n=11)	39% (n=12)	19% (n=7)
Age[d]	18-24 years	46	4% (n=2)	9% (n=4)	26% (n=12)	54% (n=25)	7% (n=3)	4% (n=2)	9% (n=4)	37% (n=17)	41% (n=19)	9% (n=4)
	25-34 years	27	0% (n=0)	4% (n=1)	22% (n=6)	56% (n=15)	19% (n=5)	4% (n=1)	4% (n=1)	19% (n=5)	56% (n=15)	19% (n=5)
	35-44 years	7	0% (n=0)	14% (n=1)	14% (n=1)	57% (n=4)	14% (n=1)	0% (n=0)	14% (n=1)	29% (n=2)	14% (n=1)	43% (n=3)
	45-54 years	3	0% (n=0)	0% (n=0)	0% (n=0)	100% (n=3)	0% (n=0)	0% (n=0)	0% (n=0)	67% (n=2)	0% (n=0)	33% (n=1)
	55-60 years	2	0% (n=0)	0% (n=0)	50% (n=1)	50% (n=1)	0% (n=0)	0% (n=0)	50% (n=1)	50% (n=1)	0% (n=0)	0% (n=0)
Post school Education[e]	1-2 years	6	0% (n=0)	0% (n=0)	0% (n=0)	100% (n=6)	0% (n=0)	0% (n=0)	17% (n=1)	17% (n=1)	33% (n=2)	33% (n=2)
	3-4 years	61	3% (n=2)	8% (n=5)	23% (n=14)	56% (n=34)	10% (n=6)	5% (n=3)	5% (n=3)	34% (n=21)	44% (n=27)	11% (n=7)
	5 and more years	18	0% (n=0)	6% (n=1)	33% (n=6)	44% (n=8)	17% (n=3)	0% (n=0)	17% (n=3)	28% (n=5)	44% (n=6)	22% (n=4)
Marital status[f]	Married/living together without children	5	0% (n=0)	0% (n=0)	40% (n=2)	60% (n=3)	0% (n=0)	0% (n=0)	20% (n=1)	60% (n=3)	0% (n=0)	20% (n=1)
	Married/living together with children	10	0% (n=0)	0% (n=0)	20% (n=2)	70% (n=7)	10% (n=1)	0% (n=0)	10% (n=1)	40% (n=4)	40% (n=3)	20% (n=2)
	Single/living on own	65	3% (n=2)	6% (n=4)	23% (n=15)	55% (n=36)	12% (n=8)	5% (n=3)	8% (n=5)	281% (n=18)	46% (n=30)	14% (n=9)
	Single/living with children	5	0% (n=0)	40% (n=2)	20% (n=1)	40% (n=2)	0% (n=0)	0% (n=0)	0% (n=0)	40% (n=2)	40% (n=2)	20% (n=1)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
N[1] = Participant number within each demographic characteristic group as indicated in Table 4.3.
[ac, ad, ae, af, bc, bd, be, bf] No significant association/difference ($p > 0.05$) between the participant colour acceptance of bread A/B (a,b) and the participant demographic characteristic (c,d,e,f)

4.3.4.2. Flavour/taste acceptance

The participant gender, age groups, post matric/-grade 12 educational levels and their marital status also did not impact their flavour acceptance for either bread A ($p > 0.05$ for each) or bread B ($p > 0.05$ for each) (Table 4.8). Most of the female and male participants indicated liking (response categories of ‘like’ and ‘like very much’) the flavour/taste of bread A (81.6% and 77.8%, respectively) and bread B (63.3% and 77.8%, respectively) ($p > 0.05$ for each). In the two predominant age groups (18 to 24 years and 25 to 34 years) and the marital status groups (married/living together with children and single/living on own) most participants indicated liking (response categories ‘like’ and ‘like very much’) the flavour/taste of both bread A (76.1% and 81.5%, respectively and 100% and 78.5%, respectively) and bread B (63% and 81.5%, respectively and 60% and 73.8%, respectively) ($p > 0.05$ for each). Most of the participants in each of the educational groupings (one to two years, three to four years and five or more years post school education) indicated liking (response categories ‘like’ and ‘like very much’) the flavour/taste of bread A (83.3%, 80.3% 77.8%, respectively) as well as bread B (100%, 70.5% and 55.6%, respectively) ($p > 0.05$ for each).

Table 4.8: Associations between the participant flavour/taste acceptance of the experimental breads and their demographic characteristics

Participant demographic charcateristics		n[1]	Degree of flavour/taste acceptance of bread (n = 85)									
			Bread A[a]					Bread B[b]				
			Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Gender[c]	Female	49	2% (n=0)	8% (n=4)	10% (n=5)	53% (n=26)	29% (n=14)	0% (n=0)	10% (n=5)	27% (n=13)	31% (n=15)	33% (n=16)
	Male	36	6% (n=2)	14% (n=5)	3% (n=1)	58% (n=21)	19% (n=7)	0% (n=0)	8% (n=3)	14% (n=5)	56% (n=20)	22% (n=8)
Age[d]	18-24 years	46	4% (n=2)	11% (n=5)	9% (n=4)	50% (n=23)	26% (n=12)	0% (n=0)	11% (n=5)	26% (n=12)	41% (n=19)	22% (n=10)
	25-34 years	27	0% (n=0)	15% (n=4)	4% (n=1)	59% (n=16)	22% (n=6)	0% (n=0)	7% (n=2)	11% (n=3)	44% (n=12)	37% (n=10)
	35-44 years	7	0% (n=0)	0% (n=0)	0% (n=0)	71% (n=5)	29% (n=2)	0% (n=0)	14% (n=1)	0% (n=0)	43% (n=3)	43% (n=3)
	45-54 years	3	0% (n=0)	0% (n=0)	0% (n=0)	67% (n=2)	33% (n=1)	0% (n=0)	0% (n=0)	33% (n=1)	33% (n=1)	33% (n=1)
	55-60 years	2	0% (n=0)	0% (n=0)	50% (n=1)	50% (n=1)	0% (n=0)	0% (n=0)	0% (n=0)	100% (n=2)	0% (n=0)	0% (n=0)
Post school Education[e]	1-2 years	6	0% (n=0)	17% (n=1)	0% (n=0)	83% (n=5)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	67% (n=4)	33% (n=2)
	3-4 years	61	3% (n=2)	10% (n=6)	7% (n=4)	51% (n=31)	30% (n=18)	0% (n=0)	8% (n=5)	21% (n=13)	41% (n=25)	30% (n=18)
	5 and more years	18	0% (n=0)	11% (n=2)	11% (n=2)	61% (n=11)	17% (n=3)	0% (n=0)	17% (n=3)	28% (n=5)	33% (n=6)	22% (n=4)
Marital status[f]	Married/living together without children	5	0% (n=0)	0% (n=0)	40% (n=2)	40% (n=2)	20% (n=1)	0% (n=0)	40% (n=2)	40% (n=2)	0% (n=0)	20% (n=1)
	Married/living together with children	10	0% (n=0)	0% (n=0)	0% (n=0)	80% (n=8)	20% (n=2)	0% (n=0)	10% (n=1)	30% (n=3)	40% (n=4)	20% (n=2)
	Single/living on own	65	3% (n=2)	12% (n=8)	6% (n=4)	51% (n=33)	28% (n=18)	0% (n=0)	8% (n=5)	18% (n=12)	45% (n=29)	29% (n=19)
	Single/living with children	5	0% (n=0)	20% (n=1)	0% (n=0)	80% (n=4)	0% (n=0)	0% (n=0)	0% (n=0)	20% (n=1)	40% (n=2)	40% (n=2)

Bread A - Experimental bread containing 5% (w/v) rooibos extract

Bread B - Experimental bread containing 2% (w/v) rooibos extract

n[1] = Participant number within each demographic characteristic group as indicated in Table 4.3.

[ac, ad, ae, af, bc, bd, be, bf] No significant association/difference ($p > 0.05$) between the participant flavour/taste acceptance of bread A/B (a,b) and the participant demographic characteristic (c,d,e,f)

4.3.4.3. Texture acceptance

As with the colour and the flavour/taste acceptance testing of the breads, most of the participants irrespective of their demographic groupings for their gender, age, post-school educational level and marital status, also indicated liking (response categories ‘like’ and ‘like very much’) the texture of both bread A and bread B (Table 4.9.). Most of the female and male participants indicated liking the texture of both breads A and B (79.6% and 77.8%, respectively for both) ($p > 0.05$ for each). Most of the participants in each of the post school education level groups (one to two years, three to four years and five or more years) also indicated liking the texture of bread A (50%, 80.3% and 83.3%, respectively) ($p > 0.05$) as well as bread B (83.3%, 81% and 66.7%, respectively) ($p > 0.05$). In both the predominant age (18 to 24 years and 25 to 34 years old) and marital status (married/living together with children and single/living on own) groups most participants indicated liking the texture of both bread A (76.1% and 74.1%, respectively and 100% and 76.9%, respectively) ($p > 0.05$ for each) and bread B (73.9% and 92.6%, respectively and 70% and 80%, respectively) ($p > 0.05$ for each).

Table 4.9: Associations between the participant textural acceptance of the experimental breads and their demographic characteristics

Participant demographic charcateristics		n[1]	Degree of textural acceptance of bread (n = 85)									
			Bread A[a]					Bread B[b]				
			Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Gender[c]	Female	49	0% (n=0)	2% (n=1)	18% (n=9)	49% (n=24)	31% (n=15)	0% (n=0)	2% (n=1)	22% (n=9)	51% (n=25)	29% (n=14)
	Male	36	3% (n=1)	6% (n=2)	14% (n=-5)	53% (n=19)	25% (n=9)	3% (n=1)	8% (n=3)	11% (n=4)	36% (n=13)	42% (n=15)
Age[d]	18-24 years	46	2% (n=1)	2% (n=1)	20% (n=9)	48% (n=22)	28% (n=13)	2% (n=1)	4% (n=2)	20% (n=9)	46% (n=21)	28% (n=13)
	25-34 years	27	0% (n=0)	7% (n=2)	19% (n=-5)	44% (n=12)	30% (n=8)	0% (n=0)	4% (n=1)	4% (n=1)	41% (n=11)	52% (n=14)
	35-44 years	7	0% (n=0)	0% (n=0)	0% (n=0)	71% (n=5)	29% (n=2)	0% (n=0)	14% (n=1)	0% (n=0)	71% (n=5)	14% (n=1)
	45-54 years	3	0% (n=0)	0% (n=0)	0% (n=0)	100% (n=3)	0% (n=0)	0% (n=0)	0% (n=0)	67% (n=2)	0% (n=0)	33% (n=1)
	55-60 years	2	0% (n=0)	0% (n=0)	0% (n=0)	50% (n=1)	50% (n=1)	0% (n=0)	0% (n=0)	50% (n=1)	50% (n=1)	0% (n=0)
Post school Education[e]	1-2 years	6	0% (n=0)	17% (n=1)	33% (n=2)	33% (n=2)	17% (n=1)	0% (n=0)	0% (n=0)	17% (n=1)	67% (n=4)	17% (n=1)
	3-4 years	61	7% (n=1)	0% (n=0)	18% (n=11)	52% (n=32)	28% (n=17)	0% (n=0)	3% (n=2)	15% (n=9)	46% (n=28)	36% (n=22)
	5 and more years	18	0% (n=0)	11% (n=2)	6% (n=1)	50% (n=9)	33% (n=6)	6% (n=1)	11% (n=2)	17% (n=3)	33% (n=6)	33% (n=6)
Marital status[f]	Married/living together without children	5	0% (n=0)	0% (n=0)	20% (n=1)	80% (n=4)	0% (n=0)	0% (n=0)	20% (n=1)	20% (n=1)	40% (n=2)	20% (n=1)
	Married/living together with children	10	0% (n=0)	0% (n=0)	0% (n=0)	70% (n=7)	30% (n=3)	0% (n=0)	0% (n=0)	30% (n=3)	60% (n=6)	10% (n=1)
	Single/living on own	65	2% (n=1)	5% (n=3)	17% (n=11)	45% (n=29)	32% (n=21)	2% (n=1)	6% (n=3)	14% (n=9)	40% (n=26)	40% (n=26)
	Single/living with children	5	0% (n=0)	0% (n=0)	40% (n=2)	60% (n=3)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	80% (n=4)	20% (n=1)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
n[1] = Participant number within each demographic characteristic group as indicated in Table 4.3.
[ac, ad, ae, af, bc, bd, be, bf] No significant association/difference ($p > 0.05$) between the participant textural acceptance of bread A/B (a,b) and the participant demographic characteristic (c,d,e,f)

4.3.5. Associations between the participant acceptance of the experimental breads and their biographic characteristics

The participant biographic characteristics such as their perceived body weight status, smoking status, physical activity status, family history of chronic disease, use of dietary supplements, perceived health status and health consciousness in relation to other adults of similar age were also associated with their sensory acceptance of the experimental breads to consider whether any of these factors influenced the acceptance of the sensory attributes of the experimental breads.

4.3.5.1. Colour acceptance

Most participants who perceived themselves to be of a optimal/normal body weight status or being slightly overweight/overweight indicated that they liked (response category 'like') the colour of bread A (51.1% and 68.8%, respectively), while of those participants who perceived themselves as underweight an equal percentage indicated being neutral to and liking (response categories 'neither like nor dislike' and 'like') the colour of bread A (33.3%, respectively) ($p < 0.05$). With regard to the colour of bread B most of the participants whether they perceived themselves as being of optimal/normal body weight status, slightly overweight/overweight or underweight indicated that they liked it (42.6%, 40.6% and 33.3%, respectively) ($p > 0.05$). Most of participants whether non-smokers or smokers indicated liking (response category 'like') the colour of bread A (50.8% and 72.7%, respectively) and bread B (41.3% and 40.9%, respectively) which was followed by a neutral response (response category 'neither like nor dislike') towards the colour for both bread A (23.8% and 22.7%, respectively) and bread B (30.1% and 36.4%, respectively) ($p > 0.05$ for each). Most of the participants who indicated being physically active indicated that they liked the colour of bread A (61.1%) which was followed by an equal percentage who indicated that they liked the colour of bread A very much or neither liked or disliked (neutral response) its colour (14.8%, respectively). In contrast most of the participants who indicated not being physically active indicated that they liked the colour of bread A (48.4%) which was followed closely by of them indicating neither liking nor disliking its colour (38.7%) ($p < 0.5$). Among these participants, whether physically active or not, most indicated liking the colour of bread B (38.9% and 45.2%, respectively) which was followed closely by them indicating neither to like nor dislike the colour (29.6% and 35.5%, respectively) ($p > 0.05$). Most of the participants who indicated no family history or a family history of chronic disease indicated liking (response category 'like') the colour of bread A (52.5% and 65.4%, respectively) ($p > 0.05$). While most of the participants who indicated no family history of chronic disease also indicated liking the colour of bread B (44.1%), most of the participants who indicated a family history of chronic disease indicated neither liking nor disliking (neutral response category) the colour of bread B (46.2%) which was followed by them liking it (34.6%). This difference in colour acceptance was, however, not significant ($p > 0.05$). Most of the participants not consuming or consuming dietary supplements indicated liking (response category 'like') the colour of both bread A (55% and 60%, respectively) and bread B (41.7% and 40%, respectively) ($p > 0.05$ for each). In the two predominant perceived health status categories in relation to other adults of similar age ('about similar to most' and 'better than most') most participants again indicated a liking (response category 'like') of the colour of bread A (60.4% and 51.7%, respectively) and bread B (37.7% and 48.2%, respectively) ($p > 0.05$ for each). In the two most predominant health consciousness perception categories in relation to other adults of similar age ('about similar to most' and 'somewhat more than most') participants also mostly indicated liking (response category 'like') the colour of both bread A (55.9% and 58.1%, respectively) and bread B (38.2% and 45.2%, respectively) ($p > 0.05$ for each) (see Table 4.10).

Table 4.10: Associations between the participant colour acceptance of the experimental breads and their biographic characteristics

			Degree of colour acceptance of bread (n = 85)									
			Bread A[a]					Bread B[b]				
Participant biographic characteristics		n[1]	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Perceived body weight status[c]	Underweight	6	17% (n=1)	0% (n=0)	33% (n=2)	33% (n=2)	17% (n=1)	0% (n=0)	17% (n=1)	17% (n=1)	33% (n=2)	33% (n=2)
	Optimal/normal weight	47	2% (n=1)	13% (n=6)	23% (n=9)	51% (n=24)	15% (n=7)	6% (n=2)	9% (n=4)	30% (n=14)	45% (n=20)	15% (n=7)
	Slightly overweight/overweight	32	0% (n=0)	0% (n=0)	28% (n=9)	69% (n=22)	3% (n=1)	3% (n=1)	6% (n=2)	38% (n=12)	41% (n=13)	13% (n=4)
	Obese	0	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)
Smoking[d]	Yes	22	0% (n=0)	5% (n=1)	23% (n=5)	73% (n=16)	0% (n=0)	0% (n=0)	5% (n=1)	36% (n=8)	41% (n=9)	18% (n=4)
	No	63	3% (n=2)	8% (n=5)	24% (n=15)	51% (n=32)	14% (n=9)	5% (n=3)	10% (n=6)	30% (n=19)	41% (n=26)	14% (n=9)
Physically active[e]	Yes	54	4% (n=2)	6% (n=3)	15% (n=8)	61% (n=33)	15% (n=8)	4% (n=2)	9% (n=5)	30% (n=16)	39% (n=21)	19% (n=10)
	No	31	0% (n=0)	10% (n=3)	39% (n=12)	48% (n=15)	2% (n=1)	2% (n=1)	6% (n=2)	35% (n=11)	45% (n=14)	10% (n=3)
Family history of chronic disease[f]	Yes	26	0% (n=0)	8% (n=2)	27% (n=7)	65% (n=17)	0% (n=0)	0% (n=0)	0% (n=0)	46% (n=12)	35% (n=9)	19% (n=5)
	No	59	3% (n=2)	7% (n=4)	22% (n=13)	53% (n=31)	15% (n=9)	5% (n=3)	12% (n=7)	25% (n=15)	44% (n=26)	14% (n=8)
Dietary supplement user[g]	Yes	25	4% (n=1)	0% (n=0)	24% (n=6)	60% (n=15)	12% (n=3)	4% (n=1)	8% (n=2)	28% (n=7)	40% (n=10)	20% (n=5)
	No	60	2% (n=1)	10% (n=6)	23% (n=14)	55% (n=33)	10% (n=6)	3% (n=2)	8% (n=5)	33% (n=20)	42% (n=25)	13% (n=8)
Own perception of health status in relation to other adults of similar age[h]	Worse than most	3	0% (n=0)	0% (n=0)	67% (n=2)	33% (n=1)	0% (n=0)	0% (n=0)	0% (n=0)	67% (n=2)	33% (n=1)	0% (n=0)
	About similar to most	53	0% (n=0)	9% (n=5)	17% (n=9)	60% (n=32)	13% (n=7)	0% (n=0)	8% (n=4)	36% (n=19)	38% (n=20)	19% (n=10)
	Better than most	29	7% (n=2)	3% (n=1)	31% (n=9)	52% (n=15)	7% (n=2)	10% (n=3)	10% (n=3)	21% (n=6)	48% (n=14)	10% (n=3)
Health conciousness perception in relation to other adults of similar age[i]	Much less than most	4	25% (n=1)	0% (n=0)	0% (n=0)	75% (n=3)	0% (n=0)	0% (n=0)	25% (n=1)	50% (n=2)	0% (n=0)	25% (n=1)
	Somewhat less than most	12	0% (n=0)	0% (n=0)	33% (n=4)	50% (n=6)	17% (n=2)	0% (n=0)	8% (n=1)	33% (n=4)	50% (n=6)	8% (n=1)
	About similar to most	34	3% (n=1)	9% (n=3)	24% (n=8)	56% (n=19)	9% (n=3)	6% (n=2)	9% (n=3)	29% (n=10)	38% (n=13)	18% (n=6)
	Somewhat more than most	31	0% (n=0)	10% (n=3)	23% (n=7)	58% (n=18)	10% (n=3)	0% (n=0)	6% (n=2)	35% (n=11)	45% (n=14)	13% (n=4)
	Much more than most	4	0% (n=0)	0% (n=0)	125% (n=1)	50% (n=2)	25% (n=1)	25% (n=1)	0% (n=0)	0% (n=0)	50% (n=2)	25% (n=1)

Bread A - Experimental bread containing 5% (w/v) rooibos extract

Bread B - Experimental bread containing 2% (w/v) rooibos extract

n[1] = participant number within each biographic characteristic group as indicated in Table 4.4.

[ad, af, ag, ah, ai, bc, bd, be, bf, bg, bh, bi] No significant association/difference ($p > 0.05$) between the participant colour acceptance of bread A/B (a,b) and the participant biographic characteristic (c, d,e, f, g,h, i)

[ac, ae] Significant difference ($p < 0.05$) between the participant colour acceptance of bread A (a) and the participant perception of their own weight status (c) and physical activity level (e)

4.3.5.2. Flavour/taste acceptance

The participant biographic categories of perceived body weight status, smoking status, physical activity status, family history of chronic disease, dietary supplement use and own health perception relative to other adults of similar age had no influence on the participants' acceptance of the flavour/taste of the experimental breads ($p > 0.05$ for each for both breads A and B) (see Table 4.11.). Of the two predominant body weight status perception categories ('optimal/normal weight' and 'slightly overweight/overweight') most participants in each indicated liking (response category 'like') the flavour/taste of both bread A (46.8% and 68.8%, respectively) and bread B (40.4% and 40.6%, respectively) ($p > 0.05$ for each). Most of the participants who did not smoke and who smoked indicated liking (response categories 'like') the flavour/taste of bread A (53.9% and 59.0%, respectively) and bread B (39.7% and 45.4%, respectively) ($p > 0.05$ for each).

Table 4.11: Associations between the participant flavour/taste acceptance of the experimental breads and their biographic characteristics

Participant biographic characteristics		n[1]	Bread A[a]: Dislike very much	Bread A[a]: Dislike	Bread A[a]: Neither like nor dislike	Bread A[a]: Like	Bread A[a]: Like very much	Bread B[b]: Dislike very much	Bread B[b]: Dislike	Bread B[b]: Neither like nor dislike	Bread B[b]: Like	Bread B[b]: Like very much
			Degree of flavour/taste acceptance of bread (n = 85)									
Perceived body weight status[c]	Underweight	6	0% (n=0)	0% (n=0)	0% (n=0)	67% (n=4)	33% (n=2)	0% (n=0)	0% (n=0)	17% (n=1)	50% (n=3)	33% (n=2)
	Optimal/normal weight	47	4% (n=2)	15% (n=7)	6% (n=3)	47% (n=22)	28% (n=13)	0% (n=0)	11% (n=5)	23% (n=11)	40% (n=19)	26% (n=12)
	Slightly overweight/overweight	32	0% (n=0)	6% (n=2)	9% (n=3)	69% (n=22)	19% (n=6)	0% (n=0)	9% (n=3)	19% (n=6)	41% (n=13)	31% (n=10)
	Obese	0	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)
Smoking[d]	Yes	22	0% (n=0)	5% (n=1)	9% (n=2)	59% (n=13)	27% (n=6)	0% (n=0)	9% (n=2)	18% (n=4)	45% (n=10)	27% (n=6)
	No	63	3% (n=2)	13% (n =8)	6% (n=4)	54% (n=34)	24% (n=15)	0% (n=0)	9% (n=6)	22% (n=14)	40% (n=25)	29% (n=18)
Physically active[e]	Yes	54	2% (n=1)	9% (n=5)	7% (n=4)	52% (n=28)	30% (n=16)	0% (n=0)	7% (n=4)	24% (n=13)	44% (n=24)	24% (n=13)
	No	31	3% (n=1)	13% (n=4)	6% (n=2)	61% (n=19)	16% (n=5)	0% (n=0)	13% (n=4)	16% (n=5)	35% (n=11)	35% (n=11)
Family history of chronic disease[f]	Yes	26	0% (n=0)	4% (n=1)	12% (n=3)	73% (n=19)	12% (n=3)	0% (n=0)	8% (n=2)	15% (n=4)	38% (n=10)	38% (n=10)
	No	59	3% (n=2)	14% (n =8)	5% (n=3)	47% (n=28)	31% (n=18)	0% (n=0)	10% (n=6)	24% (n=14)	42% (n=25)	24% (n=14)
Dietary supplement user[g]	Yes	25	0% (n=0)	12% (n=3)	8% (n=2)	52% (n=13)	28% (n=7)	0% (n=0)	16% (n=4)	24% (n=6)	32% (n=8)	28% (n=7)
	No	60	3% (n=2)	10% (n=6)	7% (n=4)	57% (n=34)	23% (n=14)	0% (n=0)	7% (n=4)	20% (n=12)	45% (n=27)	28% (n=17)
Own perception of health status in relation to other adults of similar age[h]	Worse than most	3	0% (n=0)	0% (n=0)	0% (n=0)	67% (n=2)	33% (n=1)	0% (n=0)	0% (n=0)	33% (n=1)	33% (n=1)	33% (n=1)
	About similar to most	53	4% (n=2)	6% (n=3)	2% (n=1)	64% (n=34)	25% (n=13)	0% (n=0)	13% (n=7)	13% (n=7)	42% (n=22)	30% (n=16)
	Better than most	29	0% (n=0)	21% (n=6)	17% (n=5)	38% (n=11)	24% (n=7)	0% (n=0)	3% (n=1)	31% (n=9)	41% (n=12)	24% (n=7)
Health conciousness perception in relation to other adults of similar age[i]	Much less than most	4	0% (n=0)	0% (n=0)	0% (n=0)	50% (n=2)	50% (n=2)	0% (n=0)	25% (n=1)	25% (n=1)	25% (n=1)	25% (n=1)
	Somewhat less than most	12	8% (n=1)	8% (n=1)	0% (n=0)	33% (n=4)	50% (n=6)	0% (n=0)	0% (n=0)	17% (n=2)	50% (n=6)	33% (n=4)
	About similar to most	34	0% (n=0)	18% (n=6)	12% (n=4)	50% (n=17)	21% (n=7)	0% (n=0)	6% (n=2)	12% (n=4)	47% (n=16)	35% (n=12)
	Somewhat more than most	31	3% (n=1)	6% (n=2)	0% (n=0)	74% (n=23)	16% (n=5)	0% (n=0)	13% (n=4)	29% (n=9)	39% (n=12)	19% (n=6)
	Much more than most	4	0% (n=0)	0% (n=0)	50% (n=2)	25% (n=1)	25% (n=1)	0% (n=0)	25% (n=1)	50% (n=2)	0% (n=0)	25% (n=1)

Bread A - Experimental bread containing 5% (w/v) rooibos extract

Bread B - Experimental bread containing 2% (w/v) rooibos extract

n[1] = participant number within each biographic characteristic group as indicated in Table 4.4.

[ac, ad, ae, af, ag, ah, ai, bc, bd, be, bf, bg, bh, bi] No significant association/difference ($p > 0.05$) between the participant flavour/taste acceptance of bread A/B (a, b) and participant biographic characteristic (c, d, e, f, g, h, i)

[ai] Significant difference ($p < 0.05$) between the particpant flavour/taste acceptance of bread A (a) and their health consciousness perception in relation to other adults of similar age (i)

The majority of the participants who indicated being physically active indicated liking (response categories ‘like’ and ‘like very much’) the flavour/taste of both bread A (51.9% and 29.6%, respectively) and bread B (44.4% and 24.1%, respectively). Less than half of the participants indicated not partaking in physical activity but the majority of them also indicated liking (response categories ‘like’ and ‘like very much’) the flavour/taste of both bread A (61.3% and 16.1%, respectively) and bread B (35.5% for both categories) ($p > 0.05$ for each). Most participants not having a family history of chronic disease indicated liking (response category ‘like’) the flavour/taste of bread A and bread B (47.4% and 42.4%, respectively). Most of those participants with a family history of chronic disease also indicated liking (response categories ‘like’ and ‘like very much’) the flavour/taste of both bread A (73.1% and 11.5%, respectively) and bread B (38.5% for both categories) ($p > 0.05$ for each). Most of the participants who did not consume and consumed dietary supplements indicated liking (response category ‘like’) the flavour/taste of both bread A (56.7% and 45%, respectively) and bread B (52.0% and 32.0%, respectively) ($p > 0.05$ for each).

Of the two most predominant category perceptions of own health status in relation to other adults of similar age (‘about similar to most’ and ‘better than most’), most participants indicated a liking (response categories ‘like’ and ‘like very much’) the flavour/taste of both bread A (64.1% and 37.9%, respectively) and bread B (41.5% and 41.4%, respectively) ($p > 0.05$ for each). In the two most predominant categories of the participant health consciousness perceptions in relation to adults of similar age (‘about similar to most’ and ‘somewhat more than most’), most participants indicated liking (response category ‘like’) the flavour/taste of bread A (50% and 74.2%, respectively) which was followed by them indicating liking bread A very much (response category ‘like very much’) (20.6% and 16.1%, respectively). However no participant who perceived them self to be as health conscious as other adults of their age indicated to dislike bread A very much (response category ‘dislike very much’), while no participant who perceived them self to be more health conscious than other adults of their age indicated to neither dislike nor like (neutral response category) bread A ($p < 0.05$). Most participants in both these two predominant health consciousness perception categories indicated liking (response category 'like') the flavour/taste of bread B (47% and 38.7%, respectively) ($p > 0.05$) (see Table 4.11).

4.3.5.2. Texture acceptance

The biographic factors of own perception of body weight status, smoking status, family history of chronic disease, dietary supplement use, perceived health status and health consciousness perception in relation to other adults of similar age had no influence on the participants' acceptance of the textural qualities of the experimental breads ($p > 0.05$ for each) with the exception of the physical activity status that significantly influenced bread B only ($p < 0.05$) (see Table 4.12). In the two most predominant categories of the participants own perception of their body weight status ('optimal/normal weight' and 'slightly overweight/overweight') most participants indicated liking (response category 'like') the texture of both bread A (59.6% and 43.8%, respectively) and bread B (38.3% and 53.1%, respectively) ($p > 0.05$ for each). Of those participants who did not smoke and who smoked, most indicated liking (response categories 'like') the textural qualities of both bread A (49.2% and 54.5%, respectively) and bread B (47.6% and 36.4%, respectively). Among these same participants, both non-smokers and smokers, many also indicated liking the texture very much (response category 'like very much') of both bread A (30.2% and 22.7%, respectively) and bread B (31.7% and 40.9%, respectively) ($p > 0.05$ for each).

Table 4.12: Associations between the participant textural acceptance of the experimental breads and their biographic characteristics

			Degree of textural acceptance of bread (n = 85)									
			Bread A[a]					Bread B[b]				
Participant biographic characteristics		n[1]	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Perceived body weight status[c]	Underweight	6	0% (n=0)	0% (n=0)	17% (n=1)	17% (n=1)	67% (n=4)	0% (n=0)	0% (n=0)	17% (n=1)	50% (n=3)	33% (n=2)
	Optimal/normal weight	47	2% (n=1)	6% (n=3)	13% (n=6)	60% (n=28)	19% (n=9)	2% (n=1)	6% (n=3)	17% (n=8)	38% (n=18)	36% (n=17)
	Slightly overweight/overweight	32	0% (n=0)	0% (n=0)	22% (n=7)	44% (n=14)	34% (n=11)	0% (n=0)	3% (n=1)	13% (n=4)	53% (n=17)	31% (n=10)
	Obese	0	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)
Smoking[d]	Yes	22	0% (n=0)	5% (n=1)	18% (n=4)	55% (n=12)	23% (n=5)	0% (n=0)	14% (n=3)	9% (n=2)	36% (n=8)	41% (n=9)
	No	63	2% (n=1)	3% (n=2)	16% (n=10)	49% (n=31)	30% (n=19)	2% (n=1)	2% (n=1)	17% (n=11)	48% (n=30)	32% (n=20)
Physically active[e]	Yes	54	2% (n=1)	4% (n=2)	15% (n=8)	50% (n=27)	30% (n=16)	0% (n=0)	7% (n=4)	22% (n=12)	35% (n=19)	35% (n=19)
	No	31	0% (n=0)	3% (n=1)	19% (n=6)	52% (n=16)	26% (n=8)	3% (n=1)	0% (n=0)	3% (n=1)	61% (n=19)	32% (n=10)
Family history of chronic disease[f]	Yes	26	0% (n=0)	0% (n=0)	19% (n=5)	54% (n=14)	27% (n=7)	0% (n=0)	0% (n=0)	8% (n=2)	54% (n=14)	38% (n=10)
	No	59	2% (n=1)	5% (n=3)	15% (n=9)	49% (n=29)	29% (n=17)	2% (n=1)	7% (n=4)	19% (n=11)	41% (n=24)	32% (n=19)
Dietary supplement users[g]	Yes	25	0% (n=0)	4% (n=1)	12% (n=3)	52% (n=13)	32% (n=8)	4% (n=1)	12% (n=3)	20% (n=5)	32% (n=8)	32% (n=8)
	No	60	2% (n=1)	3% (n=2)	18% (n=11)	50% (n=30)	27% (n=16)	0% (n=0)	2% (n=1)	13% (n=8)	50% (n=30)	35% (n=21)
Own perception of health status in relation to other adults of similar age[h]	Worse than most	3	0% (n=0)	0% (n=0)	33% (n=1)	67% (n=2)	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	100% (n=3)	0% (n=0)
	About similar to most	53	2% (n=1)	2% (n=1)	13% (n=7)	47% (n=25)	36% (n=19)	0% (n=0)	4% (n=2)	13% (n=7)	43% (n=23)	40% (n=21)
	Better than most	29	0% (n=0)	7% (n=2)	21% (n=6)	55% (n=16)	17% (n=5)	3% (n=1)	7% (n=2)	21% (n=6)	41% (n=12)	28% (n=8)
Health conciousness perception in relation to other adults of similar age[i]	Much less than most	4	0% (n=0)	0% (n=0)	0% (n=0)	50% (n=2)	50% (n=2)	0% (n=0)	0% (n=0)	25% (n=1)	50% (n=2)	25% (n=1)
	Somewhat less than most	12	0% (n=0)	8% (n=1)	25% (n=3)	33% (n=4)	33% (n=4)	0% (n=0)	0% (n=0)	25% (n=3)	42% (n=5)	33% (n=4)
	About similar to most	34	0% (n=0)	3% (n=1)	12% (n=4)	59% (n=20)	26% (n=9)	3% (n=1)	3% (n=1)	6% (n=2)	41% (n=14)	47% (n=16)
	Somewhat more than most	31	3% (n=1)	3% (n=1)	19% (n=6)	48% (n=15)	26% (n=8)	0% (n=0)	10% (n=3)	19% (n=6)	52% (n=16)	19% (n=6)
	Much more than most	4	0% (n=0)	0% (n=0)	25% (n=1)	50% (n=2)	25% (n=1)	0% (n=0)	0% (n=0)	25% (n=1)	25% (n=1)	50% (n=2)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
n[1] = Participant number within each biographic characteristic group as indicated in Table 4.4.
[ac, ad, ae, af, ag, ah, ai, bc, bd, bf, bg, bh, bi] No significant association/difference ($p > 0.05$) between the participant texture acceptance of bread A/B (a, b) and the participant biographic characteristic (c, d, e, f, g, h, i)
[be] Significant difference ($p < 0.05$) between the participant textural acceptance of bread B (b) and the participant physical activity status (e)

Of those participants who partook in physical activity and who did not partake in physical activity most participants which was about 50% of them indicated liking (response categories ‘like’) the texture of bread A (50% and 51.6%, respectively) which was followed by a quarter of them indicating liking the texture of bread A very much (response category ‘like very much’) (29.6% and 25.8%, respectively) ($p > 0.05$). However, for the texture of bread B an equal percentage of those participants who indicated being physically active indicated either liking its texture or liking it very much (35.2%) whereas about half of those participants who indicated not being physically active indicated liking the texture of bread B very much compared to those indicating liking it (32.3% versus 61.3%) ($p < 0.05$). Most of the participants who indicated having no family history and having a family history of chronic disease indicated a liking (response categories ‘like’ and ‘like very much’) towards the texture of both bread A (49.2% and 53.8%, respectively and 28.8% and 26.9%, respectively) and bread B (40.7% and 53.8%, respectively and 32.2% and 38.5%, respectively) ($p > 0.05$ for each).

Most of those participants who did not consume and those who did consume dietary supplements also indicated a liking (response categories ‘like’ and ‘like very much’) towards the texture of both bread A (50% and 52%, respectively and 26.7% and 32%, respectively) and bread B (50% and 32%, respectively and 35% and 32%, respectively) ($p > 0.05$ for each). Of the two most predominant categories for the participant perception of their own health status in relation to other adults of similar age (‘about similar to most’ and ‘better than most’), most participants indicated a liking (response categories ‘like’ and ‘like very much’) to both the texture of bread A (47.2% and 35.8%, respectively and 55.2% and 17.2%, respectively) and bread B (43.4% and 39.6%, respectively and 41.4% and 27.6%, respectively) ($p > 0.05$ for each). Of the two most prevalent health consciousness perception categories in relation to other adults of similar age (‘about similar to most’ and ‘somewhat more than most’) most participants also indicated liking (response category ‘like’) the texture of both bread A (58.8% and

48.4%, respectively) and bread B (41.2% and 51.6%, respectively) ($p > 0.05$ for each) (see Table 4.12.).

4.3.6. Associations between the participant acceptance of the experimental breads and their tea consumption

Participants indicated consuming rooibos (73.5%) above all other teas including black (21.2%), honeybush (18.8%), green (35.3%) and other herbal teas (17.6%) (see Table 4.5). The tea consumption had no influence on the acceptance of the sensory attributes of the experimental breads ($p > 0.05$ for each) (see Tables 4.13, 4.14, 4.15 for the colour, flavour/taste and texture acceptance, respectively).

4.3.6.1. Colour acceptance

Most of the participants who indicated not to consume or consume black tea indicated liking (response category ‘like’) the colour of both bread A (55.2% and 61.1%, respectively) and bread B (40.3% and 44.4%, respectively) which was followed by them indicating neither to like nor dislike (neutral response) the colour of both bread A (26.9% and 11.1%, respectively) and bread B (34.3% and 22.2%, respectively) ($p > 0.05$ for each). Although the majority of the participants did not consume honeybush, most of the participants consuming and those not consuming it indicated liking (response category ‘like’) the colour of both bread A (62.5% and 55.1%, respectively) and bread B (37.5% and 42%, respectively) that was followed by the participants indicating neither to like nor dislike (neutral response category) the colour of both bread A (18.8% and 24.6%, respectively) and bread B (37.5% and 30.4%, respectively) ($p > 0.05$ for each). Most of the participants indicated consuming rooibos and most of them indicated liking (response categories ‘like’) the colour of both breads A and B (56.3% and 42.2%, respectively) which was followed by them indicating neither to like nor dislike (neutral response category) the colour of both breads A and B (23.4% and

34.4%, respectively). Most of those participants who did not consume rooibos also indicated liking (response category ‘like’) the colour of both breads A and B (57.1% and 38.1%, respectively) ($p > 0.05$ for each). Of those participants who did not consume or consumed green tea some indicated neither to like nor dislike (neutral response category) the colour of bread A (27.35 and 16.7%, respectively) and bread B (36.4% and 23.3% respectively), but most participants indicated liking (response category ‘like’) the colour of both bread A (52.7% and 63.3%, respectively) and bread B (34.5% and 53.3%, respectively) ($p > 0.05$ for each). The majority of the participants who did not consume any other herbal teas and consumed other herbal teas indicated liking (response category ‘like’) the colour of both bread A (54.3% and 66.7%, respectively) and bread B (41.4% and 40%, respectively) ($p > 0.05$ for each) (see Table 4.13).

Table 4.13: Associations between the participant colour acceptance of the experimental breads and their tea consumption

			Degree of colour acceptance of bread (n = 85)									
			Bread A[a]					**Bread B[b]**				
Participant tea consumption		**n[1]**	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Black tea[c]	Yes	18	6% (n=1)	6% (n=1)	11% (n=2)	61% (n=11)	17% (n=3)	0% (n=0)	17% (n=3)	22% (n=4)	44% (n=8)	17% (n=3)
	No	67	1% (n=1)	7% (n=5)	27% (n=18)	55% (n=37)	9% (n=6)	4% (n=3)	6% (n=4)	34% (n=23)	40% (n=27)	15% (n=10)
Honeybush[d]	Yes	16	6% (n=1)	0% (n=0)	19% (n=3)	63% (n=10)	13% (n=2)	6% (n=1)	13% (n=2)	38% (n=6)	38% (n=6)	6% (n=1)
	No	69	1% (n=1)	9% (n=6)	25% (n=17)	55% (n=38)	10% (n=7)	3% (n=2)	7% (n=5)	30% (n=21)	42% (n=29)	17% (n=12)
Rooibos[e]	Yes	64	3% (n=2)	6% (n=4)	23% (n=15)	56% (n=36)	11% (n=7)	5% (n=3)	9% (n=6)	34% (n=22)	42% (n=27)	9% (n=6)
	No	21	0% (n=0)	10% (n=2)	24% (n=5)	57% (n=12)	10% (n=2)	0% (n=0)	5% (n=1)	24% (n=5)	38% (n=8)	33% (n=7)
Green tea[f]	Yes	30	7% (n=2)	3% (n=1)	17% (n=5)	63% (n=19)	10% (n=3)	7% (n=2)	30% (n=3)	23% (n=7)	53% (n=16)	7% (n=2)
	No	55	0% (n=0)	9% (n=5)	27% (n=15)	53% (n=29)	11% (n=6)	2% (n=1)	7% (n=4)	36% (n=20)	35% (n=19)	37% (n=11)
Other herbal teas[g]	Yes	15	7% (n=1)	7% (n=1)	7% (n=1)	67% (n=10)	13% (n=2)	7% (n=1)	0% (n=0)	33% (n=5)	40% (n=6)	20% (n=3)
	No	70	1% (n=1)	7% (n=5)	27% (n=19)	54% (n=38)	10% (n=7)	3% (n=2)	10% (n=7)	31% (n=22)	41% (n=29)	14% (n=10)

Bread A - Experimental bread containing 5% (w/v) rooibos extract

Bread B - Experimental bread containing 2% (w/v) rooibos extract

n[1] = Participant number within each choice of tea consumed as indicated in Table 4.5

[ac, ad, ae, af, ag, bc, bd, be, bf, bg] No significant difference/association ($p > 0.05$) between the participant colour acceptance of bread A/B (a, b) and the participant tea consumption (c, d, e, f, g)

4.3.6.2. Flavour/taste acceptance

The tea consumption of the participants had no influence on the acceptance of the flavour/taste attributes of the experimental breads ($p > 0.05$ for each) (see Table 4.12). Most of the participants who indicated not consuming and consuming black tea indicated liking (response category 'like') the flavour/taste of both breads A and B (56.7% and 50%, respectively and 38.8% and 50%, respectively) ($p > 0.05$ for each). Most of the participants who indicated not consuming and consuming honeybush also indicated liking (response categories 'like' and 'like very much') the flavour/taste of both bread A (59.4% and 37.5%, respectively and 21.7% and 37.5%, respectively) and bread B (40.6% and 43.8%, respectively and 27.5% and 31.3%, respectively) ($p > 0.05$ for each). Most of the participants who indicated consuming and not consuming rooibos indicated liking (response category 'like') the flavour/taste of both breads A (50% and 71.4%, respectively) and B (43.8% and 33.3%, respectively). Some of these participants also indicated an increased liking (response category 'like very much') for the flavour/taste of both bread A (28.1% and 14.3%, respectively) and bread B (25% and 38.1%, respectively) ($p > 0.05$ for each) as with those participants not consuming and consuming honeybush. Again most of the participants who did not consume and who did consume green tea indicated liking (response category 'like') the flavour/taste of both bread A (60% and 46.7%, respectively) and bread B (41.8% and 40%, respectively) ($p > 0.05$ for each) with some of these participants also indicating an increased liking (response category 'like very much') for the flavour/taste of both breads A and B (21.8% and 30%, respectively and 27.3% and 30%, respectively) ($p > 0.05$ for each). As determined for the consumption or not of black tea, rooibos and honeybush most of those participants who indicated not consuming or consuming other herbal teas again indicated liking (response categories 'like' and 'like very much') the flavour/taste of both bread A (57.1% and 46.7%, respectively and 22.9% and 33.3%, respectively) and bread B (42.9% and

33.3%, respectively and 24.3% and 46.7%, respectively) ($p > 0.05$ for each) (see Table 4.14.).

Table 4.14: Associations between the participant flavour/taste acceptance of the experimental breads and their tea consumption

Participant tea consumption		n^1	Degree of flavour/taste acceptance of bread (n = 85)									
			Bread A[a]					Bread B[b]				
			Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Black tea[c]	Yes	18	0% (n=0)	11% (n=2)	6% (n=1)	50% (n=9)	33% (n=6)	0% (n=0)	11% (n=2)	6% (n=1)	50% (n=9)	33% (n=6)
	No	67	3% (n=2)	10% (n=7)	7% (n=5)	57% (n=38)	22% (n=15)	0% (n=0)	9% (n=6)	25% (n=17)	39% (n=26)	27% (n=18)
Honeybush[d]	Yes	16	0% (n=0)	13% (n=2)	13% (n=2)	38% (n=6)	38% (n=6)	0% (n=0)	13% (n=2)	13% (n=2)	44% (n=7)	31% (n=5)
	No	69	3% (n=2)	10% (n=7)	6% (n=4)	59% (n=41)	22% (n=15)	0% (n=0)	9% (n=6)	23% (n=16)	41% (n=28)	28% (n=19)
Rooibos[e]	Yes	64	3% (n=2)	11% (n=7)	8% (n=5)	50% (n=32)	28% (n=18)	0% (n=0)	9% (n=6)	22% (n=14)	44% (n=28)	25% (n=16)
	No	21	0% (n=0)	10% (n=2)	5% (n=1)	71% (n=15)	14% (n=3)	0% (n=0)	10% (n=2)	19% (n=4)	33% (n=7)	38% (n=8)
Green tea[f]	Yes	30	3% (n=1)	13% (n=4)	7% (n=2)	47% (n=14)	30% (n=9)	0% (n=0)	7% (n=2)	23% (n=7)	40% (n=12)	30% (n=9)
	No	55	2% (n=1)	9% (n=5)	7% (n=4)	60% (n=33)	22% (n=12)	0% (n=0)	11% (n=6)	20% (n=11)	42% (n=23)	27% (n=15)
Other herbal teas[g]	Yes	15	0% (n=0)	13% (n=2)	7% (n=1)	47% (n=7)	33% (n=5)	0% (n=0)	7% (n=1)	13% (n=2)	33% (n=5)	47% (n=7)
	No	70	3% (n=2)	10% (n=7)	7% (n=5)	47% (n=40)	23% (n=16)	0% (n=0)	10% (n=7)	23% (n=16)	43% (n=30)	24% (n=17)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
n^1 = Participant number within each choice of tea consumed as indicated in Table 4.5
[ac, ad, ae, af, ag, bc, bd, be, bf, bg] No significant association/difference ($p > 0.05$) between the participant flavour/taste acceptance of bread A/B (a,b) and participant tea consumption (c,d, e, f, g)

4.3.6.3. Texture acceptance

No significant association/difference was also found between the participant tea consumption and textural acceptance of the experimental breads ($p > 0.05$ for each) (see Table 4.15). Of the participants who indicated not consuming or consuming black tea most indicated liking (response categories 'like' and 'like very much') the texture of both bread A (53.7% and 38.9%, respectively and 23.9% and 50%, respectively) and bread B (47.8% and 33.3%, respectively and 28.4% and 55.6%, respectively) ($p > 0.05$ for each). Most of those participants who indicated not consuming or consuming honeybush also indicated liking (response categories 'like' and 'like very much') the texture of both bread A (53.6% and 37.5%, respectively and 27.5% and 31.3%, respectively) and bread B (43.5% and 50%, respectively and 34.8% and 31.3%, respectively) ($p > 0.05$ for each). Of those participants who indicated consuming and not consuming rooibos most also indicated liking (response categories 'like' and 'like very much') the textural qualities of both bread A (46.9% and 61.9%, respectively and 32.8% and 14.3%, respectively) and bread B (43.8% and 47.6%, respectively and 32.8% and 38.1%, respectively) ($p > 0.05$ for each). Most of the participants who indicated not consuming or consuming green tea also indicated liking (response categories 'like' and 'like very much') the texture of both bread A (58.2% and 36.7%, respectively and 25.5% and 33.3%, respectively) and bread B (45.5% and 43.3%, respectively and 38.2% and 26.7%, respectively) ($p > 0.05$ for each). Of the participants who indicated not consuming or consuming other herbal teas most also indicated liking (response category 'like') the texture of both breads A and B (54.3% and 33.3%, respectively and 48.6% and 26.7%, respectively) with some of participants also indicating an increased liking (response category 'like very much') for the texture of both bread A (25.7% and 40%, respectively) and bread B (30% and 53.3%, respectively) ($p > 0.05$ for each) (see Table 4.15).

Table 4.15: Associations between the participant textural acceptance of the experimental breads and their tea consumption

			Degree of textural acceptance of bread (n = 85)									
			Bread A[a]					Bread B[b]				
Participant tea consumption		n[1]	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Black tea[c]	Yes	18	0% (n=0)	6% (n=1)	11% (n=2)	39% (n=7)	50% (n=9)	0% (n=0)	6% (n=1)	6% (n=1)	33% (n=6)	56% (n=10)
	No	67	1% (n=1)	3% (n=2)	18% (n=12)	54% (n=36)	24% (n=16)	1% (n=1)	4% (n=3)	18% (n=12)	48% (n=32)	28% (n=19)
Honeybush[d]	Yes	16	0% (n=0)	6% (n=1)	25% (n=4)	38% (n=6)	31% (n=5)	0% (n=0)	6% (n=1)	13% (n=2)	50% (n=8)	31% (n=5)
	No	69	1% (n=1)	3% (n=2)	14% (n=10)	54% (n=37)	28% (n=19)	1% (n=1)	4% (n=3)	16% (n=11)	43% (n=30)	35% (n=24)
Rooibos[e]	Yes	64	2% (n=1)	2% (n=1)	17% (n=11)	47% (n=30)	33% (n=21)	2% (n=1)	3% (n=2)	19% (n=12)	44% (n=28)	33% (n=21)
	No	21	0% (n=0)	10% (n=2)	14% (n=3)	62% (n=13)	14% (n=3)	0% (n=0)	10% (n=2)	5% (n=1)	48% (n=10)	38% (n=8)
Green tea[f]	Yes	30	3% (n=1)	7% (n=2)	20% (n=6)	37% (n=11)	33% (n=10)	0% (n=0)	0% (n=0)	30% (n=9)	43% (n=13)	27% (n=8)
	No	55	0% (n=0)	2% (n=1)	15% (n=8)	58% (n=32)	25% (n=14)	2% (n=1)	7% (n=4)	7% (n=4)	45% (n=25)	38% (n=21)
Other herbal teas[g]	Yes	15	0% (n=0)	7% (n=1)	20% (n=3)	33% (n=5)	40% (n=6)	0% (n=0)	0% (n=0)	20% (n=3)	27% (n=4)	53% (n=8)
	No	70	1% (n=1)	3% (n=2)	16% (n=11)	54% (n=38)	26% (n=18)	1% (n=1)	6% (n=4)	14% (n=10)	49% (n=34)	30% (n=21)

Bread A - Experimental bread containing 5% (w/v) Rooibos extract
Bread B - Experimental bread containing 2% (w/v) Rooibos extract
n[1] = Participant number within each choice of tea consumed as indicated in Table 4.5
[ac, ad, ae, af, ag, bc, bd, be, bf, bg] No significant association/difference ($p > 0.05$) between the participant texture acceptance of bread A/B [(a, b)] and the participant tea consumption [(c, d, e, f, g)]

4.3.7. Associations between the participant acceptance of the experimental breads and their functional food awareness and willingness to purchase

The majority of the participants were not aware of the term functional foods (63.5%), however indicated a willingness to purchase foods with additional health benefits (92.9%) (see Table 4.5.). The participant awareness for functional foods and willingness to purchase foods with health benefits had no significant ($p > 0.05$ for each) influence on the acceptance of the sensory attributes of the experimental breads (see Tables 4.16, 4.17, 4.18 for the colour, flavour/taste and texture acceptance, respectively).

4.3.7.1. Colour acceptance

Of the participants who indicated awareness or no awareness of functional foods some indicated neither to like nor dislike (neutral response category) the colour of both bread A (9.7% and 31.5%, respectively) and bread B (22.6% and 37%, respectively) while more participants indicated liking (response category 'like') the colour of both bread A (74.2% and 46.3%, respectively) and bread B (45.2% and 38.9%, respectively) ($p > 0.05$ for each). Some of the participants who indicated willingness or no willingness to purchase foods with added health benefits again indicated neither to like nor dislike (neutral response category) the colour of both bread A (22.8% and 33.3%, respectively) and bread B (31.6% and 33.3%, respectively) while more again indicated liking (response category 'like') the colour of both bread A (55.7% and 66.7%, respectively) and bread B (43% and 16.7%, respectively) ($p > 0.05$ for each) (see Table 4.16.).

Table 4.16: Associations between the participant colour acceptance of the experimental breads and their functional food awareness and willingness to purchase

Participant functional food awareness and willingness to purchase		n[1]	Bread A[a] Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Bread B[b] Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
			Degree of colour acceptance of bread (n = 85)									
Aware of functional foods[c]	Yes	36	3% (n=1)	3% (n=1)	8% (n=3)	64% (n=23)	8% (n=3)	3% (n=1)	8% (n=3)	19% (n=7)	39% (n=14)	17% (n=6)
	No	64	2% (n=1)	8% (n=5)	27% (n=17)	39% (n=25)	9% (n=6)	3% (n=2)	6% (n=4)	31% (n=20)	33% (n=21)	11% (n=7)
Purchase willingness of foods with added health benefits[d]	Yes	79	3% (n=2)	8% (n=6)	23% (n=18)	56% (n=44)	11% (n=9)	4% (n=3)	6% (n=5)	32% (n=25)	43% (n=34)	15% (n=12)
	No	6	0% (n=0)	0% (n=0)	33% (n=2)	67% (n=4)	0% (n=0)	0% (n=0)	33% (n=2)	33% (n=2)	17% (n=1)	17% (n=1)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
n[1] = Participant number within functional food awareness and willingness to purchase group as indicated in Table 4.5.
[ac, ad, bc, bd] No significant association/difference ($p > 0.05$) between the participant colour acceptance of bread A/B (a, b) and the participant functional food awareness and willingness to purchase (c, d)

4.3.7.2. Flavour/taste acceptance

Most of the participants who indicated awareness or no awareness of functional foods indicated liking (response categories 'like' and 'like very much') the flavour/taste of both bread A (51.6% and 57.4%, respectively and 25.8% and 24.1%, respectively) and bread B (38.7% and 42.6%, respectively and 32.3% and 25.9%, respectively) ($p > 0.05$ for each). Most of the participants who indicated willingness and no willingness to purchase foods with added health benefits also indicated liking (response categories 'like' and 'like very much') the flavour/taste of both bread A (54.4% and 66.7%, respectively and 25.3% and 16.7%, respectively) and bread B (43% and 16.7%, respectively and 29.1% and 16.7%, respectively) ($p > 0.05$ for each) (see Table 4.17.).

Table 4.17: Associations between the participant flavour/taste acceptance of the experimental breads and their functional food awareness and willingness to purchase

			Degree of flavour/taste acceptance of bread (n = 85)									
			Bread A[a]					Bread B[b]				
Participant functional food awareness and willingness to purchase		**n[1]**	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much	Dislike very much	Dislike	Neither like nor dislike	Like	Like very much
Aware of functional foods[c]	Yes	36	0% (n=0)	11% (n=4)	8% (n=3)	44% (n=16)	22% (n=8)	0% (n=0)	14% (n=5)	11% (n=4)	33% (n=12)	28% (n=10)
	No	64	3% (n=2)	8% (n=5)	5% (n=3)	48% (n=31)	20% (n=13)	0% (n=0)	5% (n=3)	22% (n=14)	36% (n=23)	22% (n=14)
Purchase willingness of foods with added health benefits[d]	Yes	79	3% (n=2)	10% (n=8)	8% (n=6)	54% (n=43)	25% (n=20)	0% (n=0)	8% (n=6)	20% (n=16)	43% (n=34)	29% (n=23)
	No	6	0% (n=0)	17% (n=1)	0% (n=0)	67% (n=4)	17% (n=1)	0% (n=0)	33% (n=2)	33% (n=2)	17% (n=1)	17% (n=1)

Bread A - Experimental bread containing 5% (w/v) rooibos extract

Bread B - Experimental bread containing 2% (w/v) rooibos extract

n[1] = Participant number within each functional food awareness and willingness to purchase group as indicated in Table 4.5

[ac, ad, bc, bd] No significant association/difference ($p > 0.05$) between the participant flavour/taste acceptance of bread A/B (a, b) and the participant functional food awareness and willingness to purchase (c, d)

4.3.7.3. Texture acceptance

Most of the participants who indicated awareness or no awareness of functional foods again indicated liking (response categories 'like' and 'like very much') the texture of both bread A (61.3% and 44.4%, respectively and 32.3% and 25.9%, respectively) and bread B (38.7% and 48.1%, respectively and 41.9% and 29.6%, respectively) ($p > 0.05$ for each). Again most participants who indicated willingness or no willingness to purchase foods with added health benefits indicated liking (response categories 'like' and 'like very much') the texture of bread A (50.6% and 50%, respectively and 29.1% and 16.7%, respectively) ($p > 0.05$). However, a significant difference ($p < 0.05$) was found in the texture acceptance of bread B. Most of those participants willing to purchase foods with added health benefits indicating liking (response categories 'like' and 'like very much') the texture of bread B (46.8% and 35.4%, respectively) while most of those participants not willing to purchase foods with added health benefits indicated to neither like nor dislike (neutral response category) the texture of bread B (33.3%). This was followed by the participants either liking or disliking the texture or liking or disliking the texture very much (one participant each or 16.7% over these four acceptance categories) (see Table 4.18).

Table 4.18: Associations between the participant textural acceptance of the experimental breads and their functional food awareness and willingness to purchase

Participant functional food awareness and willingness to purchase		n[1]	Bread A[a]: Dislike very much	Bread A[a]: Dislike	Bread A[a]: Neither like nor dislike	Bread A[a]: Like	Bread A[a]: Like very much	Bread B[b]: Dislike very much	Bread B[b]: Dislike	Bread B[b]: Neither like nor dislike	Bread B[b]: Like	Bread B[b]: Like very much
			Degree of textural acceptance of bread (n = 85)									
Aware of functional foods[c]	Yes	36	0% (n=0)	0% (n=0)	6% (n=2)	53% (n=19)	28% (n=10)	3% (n=1)	8% (n=3)	6% (n=2)	33% (n=12)	36% (n=13)
	No	64	2% (n=1)	4% (n=3)	19% (n=12)	38% (n=24)	22% (n=14)	0% (n=0)	2% (n=1)	17% (n=11)	41% (n=26)	25% (n=16)
Purchase willingness of foods with added health benefits[d]	Yes	79	1% (n=1)	4% (n=3)	15% (n=12)	51% (n=40)	29% (n=23)	0% (n=0)	4% (n=3)	14% (n=11)	47% (n=37)	35% (n=28)
	No	6	0% (n=0)	0% (n=0)	33% (n=2)	50% (n=3)	17% (n=1)	17% (n=1)	17% (n=1)	33% (n=2)	17% (n=1)	17% (n=1)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
n[1] = Participant number within each functional food awareness and willingness to purchase group as indicated in Table 4.5
[ac, ad, bc] No significant association/difference ($p > 0.05$) between the participant flavour/taste acceptance of bread A/B (a,b) and the participant functional food awareness and willingness to purchase (c, d)
[bd] Significant difference ($p < 0.05$) between the participant textural acceptance of bread b (b) and the purchase willingness of foods with added health benefits (d)

4.3.8. Associations with the participant willingness to purchase the experimental breads

4.3.8.1. Demographic characteristics

The majority of the participants indicated a willingness to purchase both experimental breads regardless of their demographic characteristics. The majority of the female participants indicated a willingness to purchase bread A (83.7%) and bread B (65.3%). The majority of the male participants also indicated a willingness to purchase both bread A and bread B (69.4% and 77.8%, respectively) ($p > 0.05$ for each). In the two most predominant age categories (18-24 years and 25-34 years), the majority of the participants also indicated a willingness to purchase both bread A (78.3% and 66.7%, respectively) and bread B (71.7% and 66.7%, respectively) ($p > 0.05$ for each). The participants post matric/grade 12 educational levels (one to two years, three to four years, five or more years) did not either impact the willingness to purchase the experimental breads ($p > 0.05$ for each). In the predominant post matric/grade 12 education category (three to four years post school education) an equal number of participants indicated a willingness to purchase both breads A and B (75.4%, respectively) ($p > 0.05$ for each). Considering the marital status of the participants, the marital status also had no influence on the participants' willingness to purchase the experimental breads. In the two predominant marital status groupings (married/living together with children and single living on own) most participants also indicated a willingness to purchase both bread A (90% and 73.8%, respectively) and bread B (70% and 72.3%, respectively) ($p > 0.05$ for each) (see Table 4.19.).

Table 4.19: Associations between the participant willingness to purchase the experimental breads and their demographic characteristics

Participant demographic characteristics		n[1]	Willingness to purchase the experimental breads (n = 85)			
			Bread A[a]		Bread B[b]	
			Yes	No	Yes	No
Gender[c]	Female	49	84% (n=41)	16% (n=8)	65% (n=32)	35% (n=17)
	Male	36	69% (n=25)	31% (n=11)	78% (n=28)	22% (n=8)
Age[d]	18-24 years	46	78% (n=36)	22% (n=10)	72% (n=33)	28% (n=13)
	25-34 years	27	67% (n=18)	33% (n=9)	67% (n=18)	33% (n=9)
	35-44 years	7	100% (n=7)	0% (n=0)	86% (n=6)	14% (n=1)
	45-54 years	3	100% (n=3)	0% (n=0)	33% (n=1)	67% (n=2)
	55-60 years	2	100% (n=2)	0% (n=0)	100% (n=2)	0% (n=0)
	61 years and older	0	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)
Post school education[e]	1-2 years	6	83% (n=5)	17% (n=1)	67% (n=4)	33% (n=2)
	3-4 years	61	75% (n=46)	25% (n=15)	75% (n=46)	25% (n=15)
	5 and more years	18	83% (n=15)	19% (n=3)	56% (n=10)	44% (n=8)
Marital status[f]	Married/living together without children	5	100% (n=5)	0% (n=0)	40% (n=2)	60% (n=3)
	Married/living together with children	10	90% (n=9)	10% (n=1)	70% (n=7)	40% (n=4)
	Single/living on own	65	74% (n=48)	26% (n=17)	72% (n=47)	28% (n=18)
	Single/living with children	5	80% (n=4)	20% (n=1)	80% (n=4)	20% (n=1)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
n[1] = Particpant number within each demographic characteristic group as indicated in Table 4.3.
[ac,ad,ae,af, bc, bd, be, bf] No significant association/difference ($p > 0.05$) between the participant willingness to purchase bread A/B (a,b) and the participant demographic characteristics (c,d,e,f)

The participant biographic characteristics including their own perceptions of their body weight status, their smoking status, being physically active or not, their family history of chronic disease, dietary supplement use, perceived health status and health consciousness in relation to adults of similar age were not significantly associated ($p > 0.05$ for each) with their willingness to purchase the experimental breads. In the two most predominant categories of their own perception of their body weight status (‘optimal/normal weight’ and ‘slightly overweight/overweight’) most participants indicated a willingness to purchase both bread A (70.2% and

84.4%, respectively) and bread B (65.9% and 75%, respectively) ($p > 0.05$ for each). Of those participants who did smoke and those who did not smoke most also indicated willingness to purchase both bread A (81.8% and 76.2%, respectively) and bread B (63.6% and 73%, respectively) ($p > 0.05$ for each). Most of the participants whether physically active or not, also indicated a willingness to purchase both bread A (81.5% and 71%, respectively) and bread B (70.4% and 71%, respectively) ($p > 0.05$). Most of the participants who indicated having and not having a family history of chronic disease also indicated a willingness to purchase both bread A (80.8% and 76.3%, respectively) and bread B (76.9% and 67.8%, respectively) ($p > 0.05$ for each). Of the participants who did make use of dietary supplements and those participants who did not make use of dietary supplements, both groups furthermore indicated a willingness to purchase both bread A (84% and 75%, respectively) and bread B (60% and 75%, respectively). In the most predominant health status perception in relation to adults of similar age category ('about similar to most') most participants also indicated a willingness to purchase both breads A and B (83% and 69.8%, respectively) ($p > 0.05$ for each). Of the two most prevalent health consciousness in relation to other adults of a similar age categories ('about similar to most' and 'somewhat more than most') most participants again expressed willingness to purchase both bread A (76.5% and 80.6%, respectively) and bread B (76.5% and 64.5%, respectively) ($p > 0.05$ for each) (see Table 4.20.).

Table 4.20: Associations between the participant willingness to purchase the experimental breads and their biographic characteristics

Participant biographic characteristics		n[1]	Willingness to purchase the experimental breads			
			Bread A[a]		Bread B[b]	
			Yes	No	Yes	No
Perceived body weight status[c]	Underweight	6	100% (n=6)	0% (n=0)	83% (n=5)	17% (n=1)
	Optimal/normal weight	47	70% (n=33)	23% (n=14)	66% (n=31)	34% (n=16)
	Slightly overweight/overweight	32	84% (n=27)	16% (n=5)	75% (n=24)	25%(n=8)
	Obese	0	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)
Smoking[d]	Yes	22	82% (n=18)	18% (n=4)	64% (n=14)	36% (n=8)
	No	63	76% (n=48)	24% (n=15)	87% (n=46)	27% (n=17)
Physically active[e]	Yes	54	81% (n=44)	19% (n=10)	70% (n=38)	30% (n=16)
	No	31	71% (n=22)	29% (n=9)	71% (n=22)	29% (n=9)
Family history of chronic disease[f]	Yes	26	81% (n=21)	19% (n=5)	77% (n=20)	23% (n=6)
	No	59	76% (n=45)	24% (n=14)	68% (n=40)	32% (n=19)
Dietary supplement users[g]	Yes	25	84% (n=21)	16% (n=4)	60% (n=15)	40% (n=10)
	No	60	75% (n=45)	25% (n=15)	75% (n=45)	25% (n=15)
Own perception of health status in relation to other adults of similar age[h]	Worse than most	3	100% (n=3)	0% (n=0)	100% (n=3)	0% (n=0)
	About similar to most	53	83% (n=44)	17% (n=9)	70% (n=37)	30% (n=16)
	Better than most	29	66% (n=19)	34% (n=10)	69% (n=20)	31% (n=9)
Health conciousness perception in relation to other adults of similar age [i]	Much less than most	4	75% (n=3)	25% (n=1)	50% (n=2)	50% (n=2)
	Somewhat less than most	12	83% (n=10)	17% (n=2)	92% (n=11)	8% (n=1)
	About similar to most	34	76% (n=26)	24% (n=8)	76% (n=26)	24% (n=8)
	Somewhat more than most	31	81% (n=25)	19% (n=6)	65% (n=20)	35% (n=11)
	Much more than most	4	50% (n=2)	50% (n=2)	25% (n=1)	75% (n=3)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
[1] n = Particpant number within each biographic characteristic group as indicated in Table 4.4.
[ac,ad.ae,af, ag, ah, ai, bc, bd, be, bf, bg, bh, bi] No significant association/difference ($p > 0.05$) between the participant willingness to purchase bread A/B (a,b) and the participant biographic characteristics (c, d, e, f, g, h, i)

4.3.8.2. Tea consumption

The participant consumption of the various teas including black tea, honeybush, rooibos, green tea and other herbal teas were also not significantly associated ($p > 0.05$) with their willingness to purchase the experimental breads. Of those participants who consumed black tea and those who did not consume black tea, most indicated a willingness to purchase both bread A (83.3% and 76.1%, respectively) and bread B (72.2% and 70.1%, respectively). Most participants who indicated consuming honeybush and those who indicated not consuming honeybush similarly indicated a willingness to purchase both bread A (75% and 78.3%, respectively) and bread B (75% and 69.6%, respectively). Most of the participants who consumed rooibos indicated willingness to purchase bread A and bread B (82.8% and 68.8%, respectively) as did most of those participants who did not consume rooibos (61.9% and 76.2%, respectively) ($p > 0.05$ for each). Most of those participants who consumed green tea and those participants who did not consume it indicated a willingness to purchase both bread A (80% and 76.4%, respectively) and bread B (70% and 70.9%, respectively) ($p > 0.05$ for each). Most of the participants who did not consume other herbal teas indicated a willingness to purchase both breads A and B (75.7% and 68.6%, respectively). Most of those participants who did consume other herbal teas also indicating a willingness to purchase both breads A and B (86.7% and 80%, respectively) ($p > 0.05$ for each) (see Table 4.21.).

Table 4.21: Associations between the participant willingness to purchase the experimental breads and their tea consumption

Participant tea consumption		n[1]	Willingness to purchase the experimental breads (n = 85)			
			Bread A[a]		Bread B[b]	
			Yes	No	Yes	No
Black tea[c]	Yes	18	83% (n=15)	17% (n=3)	72% (n=13)	28% (n=5)
	No	67	76% (n=51)	24% (n=16)	70% (n=47)	30% (n=20)
Honeybush[d]	Yes	16	75% (n=12)	25% (n=4)	75% (n=12)	25% (n=4)
	No	69	78% (n=54)	22% (n=15)	70% (n=48)	30% (n=21)
Rooibos[e]	Yes	64	83% (n=53)	17% (n=11)	69% (n=44)	31% (n=20)
	No	21	62% (n=13)	38% (n=8)	76% (n=16)	24% (n=5)
Green tea[f]	Yes	30	80% (n=24)	20% (n=6)	70% (n=21)	30% (n=9)
	No	55	76% (n=42)	24% (n=13)	71% (n=39)	29% (n=16)
Other herbal teas[g]	Yes	15	87% (n=13)	13% (n=2)	80% (n=12)	20% (n=3)
	No	70	76% (n=53)	24% (n=17)	69% (n=48)	31% (n=22)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
[1] n = Particpant number within each tea consumption group as indicated in Table 4.5.
[ac, ad, ae, af, ag, bc, bd, be, bf, bg] No significant association/difference (p > 0.05) between the the participant willingness to purchase bread A/B (a, b) and the participant tea consumption (c, d, e, f, g)

4.3.8.3. Functional food awareness and willingness to purchase

The participant awareness of functional foods, their willingness to purchase foods with added health benefits and their willingness to pay more for such foods were also not significantly associated (p > 0.05) with their willingness to purchase the experimental breads. Most of the participants who were not aware of functional foods indicated willingness to purchase both breads A and B (75.9% and 70.4%, respectively) as did most of those participants who indicated awareness of functional foods (80.6% and 71%, respectively) (p > 0.05 for each). Of those participants who and those participants who did not indicate a willingness to purchase foods with added health benefits most also indicated a willingness to purchase both bread A (77.2% and 83.3%, respectively) and bread B (72.2% and

50%, respectively). Most of those participants who indicated a willingness to pay more for foods with added health benefits indicated a willingness to purchase both breads A and B (79% and 72.6%, respectively) as did most of those participants who indicated not to be willing to pay more for foods with added health benefits (73.9% and 65.2%, respectively) ($p > 0.05$ for each) (see Table 4.22.).

Table 4.22: Associations between the participant willingness to purchase the experimental breads and their functional food awareness and willingness to purchase

Participant functional food awareness and purchase willingness of foods with added health benefits		n[1]	Willingness to purchase the experimental breads (n = 85)			
			Bread A[a]		Bread B[b]	
			Yes	No	Yes	No
Awareness of functional foods[c]	Yes	36	69% (n=25)	17% (n=6)	61% (n=22)	25% (n=9)
	No	64	64% (n=41)	20% (n=13)	59% (n=38)	25% (n=16)
Purchase willingness of foods with added health benefits[d]	Yes	79	77% (n=61)	23% (n=18)	72% (n=57)	28% (n=22)
	No	6	83% (n=5)	17% (n=1)	50% (n=3)	50% (n=3)
Willingness to pay more for food containing health benefits[e]	Yes	62	79% (n=49)	21% (n=13)	73% (n=45)	27% (n=17)
	No	23	74% (n=17)	26% (n=6)	65% (n=15)	35% (n=8)

Bread A - Experimental bread containing 5% (w/v) rooibos extract
Bread B - Experimental bread containing 2% (w/v) rooibos extract
n[1] = Participant number within each health functional food awareness and purchase willingness group as indicated in Table 4.5.
[ac, ad, ae, bc, bd, be] No significant association/difference ($p > 0.05$) between the participant willingness to purcahse breads A/B (a,b) and the participant functional food awareness and purchase willingness of foods with added health benefits (c,d,e)

CHAPTER 5

DISCUSSION

Fluid manipulation of a recipe formulation of the South African staple food bread through replacing the water as a recipe ingredient with black tea, rooibos or honeybush greatly increased the TAC represented by the H-ORAC$_{FL}$ of the bread formulation. The bread was tested at two different black and herbal tea concentration levels. At a 2% concentration the TAC of the bread, represented by the H-ORAC$_{FL}$ of the bread, greatly increased with the exception of the 2% honeybush concentration fluid manipulation which showed no significant difference in H-ORAC$_{FL}$ compared to the control bread formulation containing water as the liquid ingredient. The H-ORAC$_{FL}$ of the experimental breads particularly at a 5% concentration fluid manipulation was greatly increased compared to that of the control bread. The high flavonoid content in both rooibos and honeybush herbal tea, indicative of a good antioxidant potential (Marnewick 2009:282), as well as the antioxidant potential of black tea (Dreosti, 2000:692) brought along the increase in the TAC represented by the H-ORAC$_{FL}$ of the experimental breads. This was besides for the honeybush fluid manipulation at the lower 2% concentration. Nearly all experimental breads, at both 2% (w/v) and 5% (w/v), with the exception of the 2% (w/v) honeybush experimental bread, showed an increase in TAC when compared to the commercial reference bread.

Other studies confirm the use of bread as a food vehicle to increase the dietary TAC of the consumer. In an experimental study where green tea extract was added to bread, the tea catechins were relatively stable during the bread baking and more than three quarters of the total tea catechins remained after baking (Wang *et al.,* 2007:471). A further study, using barley flour as replacement flour to wheat flour during bread baking to increase the antioxidant content of baked bread, also showed an increase in the TAC (Holtekjølen *et al.,* 2008:421). Even mango peel, a by-product of mango processing, that has been powdered and added to macaroni preparations, has shown to increase the polyphenol, carotenoid and dietary fiber contents of the macaroni preparations. These products also exhibited improved antioxidant activity (Ajila *et al.,* 2010:223). However, although the TAC of the experimental bread formulations was greatly increased at a 5% herbal tea concentration, sensory changes in the product were also detected such as a change in colour due to the increase in rooibos concentration as well as a definite taste/flavour of the rooibos, as well as negative sensory changes in the 5% herbal concentration using both honeybush and black which resulted in changes in texture and overpowering taste and smell of the particular tea used in the experiment. These sensory attributes needed to be acceptable to consumers, comparable to the 2% herbal tea concentration fluid manipulation. The experimental bread formulations using 2% (w/v) and 5% (w/v) rooibos extract respectively were selected for the consumer acceptance testing as both bread formulations had an increased TAC and showed significant difference ($p < 0.05$ for each) with the control and commercial reference breads as well as rooibos being a popular and proudly South African product.

During the shelf life testing of the selected breads, which took place over a four day period similar to the lifespan of freshly baked bread which is three to four days, the bread showed characteristics typical of staling bread. Characteristics such as firmness, especially around the edges of the bread and a slight decrease in the elasticity of the bread slice, which was measured though compression of the bread slice, occurred. Mould development did not occur over the four day period. The fluid manipulation and the use of rooibos as the fluid replacement for water may have had a preservative influence on the bread shelf life. Rooibos is a rich source of flavonoids, and have an antioxidant affect, which results in the prevention of the oxidative process that causes the sensory characteristics of foods to deteriorate (Parnes, 2007:1).

More than half of the participant sample who volunteered for the consumer acceptance testing were females and within the age group 18 to 24 years. Most of the participants had three to four years and more post-matric/-grade 12 education and were single living on their own with no dependents. Most of these participants showed characteristics of following a healthy lifestyle. The majority of the participants had an optimal/normal body weight status, were non smokers, physically active and not having a history of chronic disease. They, on providing informed consent, evaluated the bread sensory attributes in terms of the taste/flavour, colour and texture acceptance of both the experimental breads with bread A being at a 5% rooibos concentration and bread B being at a 2% concentration.

The participants' positive overall acceptance of both experimental breads was seen through the response categories 'neither like nor dislike' (neutral response), 'like' and 'like very much' as the three response categories most commonly indicated. These are comparable to those participants' responses as used in product development whereby hedonic tests are used and responses include 'fair' (neutral response), 'good' and 'very good' (Murano, 2003:432). During a study investigating the antioxidant and sensory profiles using barley flour as replacement flour to wheat flour to increase the TAC of bread, sensory results showed that by using varieties of barley flour the sensory profiles did change; however the changes corresponded well with the phenolic content of each experimental bread (Holtekjølen *et al.,* 2008:419, 421). In a study using green tea extract to increase the TAC of bread as well as to investigate the effect the extract has on the quality of the baked bread, sensory analysis showed that both the product and sensory quality was not significantly compromised on such recipe manipulation (Wang *et al.,* 2007:478). No significant difference was also found between the colour, taste and texture of the control macaroni and the mango peel powder (up to 5% level) as the antioxidant source (Ajila *et al.,* 2010:222).

The demographic characteristics of the participants, such as their gender, age, post-matric/-grade 12 educational level and marital status did not influence their acceptance of either the colour, taste/flavour or texture attribute acceptance of the experimental breads. Of the biographic characteristics of the participants, which related mostly to their health and lifestyle characteristics, the majority characteristics such as their smoking habit, family history of chronic disease, dietary supplement use and perception of own health status relative to other adults of similar age, also did not influence the participant colour, taste/flavour and texture attribute acceptance of the experimental breads.

There was however certain biographic characteristics that significantly ($p < 0.05$) influenced the participant acceptance of selected sensory attributes of the experimental breads, with more of the participants showing a positive acceptance of the experimental breads, which can be seen by the majority of participants whose response category was ‘like’. A significant difference ($p < 0.05$) was found between the participants’ perceived body weight status as well as their physical activity level and the colour acceptance of experimental bread A. A significant difference ($p < 0.05$) was also found between the participants’ perception of their own health consciousness relative to other adults of similar age and their flavour/taste acceptance of experimental bread A. There was also a significant difference ($p < 0.05$) between the participants’ physical activity status and their acceptance of the textural characteristics of experimental bread B. Biographic factors influenced participants acceptance. Due to the lack of other studies of this nature, reference to these results found in relation to the results of other studies can therefore not be made.

Food choice and food selection is influenced by many interrelating factors. Like any complex human behavior food choice is influenced by physiological and nutritional needs, along with social and cultural factors (Shepherd, 1999:807). The social and cultural influence include factors such as the preference influence including familiarity to an ingredient(s) or a food item, family members attitudes and behaviors, as well as the family environment (Chase *et al.,* 2003:501) compared to the demographic and the biographic factors alone. Social context and setting of food consumption is also an influence as well as the cost of food and buying habits of food. Nutrition and health is also considered, but can be considered as less important than cost and preference (Chase *et al.,* 2003: 503). Although there is much awareness of the impact of diet and health on the reduction of specific diseases, limited knowledge is available on how to influence the dietary behaviour of consumers in an effective way. It is therefore necessary to understand what influences and determines individual's choices of foods and what obstacles may influence consumer choice (Shepherd, 1999:809). In this study only limited participant biographic characteristics related to health and lifestyle influenced the acceptance of certain sensory attributes of the experimental breads which is beyond the scope of this study to discuss and/or explain.

Second to water, tea is the most popular consumed beverage in the world (Wu & Wei, 2002:443). Tea is considered a healthy drink and a contributor of dietary antioxidants as well as a potential functional food. However, no official health claims can be allocated to teas or herbal teas (Dufresne & Franworth, 2001:416). Both rooibos and honeybush herbal teas contain unique polyphenolic compounds which differ from the *Camillia sinensis* teas, and due to these unique compounds both herbal teas may have antioxidant health benefits (Marnewick 2009:279). The majority of the participants indicated to consume rooibos compared to black tea and other herbal teas; however, this may not be associated with the health benefits of rooibos but could be related to familiarity of the ingredient, taste preference, awareness of rooibos compared to other herbal teas as well as it being a 'proudly South African' product. Despite this there was no association between the participant tea consumption and their acceptance of the colour, taste/flavour and texture attributes of both the experimental breads. From the collected results it can be deduced that the majority of the participants consumed rooibos and not other teas including black tea, honeybush, green tea and other herbal teas. However, there was also a positive acceptance of both the experimental breads having rooibos as the fluid ingredient among those participants who commonly consumed the other teas besides rooibos.

Although most of the participants had no awareness of the term functional foods, most were willing to purchase foods containing added health benefits and were willing to pay more for foods containing added health benefits. The participants' awareness of functional foods and their willingness to purchase foods containing added health benefits had no influence on the colour and flavour acceptance of both the experimental breads. No influence was also found between the participants' willingness to purchase foods with added health benefits and the textural acceptance of Bread A, but a significant difference ($p < 0.05$) was found between the participants' willingness to purchase food with added health benefits and the textural acceptance of Bread B. Product sensory attributes such as the flavour, appearance/colour and mouthfeel/texture acceptance all influence the consumer acceptance of a new food product and can provide an indication of consumer willingness to purchase a new food product which in this study was found only for the texture of experimental bread B. However due to the lack of studies of this nature speculation and discussion of this aspect is not realistic.

The participants who partook in the study were predominantly a young adult group who were single/living on their own without children, of a higher education bracket (three to four years post matric/-grade 12 education) and presented many characteristics of a healthy lifestyle as being predominantly non-smokers, physically active and with no family history of chronic disease. The participants were furthermore also not a true reflection of the greater South African population as they were positioned within the City of Cape Town Metropolitan Municipality. The participants were also majority rooibos drinkers while black tea is the most commonly consumed in South Africa (Nel & Steyn, 2002:75). This study sample population therefore limits the generalisation of the results. However, the results show the potential for further studies as the participants, who indicated spending power and who are the future parents of tomorrow, indicated a general acceptance of bread with functional food characteristics.

The use of a 5-point hedonic scale instead of the more accepted 9-point hedonic scale used in sensory evaluations (Murano, 2003:432), was a combination of the categories of a traditional hedonic scale, including the response categories ‘dislike very much’ as the extreme negative, ‘neither like nor dislike’ as the neutral and ‘like very much’ as the extreme positive, and the five category rating used for the rating of the food product development with ‘very poor’ as the extreme negative, ‘fair’ as the neutral and ‘very good’ as the extreme positive categories. Although the use of a 5-point and not a 9-point hedonic scale may be considered a limitation of the study it allowed for a corresponded food product development rating and reduced the possibility of empty cell numbers across the categorical participant responses in terms of the acceptance attribute association/difference and the demographic, biographic and other variable determinants that may have impacted the chi-square statistical analysis. It is assumed that this, however, did not greatly impact the results of the study.

CHAPTER 6
CONCLUSIONS

The H-ORAC$_{FL}$ of the experimental breads indicated that the TAC of all the experimental bread formulations were higher compared to that of the control bread and the commercial reference bread, with the exception of the honeybush experimental bread at a 2% (w/v). The highest TAC was found for the experimental bread using black tea at a 5% (w/v). There was a significant difference ($p < 0.05$ for each) between the control and the experimental breads using 2% and 5% (w/v) respectively with the exception of the 2% (w/v) honeybush experimental bread formulation which showed no significant difference ($p > 0.05$). However, the experimental bread using rooibos 5% (v/w) was not much lower than the experimental bread using 5% black tea and was as a result chosen for the consumer acceptance testing as well as the experimental bread using rooibos 2% (v/w), both incorporating the proudly South African product rooibos. The null hypothesis stated for the study of no significance difference between the TAC of the control bread formulation and reference/commercial bread, both which contained water as the liquid ingredient and the experimental bread formulations was thus rejected besides for the honeybush experimental bread formulation at 2% (v/w). The study showed the beneficial use of a staple food as a vehicle to increase the dietary TAC of consumers and not only through the increased intake of plant foods such as fruit and vegetables along with wholegrains which is often recommended.

Although the experimental breads had a change in the liquid ingredient (2% v/w and 5% v/w) rooibos, compared to the water inclusion in the control bread, the sensory attributes including colour (visual appearance), flavour/taste and texture as well as the participants willingness to purchase the experimental breads were favoured positively. From the consumer acceptance results it can be deduced that certain response categories were found to be indicated more often; these included the neutral response (response category ‘neither like nor dislike’), and more often the ‘like’ and ‘like very much’ responses. These categories can be comparable to those categories used in product development rating such as ‘fair’ (neutral response), ‘good’ and ‘very good’, and can then be concluded that the experimental breads were acceptable to the consumers. The positive acceptance of the experimental breads for food product development highlights an opportunity for industry, specifically those food companies focusing on bread production, for such an undertaking. Previous studies have shown positive results in increasing the TAC of breads by incorporating barley flour (Holtekjølen *et al.,* 2008:414) as well as green tea extract (Wang *et al.,* 2007:470), both not only increasing the antioxidant levels of the experimental compared to the control breads but these experimental breads also showing a positive consumer acceptance regarding their sensory attributes.

The participant demographic factors such as their gender, age, education level and marital status had no impact on the acceptance of the sensory attributes of both the experimental breads. As with the demographic factors a number of biographic factors including their smoking status, family history of chronic disease, dietary supplement use and own perception of health status in relation to other adults of similar age also did not influence the acceptance of the sensory attributes of the experimental breads. Certain participant biographic factors such as their perceived body weight status, physical activity status and health consciousness perception relative to other adults of similar age influenced the acceptance of only some of the sensory attributes of the experimental breads along with the participants’ willingness to purchase foods with added health benefits. It is necessary to consider the possibility that biographic factors such as the above-mentioned health and lifestyle characteristics may be important in the consumer acceptance of certain food products, especially those food products with added health benefits. However, no conclusive biographic pattern emerged and therefore no concrete conclusions can be drawn from this acceptance trend but rather speculative conclusions.

Despite the majority of the participants being rooibos consumers the type of tea usually consumed by the participants did not impact their acceptance of either of the experimental breads. The food industry can thus undertake the food product development venture by increasing the TAC of bread using fluid manipulation in the recipe formulation and in particular replacing the water as liquid with rooibos at a concentration as high as 5% (v/w). Even though most of the participants had no awareness of the term functional foods, most were willing to purchase and to pay more for foods containing added health benefits that should provide further support to industry to initiate such a food product development undertaking. However, in such product development the sensory attributes of the developed product should be considered as the texture acceptance difference between the two breads found in this study could impact willingness to purchase.

CHAPTER 7

RECOMMENDATIONS

Much attention has been placed on the health and nutritional aspects of a diet rich in fruits and vegetables which can offer protection against oxidative stress and the resultant chronic degenerative disease development (Lajolo, 2002:147). Currently South Africans do not have adequate intakes of fruits and vegetables (Love & Sayed, 2001:S24) which results in a decreased intake of antioxidants (Dufresne & Farnworth, 2001:407). The suggested daily dietary TAC per person is calculated to be an estimate of 20 513 ɥmole TE/person/day in a recent exploratory study (Louwrens *et al.,* 2009:199), which considered the dietary guidelines pertaining to the intakes of vegetables and fruit, legumes, wholegrains and beverages including tea and coffee (Louwrens *et al.,* 2009:199). The average South African dietary TAC was also calculated, with the dietary intakes based on secondary data, that suggested an average adult South African dietary TAC of 11 433 ɥmole TE/person/day that was nearly 50% less than the estimated suggested TAC per person per day. The beverage group, including the intake of tea and coffee, was the highest contributor and the grains group the second largest contributor towards the TAC (Louwrens *et al.,* 2009:199). Such research is supportive for studies, such as this one, which demonstrate the use of a staple food as a vehicle to increase the dietary TAC that makes use of both grains and beverages as the intakes of both these food types can also be improved upon.

Although the major recommendation for increasing dietary antioxidants is through increasing fruit and vegetable intake, another method of increasing dietary antioxidants can be through the development of functional foods containing antioxidants (Battino & Mezzetti, 2006:1099). A basic food item such as bread can be used as a vehicle to increase the dietary TAC through using an antioxidant rich food item or an extract of a particular antioxidant rich food item; an example of this would be the use of a rooibos extract added to foods to increase the TAC of the food which would be more practical in the larger food production plant environment. The research showed the ease of using rooibos and bread as a vehicle for increasing the TAC of a commonly consumed product that can for example be accomplished in a smaller food production environment such as the home. The confirmed consumer acceptance found in this study can be used as a development endeavor for future food development along with using the concentrations of rooibos [2% (w/v) and 5% (w/v)] as a guide for future methods of increasing the TAC of a staple food such as bread and using rooibos for the antioxidant provision.

The participant sample of this exploratory research study were predominantly female, young adults, with three to four years post school education, as well as participants being aware of following a healthy lifestyle which can be seen through the majority being non-smokers, participating in physical activity, having a positive perception of own heath status and health consciousness comparable to other adults of similar age and perceived themselves of being of optimal weight. The food product development acceptance within this niche participant market used in this study provides the evidence for a venture to be undertaken of increasing the TAC of a staple food being initially aimed at a participant market related to health conscious consumers. The participant sample characteristics of being predominantly women, more highly educated (Girios *et al.,* 2001:418; Robinson & Smith, 2003:177), more active, possessing a healthier body weight status (Robinson & Smith, 2003:177), concerned with nutrition and fitness and leading a "well-orientated" lifestyle relates to the characteristics of the health conscious consumer (Robinson & Smith, 2003:177).

In the current food market "health" bread is readily available. However, this may not necessarily be cost effective to the economically disadvantaged sector of the population. There is a great need for foods, especially staple foods which are consumed on a regular basis by all economic sectors, which contain health benefits and which is affordable to all economic sectors. Currently within the South African population, vegetable and fruit intake which relates to antioxidant intake is strongly related to the availability and seasonal fluctuations of food products, along with affordability factors and household taste preferences (Love & Sayed, 2001:S29). These factors, especially affordability will have to be overcome in the context of a staple food with antioxidants for it to reach market penetration and product development success. There is a demand for the increase in the availability of healthier choices as well as encouraging healthier food choices through improved pricing strategies, especially with groups with less disposable income (Buttris *et al.,* 2004:337); however, price considerations are as important as educating the need for a food product with added health benefits which is attractive in both sensory attributes and price. As the sensory attributes of the rooibos breads were found acceptable, the pricing strategy requires initial attention for further development work to continue. Although education, marketing and advertising and commercialisation are all part of encouraging and changing purchasing behavior, pricing strategies are very important to the success of a food product. Consideration should however be given to obtaining consumer groups representing different socio-economic sectors and households (incorporating households with children) of the South African population for broader consumer acceptance testing of the product.

Although the consumption of fruit and vegetables is encouraged within the food-based dietary guidelines (FBDGs), another recommendation related to the South African FBDGs is the consumption of cereals and grains and an increase in the consumption of less refined cereals and grains in the unprocessed or minimally processed form (Vorster & Nell, 2001:S17). Research has shown that South Africans consume more refined grains compared to that of whole grains, through the consumption of low fibre carbohydrate food items (Vorster & Nell, 2001:S19). An equal or even larger amount of phytochemicals can be provided by the consumption of whole grains that should be encouraged to be consumed on a daily basis for up to one or two servings daily (Vorster & Nell, 2001:S23). It is thus recommended to further this food product development action by incorporating rooibos as a fluid replacement ingredient in wholegrain bread. Previous research has shown demographic groupings which include the youth and adults, and including being female, of nonwhite race, and of a lower income bracket, of having a lower wholegrain intake. Other factors which may influence a decreased wholegrain intake include disliking the taste, texture and appearance of wholegrain foods (Larson *et al.,* 2010:230). This information will be useful in further studies to determine the acceptance of wholegrain products such as the staple food bread incorporating rooibos as an ingredient to increase the TAC, as the study sample can be selected to be a true reflection of the sector which may be in need of increased wholegrain intake within the South African population.

Poor iron status is a growing problem globally, especially amongst children and women. Iron status is not only affected by iron intake but other dietary factors such as the polyphenols from tea made from *Camellia sinensis* (Hogenkamp *et al.,* 2008:430). Results from the Transition and Health during Urbanization of South Africans (THUSA) study (1996-1998) showed that cultural habits of South Africans include tea as a beverage between meals and as a drink to accompany meals (Hogenkamp *et al.,* 2008:435). During the THUSA study, over a set time period of 16 weeks, the possible difference between the effect of rooibos and black tea on iron status of black South African school children was investigated with no difference shown on the iron markers (Hogenkamp *et al.,* 2008:430). A study by Breedt and co workers, (2005:983, 985), investigated the effect of black tea and rooibos consumption on iron status of primary school children. A parallel investigation was done where the subjects received two 200ml servings of either black tea or rooibos with milk and sugar. Their dietary intakes were measured by a 24-hour dietary recall. The study results showed that rooibos in contrast to ordinary tea did not significantly affect iron absorption (Breedt *et al.,* 2005:983, 985). These results demonstrate the ability for food product development incorporating rooibos as an antioxidant source which can be used in food products consumed in between meals or as part of meals.

Typical South African foods which are commonly consumed and that can provide further recipe opportunities for rooibos inclusion, particularly in the household, are cooked pumpkin, butternut and hubbard squash, cooked sweet potato without skin, tomato and onion stew, beef mince, prepared chicken dishes such as stews and pies, bobotie and cottage pie (Nel & Steyn, 2002:75-94). In addition new product development food industry endeavors incorporating rooibos can also be initiated. New food products which are already available in South African food retail stores incorporating rooibos include yoghurt, drinking yoghurt and fruit juices which can be expanded on. Supermarket-based interventions to introduce new products, such as foods with added health benefits should allow consumers to taste the product and engage with educated suppliers to encourage purchasing.

A range of approaches can be used to encourage dietary change amongst consumers. One of the main challenges is to encourage interest in food behavior modification (Buttris *et al.,* 2004:335), which through this study can be seen as presented through the willingness of the participants to purchase both the experimental breads and the willingness to pay more for foods with added health benefits. It must be noted that to make a successful change in food behavior tailored approaches have been more successful in the past as different approaches suit different population groups. The initial approach must include a certain level of education for all population groups (Buttris *et al.,* 2004:335); parents and care givers need to be educated on the benefits not only of healthy eating and following the FBDGs but the attention needs to be focused on the intake and use of readily available nutritional foods. This is one of the main benefits of using a staple food as a food vehicle to increase dietary antioxidant levels. When educating care givers, parents and younger children, an option can include hands-on activities which can provide a sense of ownership as well as introducing practical interventions which can include cook and eat classes showing the benefits of healthy eating (Buttris *et al.,* 2004:335). In such activities the incorporation of antioxidant rich recipe ingredients as well as educating how recipe formulations can be adapted to increase antioxidant intake can be included.

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ADDENDUM A
Base recipe

Brown bread

Makes: 4 large loaves

Ingredients

1	kg	Brown bread flour	750g	325g
1	kg	Cake flour	1.250kg	625g
3	pkts	Instant yeast		
5	tsp	Salt		
200	ml	Vegetable oil		
100	ml	White sugar		
1	l	Warm water	1.2l	600ml

Method

1. Mix all dry ingredients in large bread mixer
2. Add oil and switch mixer on
3. Add water
4. Mix for 10 minutes
5. Remove and place in lightly oiled bowl
6. Cover with damp cloth and place on top of oven on cooling rack
7. Proof until double, knock all the air out and proof again until double
8. Shape into four (4) loaves
9. Place on baking trays and proof until double
10. Brush with egg and milk glaze
11. Top with seeds (optional)
12. Make cuts into dough
13. Bake at 160ºC until light brown
14. Let cool on cooling rack

ADDENDUM B
Control bread

Control Bread

Yeast:

200	ml	water	Water temperature: 40˚C
10	ml	sugar	
25	g	fresh yeast	

Froth time: 23 ½ minutes

300	g	brown bread flour
450	g	white bread flour
10	ml	salt
15	ml	sugar

Add:

200	ml	water	Water temperature: 40˚C
10	ml	vinegar	
25	ml	oil	

Method:

1. Add wet ingredients to dry ingredients
2. Knead (speed no.1) for 5 minutes
3. Place in oil rubbed bowl & in prover for 45 minutes
4. Weight of bread = 1.241kg
5. Knock down for 1 minute
6. Weight of bread = 1.246kg/3 = 415g per bread
7. Shape into loaves
8. Prover for 15 minutes
9. Bake at 180˚C for 26 minutes
10. Weight of baked bread = 370g per bread
11. Height of baked bread = 7.5cm

Additional Comments:

- Bread good texture
- Soft but not dry

ADDENDUM C
Experimental bread recipe

Experimental rooibos bread

Rooibos infusion:

2g/100ml (boiling water)

Infused 5g rooibos with 250 ml boiling water for 10 minutes, strained and allowed cooling until 40˚C

Yeast:

250	ml	infusion	infusion temperature:	40˚C
10	ml	sugar		
25	g	fresh yeast		
Froth time:		23 ½ minutes		

Ingredients:

300	g	brown bread flour
450	g	white bread flour
10	ml	salt
15	ml	sugar

Add:

Infused 4g rooibos with 200 ml boiling water for 10 minutes, strained and allowed cooling until 40˚C

200	ml	infusion	infusion temperature:	40˚C
10	ml	vinegar		
25	ml	oil		

Method:

1. Add wet ingredients to dry ingredients
2. Knead (speed no.1) for 5 minutes
3. Place in oil rubbed bowl and in prover for 45 minutes
4. Weight of bread = 1.176kg
5. Knock down for 1 minute
6. Weight of bread = 1.175kg/3 = 391.65g per bread
7. Shape into loaves
8. Prover for 15 minutes
9. Bake at 180˚C for 26 minutes
10. Weight of baked bread = 360g per bread
11. Height of baked bread = 6.5cm

Additional comments:

- Dough much drier, needs additional liquid
- Elasticity was decreased
- Colour difference but not unacceptable – dough more golden
- Yeast proving quicker time
- During knock down dough much denser and tougher to handle

Experimental honeybush bread

Honeybush infusion:

2g/100ml (boiling water**)**

Infused 5g honeybush with 250 ml boiling water for 10 minutes, strained and allowed cooling until 40˚C

Yeast:

250	ml	infusion	infusion temperature:	40˚C
10	ml	sugar		
25	g	fresh yeast		
Froth time:		23 ½ minutes		

Ingredients:

300	g	brown bread flour
450	g	white bread flour
10	ml	salt
15	ml	sugar

Add:

Infused 4g honeybush with 200 ml boiling water for 10 minutes, strained and allowed cooling until 40˚C

200	ml	infusion	infusion temperature:	40˚C
10	ml	vinegar		
25	ml	oil		

Method:

1. Add wet ingredients to dry ingredients
2. Knead (speed no.1) for 5 minutes
3. Place in oil rubbed bowl and in prover for 45 minutes

4. Weight of bread = 1.146kg
5. Knock down for 1 minute
6. Weight of bread = 1.145kg/3 = 381.66g per bread
7. Shape into loaves
8. Prover for 15 minutes
9. Bake at 180˚C for 26 minutes
10. Weight of baked bread = 353g per bread
11. Height of baked bread = 5.5cm

Additional comments:

- Dough much drier, needed additional liquid
- Took very long to come together as a homogenous mixture compared to the others
- Did not form one round ball prior to proving
- Yeast grew quickly
- Only slight difference in colour

- Attempted rooibos experimental bread with 500ml of liquid but dough very gooey and soft (almost batter-like).
- Decided additional 100ml not viable for good bread making so changed to additional 50ml

ADDENDUM D
Questionnaire

Instructions for completion

Please complete the 2 sections of the questionnaire by indicating your answer with a cross (x) mark in the block opposite the question. Only indicate one answer for each question.

SECTION A: CONSUMER DEMOGRAPHIC, HEALTH STATUS AND AWARENESS INFORMATION

For Office use only

1 Indicate your gender.

Female	1	1
Male	2	

2 Indicate your age.

18 - 24 years	1	2
25 - 34 years	2	
35 - 44 years	3	
45 - 54 years	4	
55 - 60 years	5	
61 years and older	6	

3 Indicate your years of after school education completed.

1 - 2 years (First and secondary year of study)	1	3
3 - 4 years (Third and fourth year of study)	2	
5 and more years (Postgraduate study)	3	

4 Indicate your marital status.

Married/living together without chidren	1	4
Married/living together with children	2	
Single/living on your own	3	
Single/living with children	4	

5 How would you describe your body weight status?

Underweight	1	5
Optimal / Normal body weight	2	
Slightly overweight / Overweight	3	
Obese	4	

6 Are you a current smoker?
(Current smokers include those persons who smoked any tabacco in the past 12 months and those who quit within the past year)

Yes	1	6
No	2	

7 Are you currently 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	7
No	2	

8 Do you currently use dietary supplements
(Dietary supplements include vitamins, minerals, herbs or botanicals, and amino acids intended to supplement the diet)

Yes	1	8
No	2	

9 How do you perceive your own health status (complete mental, physical and social well-being and not merely the absence of disease or infirmity) relative to that of other adults of your age?

Worse than most	1	9
About similar to most	2	
Better than most	3	

10 How health conscious do you perceive yourself to be relative to that of other adults of your age?

Much less than most	1	10
Somewhat less than most	2	
About similar to most	3	
Somewhat more than most	4	
Much more than most	5	

11 Do you have a family history of chronic degenerative disease?
(Note: Chronic degenerative disease include arthritis, cardiovascular disease, cancer, diabetes, obesity etc. which are permanent or persisiting and need long term supervision, observation and care)

Yes	1	11
No	2	

12 Which diagnosis of the following chronic degenerative diseases would you be most concerned about?

Cancer	1	12
Cardiovascular disease (or high blood cholesterol)	2	
Diabetes mellitus (or high blood sugar)	3	
Hypertension (or high blood pressure)	4	
Obesity	5	
Stroke	6	
Other (Please specify)………………………………………	7	

13 Have you heard of the term "functional foods"

Yes	1	13
No	2	

14 Would you be more likely to purchase a food product if it contained added health benefits?

Yes	1	14
No	2	

15 Would you be willing to pay more for a food product if it contained added health benefits?

Yes	1	15
No	2	

16 If you answered yes, to Question 15, how much more are you willing to pay more?
(*Please indicate clearly as a percentage)*

……….%	16

17 Do you consume any of the following teas or herbal teas (whether unflavored or flavored)?

17.1	Black tea	Yes	1	No	1	17
17.2	Honeybush	Yes	2	No	2	18
17.3	Rooibos	Yes	3	No	3	19
17.4	Green tea	Yes	4	No	4	20
17.5	Other herbal teas	Yes	5	No	5	21

SECTION B: CONSUMER ACCEPTANCE OF BREAD

BREAD A

1 How much do you like the colour (visual appearance) of the bread?

Dislike very much	1	22
Dislike	2	
Neither like nor dislike	3	
Like	4	
Like very much	5	

2 How much do you like the flavour / taste of the bread?

Dislike very much	1	23
Dislike	2	
Neither like nor dislike	3	
Like	4	
Like very much	5	

3 How much do you like the texture of the bread?

Dislike very much	1	24
Dislike	2	
Neither like nor dislike	3	
Like	4	
Like very much	5	

4 Would you purchase this bread?

Yes	1	25
No	2	

BREAD B

1 How much do you like the colour (visual appearance) of the bread?

Dislike very much	1	26
Dislike	2	
Neither like nor dislike	3	
Like	4	
Like very much	5	

2 How much do you like the flavour / taste of the bread?

Dislike very much	1	27
Dislike	2	
Neither like nor dislike	3	
Like	4	
Like very much	5	

3 How much do you like the texture of the bread?

Dislike very much	1	28
Dislike	2	
Neither like nor dislike	3	
Like	4	
Like very much	5	

4 Would you purchase this bread?

Yes	1	29
No	2	

THANK YOU FOR YOUR PARTICIPATION