Barriers and facilitators of brown rice consumption, sensory acceptability and its effect on blood glucose level among university staff

Thesis submitted in fulfilment of the requirements of the degree of:

Master of Applied Science in Food and Nutrition

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at the

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Supervisor: Dr Ashika Naicker Date: 17/05/2021

Co-supervisor: Mrs Evonne Singh Date: 17/05/2021

DECLARATION

I, Anjellah Reddy, hereby declare that the research work presented by this thesis is my original work and all the materials used are appropriately acknowledged and explicitly referenced. A reference list is attached to the thesis.

I also confirm that the thesis has not been submitted in any of its part or entirety for any degree in any other institution of higher learning internationally or locally.

I therefore give permission that my work be available for replication and/or for re-printing, for inter-library loan, and for the title and abstract of my thesis to be made available to other educational institutions and students that might need it.

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DEDICATION

This thesis is dedicated to:

All Mothers

"To those who consider life something other than a monstrous belly with a golden navel for all to worship;

To those who have tasted and preferred renunciation, simplicity and freedom;

To those who make an art of living;

To those who cultivate poverty as a spiritual exercise, whatever their religion;

To those who find in each moment a life to live for;

To the unwilling poor, victims of society, property, climate, injustice, ignorance, overpopulation, stupidity, evil or dumb pride;

Because it is clear that people's kitchens all over the world have learned to adapt to what's available and from the nearly nothing at their disposal make something more than just enough to live, make sturdy, simple pleasures and elemental feasts."

- Couffignal 1979:1

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- My three daughters, Yentl, Xavania, and Zarasha, for "Everything."

- My seven Siblings, for all our shared, joys and sorrows.

- My "Best" Friends, my Blessings, who love and sustain me beyond measure, every day.

- And finally, with utmost reverence, to every Man, Woman, and Child who toiled the fields in the scorching heat and the madness of the monsoons, to give us a handful of rice. Much Thanks Always.

ABSTRACT

Background: South Africa is undergoing an epidemiologic and nutrition transition, characterized by a surge in the prevalence of overweight and obesity levels, with a noticeable increase in the consumption of high energy-dense, low nutritive foods and beverages, and a marked decrease in physical activity. Food consumption patterns in South Africa have changed dramatically over the past decades, and will most likely continue to transform over the coming decades. Diabetes is on the rise in South Africa, and a significant body of evidence suggests that targeted interventions, such as the inclusion of whole grains and a plant-based diet, are beneficial towards lowering blood glucose levels. A shift to substitute white rice with brown rice, and to increase awareness on the impact of brown rice consumption, can be a solution towards enabling behaviours aimed at subsequently maintaining and lowering blood glucose levels among adults. However, this can only happen if barriers and facilitators of brown rice consumption are identified and addressed. Additionally, pairing brown rice with meals typically enjoyed by a target population may increase acceptability of brown rice inclusion in the diet.

Aim: The purpose of this research was to determine barriers and facilitators of brown rice consumption, and the sensory acceptability of brown rice when paired with typical South African dishes, lastly, to measure the effect of a brown rice meal on blood glucose level among staff members of the Durban University of Technology (DUT).

Methodology: The study used a mixed methods approach; qualitative methods were used to assess the barriers and facilitators of consuming brown rice through three focus group discussions (FGDs). A quantitative method approach was applied to assess the sensory acceptability, appropriateness, and palatability of paired meals with brown rice. A selection of measuring tools and techniques were utilized, namely, FGDs, starch food frequency questionnaire (SFFO); sensory acceptability tests of brown rice cooked using various methods; sensory acceptability tests of brown rice paired dishes; anthropometrics and clinical measurements of participants, and pre-prandial and 2-hour post-prandial blood glucose measurements.

Results: Three FGDs were conducted until meaningful saturation was reached; two face-to-face and one in the online mode. The total number of participants in the three FGD groups

consisted of 24 participants, comprising of 25% (n=6) men and 75% (n=18) women participants. Five broad themes were identified: perceptions of healthy and unhealthy foods, factors that determine food choice, factors that influence rice choice, barriers, and facilitators of including brown rice in the diet. The FGDs outlined the following barriers: brown rice is not as tasty as white rice; it requires a longer cooking time; participants had limited preparation skills; brown rice is expensive, and the designated family shopper purchases only white rice. On the other hand, facilitators of brown rice consumption included favourable sensory attributes such as crunchy mouthfeel, nuttiness, non-sticky texture and an earthy aroma. The SFFQ was administered to 94 Durban University of Technology participants who work at the institution. Significantly, the most frequently consumed starch was potatoes, where 63.8% of the study participants had eaten potatoes in the previous 7 days (p=.010). This was followed by brown bread (48.7%) and white parboiled rice (42.6%). In the total rice category, 89.4% of participants reported consuming rice, of which brown rice was the least consumed (11.7%). This alluded to a strong potential to shift from white to brown rice consumption if barriers could be overcome. For the sensory acceptability tests of brown rice paired dishes, two meals, butter chicken and lamb curry, were paired with brown rice. A strong liking was shown for both these paired meals when examining all sensory attributes (appearance, taste, smell and texture*)* with brown rice. The sensory evaluation (n=60) of butter chicken paired with brown rice using the 9-point hedonic scale showed that taste had the highest ranking of 7.97, followed by appearance at 7.95, texture at 7.90 and smell at 7.82. The sensory evaluation (n=60) of lamb curry paired with brown rice showed that appearance had the highest ranking at (7.87), followed by texture at (7.69), taste at (7.67) and smell at (7.52). Four different cooking methods were used to cook brown rice, namely, stove-top, gas, microwave and oven. Although brown rice prepared using microwave cooking was most preferred at (28.8%), the chi-square goodness-of-fit test showed that all four cooking methods were equally preferred (p=.834). The anthropometric results showed that the (n=51) mean waist circumference (WC) for both men and women in this study was higher than the recommended WC cut-off points. The anthropometric status in this study denotes that high WC places participants in this study at a greater risk of chronic diseases. The anthropometric measure for weight (n=58), one participant was underweight (1.15%); 28.4% (n=25) participants were normal weight; 35.22% (n=31) participants were overweight, and 35.23% (n=31) participants were obese. The anthropometric for height (n=58) in centimetres was indicated at 1.60 for women and 1.71 for men. After participants observed an overnight fast, (n=60) the mean pre-prandial blood glucose level was 5.54 mmol/L, 2 hours after consuming a healthy brown rice breakfast, the mean post-prandial

blood glucose was 5.45 mmol/L. Analysis from a Wilcoxon signed ranks test showed that there was no significant difference in blood pre to post eating, (p=.771). Analysis using a paired t-test showed that there was no significant difference in blood values before and after eating, (p=.431), meaning that blood glucose levels were maintained after consuming the brown rice breakfast. The findings of this result endorse the healthful benefits of brown rice, as it is widely evidenced in existing literature that brown rice reduces insulin spikes and aids in the stabilisation of the body's blood sugar levels due to its low glycaemic index. There is potential to shift participants from white to brown rice however, this can be facilitated by deliberately pairing brown rice with dishes most preferred by the target population. Once palates become more accustomed to brown rice, it may be easier to encourage brown rice consumption with other dishes. No significant differences in post-prandial blood were found across the Body Mass Index (BMI) categories, F (3, 51) (p= .970, p=.414). However, there was a significant moderate positive correlation (r=.365) between WC and post-prandial blood scores, (p=.011) alluding to the risk factor association of increased WC and blood glucose levels.

Conclusion: The health benefits associated with brown rice consumption as outlined in this research, warrants that further research be conducted on the acceptance of brown among consumers in South Africa. The favourable acceptance of brown rice when paired with butter chicken, lamb curry; egg fried rice and breakfast muesli concept as depicted in this study, indicates scope for a much larger percentage of brown rice consumption than the current 11.7%. It also alludes to the importance of contextualising meal combinations and sensory acceptability, to fit specific contexts and thus influence consumption patterns. Shifting individuals starch preference to more healthful starches, like brown rice, can contribute to health gains for a target population. Alongside this, consumer education, recipes and sensory sampling can help consumers feel part of the solution. Many studies have documented the healthful benefits of making the transitional shift from white rice to brown rice. However, this study notes despite its healthful benefits, that the acceptance of brown rice has been limited, compelling the activation of consumer education and practical preparation solutions to ease consumer acceptance of brown rice.

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
CMD	Cardiometabolic Diseases
CMS	Cardiometabolic Syndrome
CRP	C-Reactive Protein
COVID-19	The name of the disease caused by the SARS-CoV2 virus
CVDs	Cardiovascular Diseases
DAFF	Department of Agriculture, Forestry and Fisheries
DUT	Durban University of Technology
EDNP	Energy Dense and Nutrition Poor
FAO	Food and Agricultural Organisation
FPG	Fasting Plasma Glucose
FGD	Focus Group Discussion
GABA	Gamma-Aminobutyric Acid
GBR	Germinated Brown Rice
GI	Glycaemic Index
GT	Gelatinisation Temperature
GTA	Global Trade Atlas
HbA1c	Glycated Haemoglobin
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
IDF	International Diabetes Federation
IPO	International Pasta Organisation
IRGB	International Rice Gene Bank
KZN	KwaZulu-Natal
LMICs	Low- and Middle-Income Countries
NCDs	Non-Communicable Diseases
NGO	Non-Governmental Organisation
NHI	National Health Insurance
PPG	Post-prandial Plasma Glucose
SA	South Africa
SAMRC	South African Medical Research Council
SD	Standard Deviation

SDGs	Sustainable Development Goals
SFFQ	Starch Food Frequency Questionnaire
SSIIa	Starch synthase IIa
T2D	Type 2 Diabetes Mellitus
UN	United Nation
US	United States
WC	Waist Circumference
WHO	World Health Organisation

CHAPTER 1: INTRODUCTION AND IMPORTANCE OF THE STUDY

1.1 INTRODUCTION

This chapter will provide an overview of the research study and highlight the importance of making the transition from white rice to brown rice consumption. South Africa is undergoing an epidemiologic and nutrition transition, characterised by the rise in the prevalence of overweight and obesity, an increase in the consumption of high energy-dense foods and beverages, and a decrease in physical activity (Vorster *et al.* 2011: 429; Popkin *et al.* 2012: 3). At the same time, type-2 diabetes mellitus (T2D) and cardiometabolic diseases (CMD), including cardiovascular diseases (CVDs), have moved up to the second and third cause of death and disability in South Africa (Stats SA 2016). The International Diabetes Federation (IDF), reported that in 2017, South Africa recorded a 5.4% prevalence of diabetes type-2 mellitus (International Diabetes Federation, 2019), and this increased more than two-fold in 2019, with a prevalence of 12.4% (IDF 2019). Several studies have documented the benefits of making the transitional shift from white rice to brown rice (Fung *et al.* 2002: 535; Malik *et al.* 2019: 1389). However, in South Africa, the adoption of brown rice has been limited with no published studies been documented. Food consumption patterns in South Africa have changed substantially over the past decades and most likely will continue to change over the coming decades. The adoption of brown rice in the diet would be considered a healthful change to improved wellness and nutrition.

1.2 IMPORTANCE OF THE STUDY

Given that the prevalence of lifestyle diseases has increased alarmingly in South Africa and that the nutritional quality of diet has a large impact on this prevalence, measures to modify diet are sought-after. Simply substituting brown rice for white rice as a staple food item may reduce fasting glucose and insulin levels (Malik *et al.* 2019: 1389). Lack of awareness of the health benefits, texture, palatability, scarcity, and food cost are barriers to the consumption of whole grains. However, the promotion of the health benefits and subsidies to reduce the cost of brown rice, are strategies that might increase the consumption of brown rice (Kumar *et al.* 2011: 1517; Zhang *et al.* 2010: 1216).

White rice remains a staple in South Africa after maize, but little is known about why the transition from white to brown rice consumption has not taken off in this country despite its numerous health benefits (Esterhuizen 2018). The purpose of the research is thus to determine the barriers and facilitators of brown rice consumption, the sensory appropriateness and palatability of typical South African meals paired with brown rice, as well as to establish the impact of brown rice consumption on blood glucose levels among university staff.

South Africa needs to address dietary changes with a sense of urgency to combat the many chronic diseases that plague the nation. Active steps must be taken to reduce the prolific consumption of foods high in sugar, salt, fat, animal protein, and trans fats, and the snacking habits of South Africans must be rechannelled towards healthier choices of plant-based foods (Steyn and Damasceno 2006). The modification of diet quality is an important component of lifestyle interventions, particularly given the negative health impacts of shifting from diets high in fresh produce and whole grains to diets high in refined carbohydrates and added sugars (Malik *et al.* 2013: 13; Mattei *et al.* 2012: 1325).

This study utilised a mixed methods approach; qualitative methods will be used to assess the barriers and facilitators of consuming brown rice, through focus group discussions (FGDs), and quantitative methods will be used to assess sensory acceptability of paired meals with brown rice, sensory acceptability of brown rice using various cooking methods and pre- and post-prandial blood glucose will be measured to determine the effect of brown rice consumption on blood glucose levels among participants.

1.3 PROBLEM STATEMENT

Diabetes is on the rise in South Africa and substantial evidence indicates that targeted interventions, such as the inclusion of whole grains in the diet, are beneficial towards lowering blood glucose levels (Malik *et al.* 2013: 13; Mattei *et al.* 2012: 1335). A shift to replace white rice with brown rice in the diet, and to increase awareness of the benefits of brown rice consumption, can be a solution towards enabling behaviours aimed at maintaining and lowering blood glucose levels among adults.

1.4 AIM OF THE STUDY

The purpose of this research was to determine barriers and facilitators of brown rice consumption, and the sensory acceptability of brown rice when paired with typical South African dishes, lastly, to measure the effect of a brown rice meal on blood glucose level among staff members of the Durban University of Technology (DUT).

1.5 OBJECTIVES

- To explore barriers and facilitators of brown rice consumption among participants through FGDs.
- To assess the starch intake of participants through a starch food frequency questionnaire (SFFQ).
- To establish the sensory acceptability and palatability of meals paired with brown rice by means of sensory analysis.
- To determine the preferred cooking method of brown rice prepared using various cooking methods through sensory analysis paired preference tests.
- To determine the anthropometric status of participants.
- To determine the fasting pre-prandial blood glucose level and the 2-hour post-prandial blood glucose level of participants after consuming a meal paired with brown rice.

1.6 ASSUMPTIONS

- It was assumed that only non-diabetic staff (permanent/contract) of Durban University of Technology (DUT) based at Steve Biko, Ritson and ML Sultan campus would participate in this workplace study.
- It was assumed that all staff who participated in the blood draw, observed the overnight fast.
- It was assumed that participants answered questions honestly and without bias.

1.7 DELIMITATIONS

- The study was limited to only pre-diabetic, permanent and contract staff at the university.
- The study was limited to one variety of brown rice for the sensory tests.

1.8 DEFINITION OF TERMS

Antioxidants: Substances that can prevent or slow damage to cells caused by free radicals, unstable molecules that the body produces as a reaction to environmental and other pressures (Ware 2018).

Ayurveda: A type of traditional Hindu medicine that treats illnesses using a combination of foods, herbs and breathing exercises (Oxford University Press 2021f).

Barriers: Anything that prevents an action from happening or makes it more difficult to occur (Cambridge University Press 2021).

Basmati rice: A long-grain rice with a delicate fragrance, grown in India and Pakistan (Lexico 2021).

Best Buys: A product that has been carefully tested and that a consumer organisation says offers the best value for money in relation to other similar products (Longman 2021).

Body Mass Index: A measure of body fat that is the ratio of the weight of the body in kilograms to the square of its height in meters (Merriam Webster 2021c).

Brown rice: means rice kernel from which the husk only has been removed (SA, DAFF 2020: 14).

Cardiometabolic diseases: are the grouping of the disorders: abdominal adiposity, hypertension, dyslipidaemia, hyperinsulinaemia and glucose intolerance that collectively leads to CVD and type 2 diabetes (Fisher 2006: 95).

Composite dishes: are consumed at main meals (i.e., lunch or dinner), where preparation involves culinary skills and contains ingredients from at least three of five main food groups: meat/poultry/fish and eggs, dairy products, fruit and vegetables, starchy foods including legumes and added sweets and fats (Nirdnoy *et al.* 2021).

COVID-19 Virus: Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus (WHO 2021e: paragraph 1 line 1).

Diabetes mellitus: is a heterogeneous metabolic disorder characterized by the presence of hyperglycaemia due to impairment of insulin secretion, defective insulin action or both (Punthakee *et al*. 2018: 10).

Endosperm: The part of a seed which acts as a food store for the developing plant embryo (Oxford University Press 2021b).

Epidemiological Transition: Changing patterns of population age distributions, mortality, fertility, life expectancy, and causes of death (McKeown 2009: 19S).

Facilitator: A person-activity that helps somebody do something more easily by discussing problems, giving advice, etc. rather than telling them what to do (Oxford University Press 2021c).

Flavonoids: A group of natural substances with variable phenolic structures, are found in fruits, vegetables, grains, bark, roots, stems, flowers, tea and wine (Panche *et al.* 2016: e47).

Food Frequency Questionnaire: Used to assess the frequency with which foods are consumed (Rodrigo *et al*. 2015: 56).

Furfural: A colourless, oily liquid. Obtained from bran, sugar, wood, corncobs, or the like, by distillation: used chiefly in the manufacture of plastics and as a solvent in the refining of lubricating oils (Dictionary.com 2021).

Functional Foods: Dietary items that, besides providing nutrients and energy, beneficially modulate one or more targeted functions in the body, by enhancing a certain physiological response and/or by reducing the risk of disease (Donato-Capel *et al*. 2014: 389).

Generation-Z: The generation reaching adulthood in the second decade of the 21st century, perceived as being familiar with the internet from a very young age (Oxford University Press 2021g).

Green Revolution: The green revolution is the increase in agricultural production that has been made possible by the use of new types of crops and new farming methods, especially in developing countries (Collins 2021).

Green Super Rice: Is rice varieties that can produce high and stable yields under fewer inputs (water, nutrients, and pesticides) and adverse conditions (Jewel *et al*. 2019: 368).

Healthy Foods: A food that is low in fat and saturated fat and that contains limited amounts of cholesterol and sodium (Marks 2021a).

Inductive coding: A data analysis process whereby the researcher reads and interprets raw textual data to develop concepts, themes or a process model through interpretations based on data (Hunkirchen 2020).

Lignan: A member of a group of substances found in plants that have shown estrogenic and anticancer effects. Lignans have been used in some cultures to treat certain medical problems (National Cancer Institute 2021).

Non-Communicable Diseases: is a medical condition or disease which by definition is non-infectious and cannot be passed from person to person (South African Government 2021).

Obesity: abnormal or excessive fat accumulation. A BMI ≥ 30 kg/m^2 is defined as obese (WHO 2020c).

Overweight: abnormal or excessive fat accumulation that may impair health. The prevalence of overweight assessed by using body mass index, defined as the weight in kilograms divided by the square of the height in metres kg/m^2 $\geq$ 25 kg/m^2 is defined as overweight (WHO 2020c).

Parboiled rice: husked or milled rice processed from paddy or husked rice that has been soaked in water and subjected to a heat treatment so that the starch is fully gelatinized, followed by a drying process (SA, DAFF 2020:16).

Phenols: Compounds containing hydroxylated aromatic rings, the hydroxy group being attached directly to the phenyl, substituted phenyl, or another aryl group (Swanson 2003: 5729).

Prediabetes: a practical and convenient term referring to impaired fasting glucose impaired glucose tolerance, or a glycated haemoglobin of 6.0% to 6.4%, each of which places individuals at high risk of developing diabetes and its complications (Punthakee 2018: 10).

Satiety: The state or feeling of being completely full of food, or of having had enough of something (Oxford University Press 2021d).

Recommended Dietary Allowances: The RDA, the estimated amount of a nutrient (or calories) per day considered necessary for the maintenance of good health by the Food and Nutrition Board of the National Research Council/ National Academy of Sciences (Marks 2021b).

Rice Tiller: Rice tiller is a specialized grain-bearing branch that is formed on the unelongated basal internode and grows independently of the mother stem (culm) by means of its own adventitious roots (Li *et al.* 2008: 618).

Type 1 diabetes mellitus: occurs when the immune system attacks the pancreas, which causes the pancreas to stop producing insulin (Öberg 2019: e10250).

Type 2 diabetes mellitus: is a condition in which cells cannot use blood sugar (glucose) efficiently for energy. This happens when the cells become insensitive to insulin and the blood sugar gradually gets too high (Öberg 2019: e10250).

Urbanisation: The process in which towns, streets, factories, etc. are built where there was once countryside (Oxford University Press 2021e).

Volatile: A substance that is readily vaporizable at relatively low temperature (Merriam Webster 2021a).

White rice: Rice from which the hull and bran have been removed by milling (Merriam Webster 2021b).

Wonder bag: A simple but revolutionary non-electric slow cooker. After bringing a pot of food to the boil and placing it in a Wonder bag, the food will continue cooking for up to 12 hours without an additional energy source (Wonderbag 2021).

Zero-rated: Products that are exempt from that Value Added Tax (VAT) (Majaski 2021).

1.9 RESEARCH PLAN

The framework of the research study is represented in Figure 1.1

April -June 2019	Compile research proposal and present research topic to department research committee.
July- October 2019	Obtain faculty and ethical clearance.
November 2019	Obtain DUT gatekeeper permission.
December 2019- July 2020	Conduct FGDs.
August- September 2020	Analyse FGDs and conduct brown rice cooking trials.
October- December 2020	Conduct sensory, anthropometry and clinical tests.
January- February 2021	Results, analysis and interpretation.
March- April 2021	Report writing and editing.
May 2021	Final thesis submission.

Figure 1.1 Framework of the research

1.10 STRUCTURE OF THE THESIS

Chapter 1: Introduction and importance of the study

The chapter provides the background to the study and the research problem, and this thesis will be presented in the form of five chapters, and offers an overview, including the significance of the study, from a South African perspective.

Chapter 2: Literature review

A summary of the research studies in this chapter will focus on the prevalence of NCDs and the importance of the acceptability, of brown rice consumption in a road map towards positive health outcomes.

Chapter 3: Research methodology

The research design, methods and tools used to carry out the study, including ethical considerations, participant's selection criteria, and statistical analysis, are presented in this chapter.

Chapter 4: Results and discussion

This chapter offers a compilation of the data collected and correlations drawn, with a discussion of the outcomes relative to the reviewed literature.

Chapter 5: Conclusion and recommendations

Limitations to the study and suggestions for future research are included here, along with the conclusions of the research study.

1.11 REFERENCING STYLE

The referencing style used in this thesis is according to the guidelines used by DUT, viz. the Harvard referencing style.

1.12 CONCLUSION

In Chapter One, the importance and need for the research study has been outlined. In the next chapter, the literature is examined.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The main purpose of this chapter is to review and present the literature that is available on research conducted by various authors. This pertains to a larger body of scientific research relating to the global burden of non-communicable diseases (NCDs), the associated disease conditions of NCDs and the risk factors, and measures to mitigate NCDs. Facilitators and barriers of brown rice and its impact on blood glucose level is reviewed. Further to this, the inclusion and consumption of brown rice in the diet is reviewed, globally and in South Africa.

2.2 GLOBAL BURDEN OF NON-COMMUNICABLE DISEASES

Non-communicable diseases have become a leading public health concern globally and leads to the death of approximately 41 million people annually, according to the World Health Organisation (WHO 2021b: para. 1 line 1). The WHO projects that by 2025, NCDs will account for over 70% of all deaths globally, with 85% of these premature deaths occurring in developing countries (WHO 2015). With the human, social and economic consequences of NCDs impacting all countries, the global priority is to address chronic disease, which is increasing rapidly (WHO 2014: 3).

Non-communicable diseases, also known as chronic diseases, are defined as a medical condition or disease that is not caused by infectious agents, is non-transmissible, lasts for a long period, and progresses slowly (Kamineni 2019: para. 1 line 3). The main types of NCDs include cardiovascular diseases, cancers, chronic respiratory diseases, diabetes and mental illness (WHO 2021b: para. 1 line 2). Non-communicable disease risk factors, result from a characteristic western and predominantly urban lifestyle, combined with adverse environmental factors (Kamineni 2019: para. 1 line 3). Non-communicable diseases are further influenced by factors such as inadequate planning in urbanisation, the globalisation of unhealthy lifestyles and a growing senior citizen population (Pandey *et al*. 2018: 18).

The burden of NCDs has grown in the past two decades with distressing outcomes in the health sector. This plight is not helped with the current global attention focusing on the fight against

the COVID-19 pandemic. Worryingly, people with underlying health conditions such as NCDs have a higher risk of severe COVID-19 disease and are more likely to die from COVID-19. The latest medical literature confirms that people living with NCDs are at a higher risk of severe complication if they contract COVID-19 (CANSA 2021: para. 1 line 5). An important way to control NCDs is to focus on reducing the risk factors associated with these diseases. The major risk factors for NCDs include an unhealthy diet, lack of physical activity, tobacco use and the harmful use of alcohol (WHO 2021b: para. 1 line 2).

2.3 GLOBAL PREVENTION AND CONTROL OF NON-COMMUNICABLE DISEASES

A surge of commitments and advocacy has helped to advance the NCD agenda in the past five years, including the adoption of the WHO Global NCD Action Plan 2013-2020, the first set of global NCD targets, and the 2030 Agenda for Sustainable Development Plan, which includes NCDs (Lee *et al.* 2013: 13). With these commitments and advocacy, the global community has the chance to change the developments of NCDs. The WHO Global NCD Action Plan 2013-2020, is based around four interconnected strategic pillars for action (Figure 2.1). Essentially, advocacy efforts need to be scaled-up and transformed, accountability has to be promoted, and the capacity of civil society organisations and alliances have to be strengthened, with knowledge exchange of evidence-based NCD policy and practices (Non-Communicable Diseases Alliance 2016a: 10).

Figure 2.1: NCD Alliance Strategic Plan 2016-2020 (Non-Communicable Diseases Alliance 2016b)

The WHO Global monitoring framework on NCDs monitors implementation of the NCD global action plan through checks and reports on the realisation of the 9 global targets for NCDs, by 2025, compared to a baseline in 2010 (Figure 2.2) (WHO 2013). Governments are therefore encouraged to (i) set national NCD targets for 2025 based on national circumstances; (ii) develop multisectoral national NCD plans to reduce exposure to risk factors and enable health systems to respond, and (iii) measure pre-post results considering the Global Action Plan (WHO 2013). The 9 voluntary global targets are aimed at combatting global mortality from the four major NCDs, accelerating action against the leading risk factors for NCDs and strengthening national health system responses.

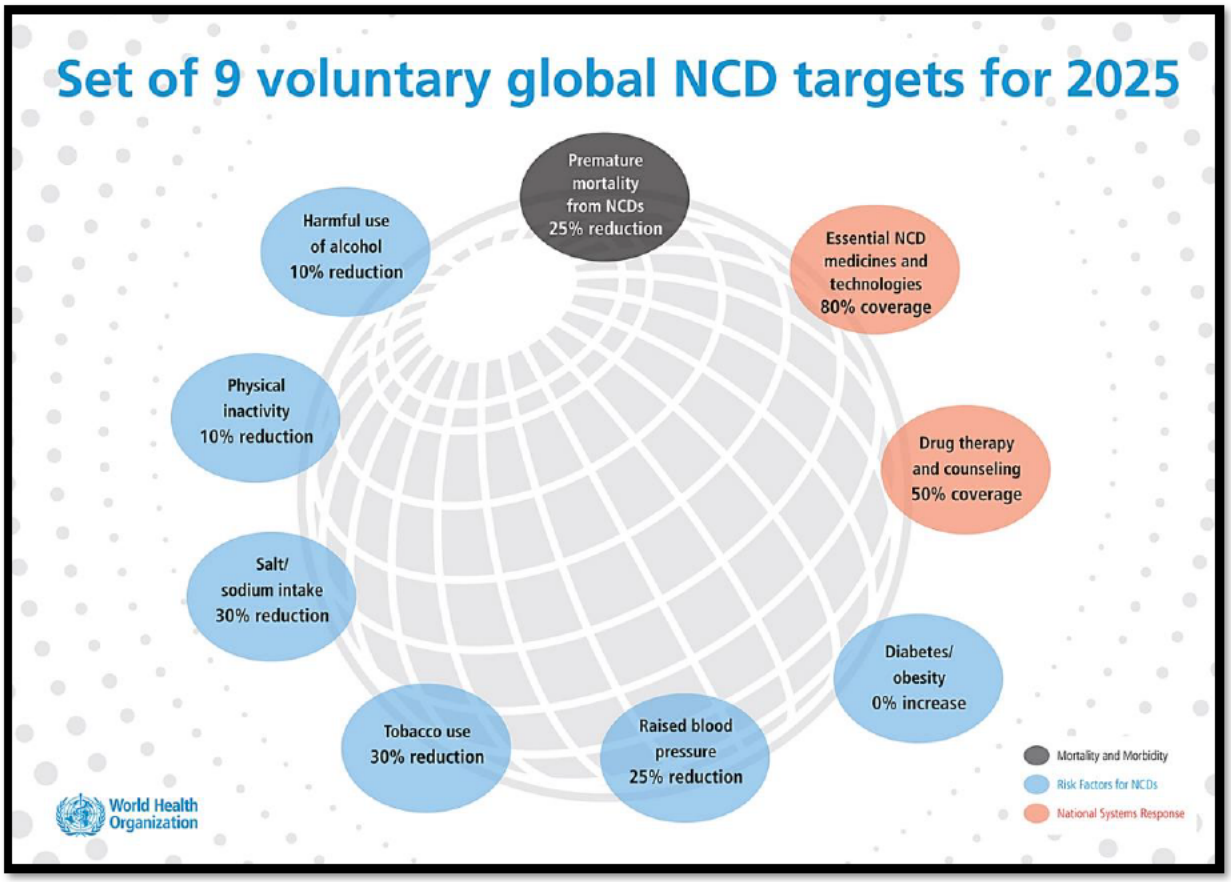

Figure 2.2: The 9 voluntary global targets for NCDs (World Health Assembly 2013)

The 2030 Agenda for Sustainable Development Goal (SDG) recognises that the burden of NCDs worldwide was not addressed in the Millennium Development Goals. The target is to reduce premature deaths from NCDs by one-third by 2030 (SDG target 3.4), strengthen implementation of the World Health Organisation Framework Convention on Tobacco Control (3.a), strengthen the prevention and treatment relating to the harmful use of alcohol (3.5), support the research and development on medicines for NCDs that primarily affect developing countries (3.b), and achieve universal health coverage (3.8) (WHO 2013). In Figure 2.3, the interlinkages between SDGs, calling for an integrated approach, are illustrated.

Figure 2.3: Interlinkages connecting SDG target 3.4 and other SDGs (Non-Communicable Diseases Alliance 2017)

Throughout the world, there is growing uneasiness as NCDs disproportionately affect low- and middle-income countries (LMICs). Deleteriously, LMICs are experiencing a growing incidence of overweight and obesity, particularly in urban areas, leading to an increase in NCDs

such as cardiovascular disease, diabetes, and certain types of cancers (WHO 2021a: para. 4 line 3).

2.4 NATIONAL PREVALENCE OF NON-COMMUNICABLE DISEASES

In South Africa, the prevalence of NCDs has increased, creating a challenge for the health system. Statistics South Africa (Stats SA) claims that NCDs account for 57.8% of all deaths, of which 60% are premature (under 70 years of age) (Stats SA 2016: 21). According to the 2019 South African Health Review, and a 2014 Burden of Disease Analysis, NCDs accounted for the largest broad cause of years of life lost in South Africa. In South Africa, NCDs are expected to be on a sharp increase in the next two decades. In the absence of innovative interventions, the health services could in the future become overwhelmed with patients requiring acute as well as long-term health care (Freeman *et al.* 2020: 3). On a global scale, the United Nations has declared that NCDs are not only a health but a development concern, requiring government and societal intervention (Department of Health 2013).

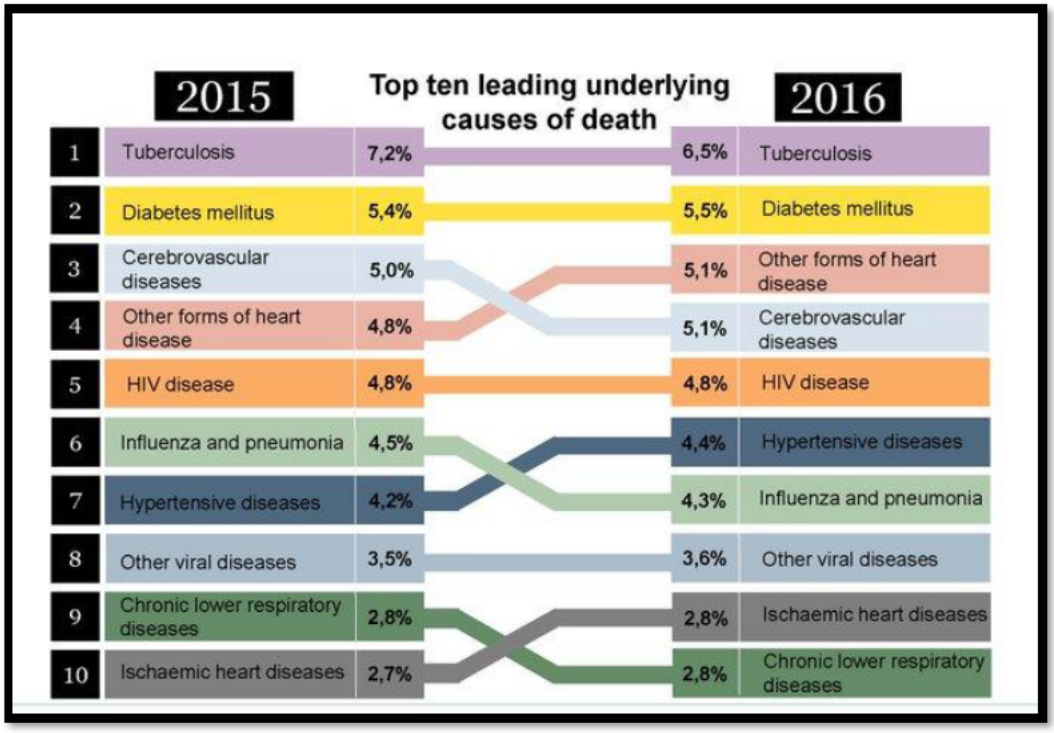

Figure 2.4: Top 10 leading causes of death in South Africa (Stats SA 2018)

In 2016, the leading cause of death in South Africa was tuberculosis (6.5%), followed closely by diabetes mellitus (5.5%), other forms of heart disease (5.1%) and cerebrovascular disease (5.1%) (Stats SA 2016) (Figure 2.4). By comparison, a decade ago, the top three main causes

of death in South Africa were poorly defined; unknown causes accounted for 13.6% deaths, tuberculosis accounted for 12.6% deaths, and influenza and pneumonia contributed towards 7.7 % of deaths (Stats SA 2017: 24). In 2017, while tuberculosis remained the leading cause of death, it has shown a year-to-year decline in the cause of deaths. This is unlike diabetes mellitus, which has shown a year-to-year increase as the cause of deaths (Stats SA 2017: 9). Notably, six of the top ten underlying natural causes of death in 2017 were from NCDs, and it must also be noted that death from NCDs rose at older ages, especially due to cancers and CVDs (Stats SA 2017: 41).

2.4.1 DIABETES MELLITUS

The prevalence of diabetes has steadily climbed to 4.5 million people in South Africa, with much of the population still undiagnosed (Pheiffer *et al.* 2018: 1). Studies investigating the prevalence of the disease found that 62.5% of patients with diabetes in sub-Saharan Africa is remain undiagnosed (Pastakia *et al.* 2017: 247). The consumption of high-caloric processed foods is on the rise, and this has a significant impact on diabetes nationally (Pheiffer *et al.* 2018: 1). Powerful marketing and promotions led by the food and beverage industries in the country aggravate the problem. The role of self-management education in diabetes prevention has proven to be a new and difficult challenge (Powers *et al.* 2016: 43).

People with a genetic predisposition to developing diabetes are considered high risk when exposed to complicated forms of viral infections, making them more vulnerable to the COVID-19 virus. The Centre for Diabetes and Endocrinology (Distiller 2020) further highlights that the prevalence of diabetes in South Africa varies by race, with the highest prevalence recorded among women of Asian descent (7.1%), followed by Coloureds (4.3%), Africans (3%) and Whites (3%). With regard to diabetes mortality rate, Asian men ranked the highest (4.9 %), while the diabetes mortality rate was generally similar among the African, Coloured and White populations (2.0-2.5%).

The soaring morbidity and mortality rates of diabetes are attributed to late diagnosis within an under functioning healthcare system (WHO 2016). Planned interventions are needed to develop sustainable strategies that address the policy-related issues for patients with diabetes in sub-Saharan Africa, warranting a multi-pronged and integrated approach, which includes

preventative measures aimed at policy-based requirements, improved health, lifestyle modifications and disease management (Pastakia *et al.* 2017: 247).

2.4.2 CARDIOVASCULAR DISEASE

The Heart and Stroke Foundation of South Africa concur that CVD is the leading cause of death in South Africa, after Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS). CVD is accountable for 17.3% deaths in South Africa (Byrne *et al.* 2016). Cardiovascular disease describes a range of disorders that affect the heart and blood vessels, such as hypertension, stroke, atherosclerosis, peripheral artery disease, and vein diseases (American Heart Disease 2021: para. 1 line 3). The development of CVD is associated with unhealthy dietary patterns, together with a more sedentary lifestyle, genetics, aging, smoking and diabetes (Figure 2.5) (Casas *et al.* 2018: 3988).

Cardiovascular disease often coincides with multiple co-morbidities, such as obesity, diabetes, hypertension, or dyslipidaemia, which represent four of the ten key risk factors for all-cause mortality worldwide. The increasing prevalence of CVD over the last 25 years has become a public health priority, in particular, the prevention of CVD through lifestyle interventions. According to several valid bodies of scientific evidence, it is reported that nutrition intervention is the most preventative factor of CVD deaths and may even reverse heart disease (Casas *et al.* 2018: 3988).

The SDGs form the basis for determining the progress of countries towards improving health results and developments until 2030. Nevertheless, real action requires unwavering global data on CVD, its main risk factors, and the information on major challenges to effective CVD treatment and prevention for an evidence-based health policy to be planned and executed (Joseph *et al.* 2017: 694). Many sub-sets of cardiovascular diseases can be prevented by managing behavioural risk factors such as tobacco use, unhealthy diet and obesity, physical inactivity and the harmful use of alcohol. Population-wide investment in intervention strategies is needed to manage the risks; for example, early detection, counselling and medication can be used to address these challenges (Anon 2015). According to several valid bodies of scientific evidence, it is reported that nutrition intervention is the most effective strategy and a preventive factor of CVD deaths that may even reverse heart disease (Casas *et al.* 2018: 3988).

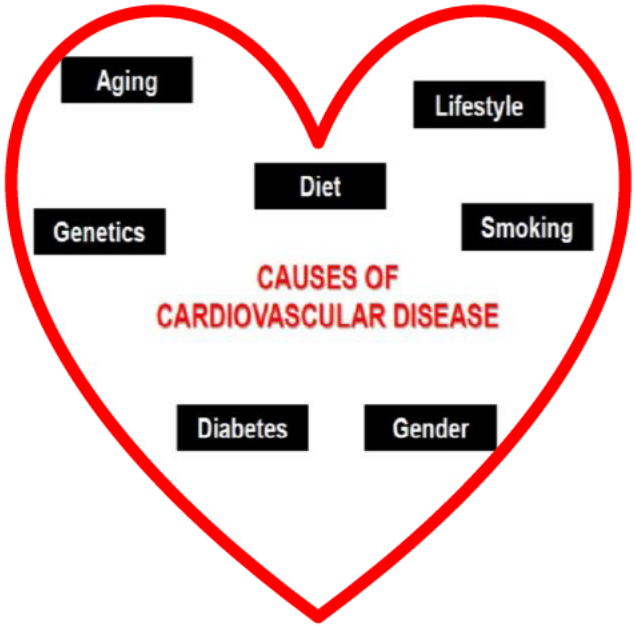

Figure 2.5: Causes of Cardiovascular Disease (Casas *et al*. 2018: 3988)

2.4.3 HYPERTENSION

With reference to the Heart and Stroke Foundation of South Africa, this country has the highest rate of high blood pressure reported among people aged 50 and over, in the world, in any period in history. In addition, hypertension is the leading risk factor for death from CVD, and is accountable for 13% of deaths globally (Byrne *et al*. 2016).

The past decade has seen the burden of high blood pressure, shift from high-income to LMICs. The Heart and Stroke Foundation of South Africa has stated that South Africa has one of the highest prevalence of hypertension in the world. The "silent killer" often presents as asymptomatic, with no visible warning signs; however, the end results are often fatal. Hypertension can be managed effectively with medication but this then contributes an adverse impact on productivity, negatively affecting the work environment and the economic growth of the country due to work place dynamics like absenteeism (Seedat *et al*. 2014: 294).

Some segments of the South African population are more susceptible to hypertension than others. Black African population groups are most at risk, irrespective of where they reside, from Africa to the Caribbean, US, or Europe, as they are predisposed to develop hypertension and associated organ damage, at a much earlier age, with a lower rate of resistance than other race groups. This may be related to the increased cardiovascular risks of Black African people

due to physiological differences when compared to other race groups (Unger *et al.* 2020: 1357). There are noteworthy differences in blood pressure prevalence and control rates based on race/ethnicity. Explanations of ethnic/racial inequalities are multifactorial, and the importance of unpacking these differences may lie with the underlying pathophysiology of the disease progression and response to treatment, hypertension control, irregularity in sodium retention and nightly blood pressure dropping. Social factors, including early life trepidations, limited access to health care, and poverty, have been theorized to describe the heterogeneity of blood pressure rates and control, among different ethnic groups. Additionally, BMI disparities exist among racial groups that correlate with the risk of hypertension. As noted by Saeed *et al.* (2020: para. 4 line 5), interactions between genetic and social factors leading to body weight changes, as differences in fat distribution relating to visceral versus subcutaneous and sodium and potassium balance continue to be poorly understood and are pertinent for future research and investigation.

Studies concur that although numerous initiatives are available, the prevalence of raised blood pressure and the adverse impact on cardiovascular morbidity and mortality, is increasing globally, regardless of demographics. In measuring the prevalence of hypertension, even in a rural setting, lifestyle and dietary habits are common denominators responsible for the high prevalence of NCDs that encumbers quality of life (Carey *et al.* 2018: 1293). Population-wide initiatives can be used as a targeted approach to reduce the global burden of raised blood pressure. For example, 4.1 million annual deaths have been attributed to excess salt/sodium intake. Therefore, salt-reduction programmes and activities that can offer high impact solutions to lowering blood pressure can be useful (Unger *et al.* 2020: 1357).

2.5 RISK FACTORS FOR NON-COMMUNICABLE DISEASES

Non-communicable diseases have been driven by four major modifiable risk factors: unhealthy diets. physical inactivity, the harmful use of alcohol and tobacco use. These risk factors risk factors associated with NCDs can be modified through behavioural changes and lifestyle choices (WHO 2021b).

2.5.1 UNHEALTHY DIET

The transition from traditional foods to a more western diet has shaped the shift towards meals that are highly refined, energy-dense but nutritionally poor, and high in sugar, salt, fats and increased animal protein in the diet (Olatona *et al.* 2013: para 3. line 3). Portion size is highlighted by the supersize phenomenon and alongside this, there is a decrease in the inclusion of fibre-rich fresh fruit and vegetables. To foster change, environmental and policy interventions can be considered as the most effective strategies for creating healthier food environments (Spires *et al.* 2016:35).

Many countries differ extensively regarding dietary factors which have the greatest impact on poor health, and this is no different in South Africa. A review of dietary consumption patterns in 2017, across 195 countries revealed that the leading dietary risk factors for NCD mortality are collectively diets that are high in sodium, low in whole grains, low in fruit, low in nuts and seeds, low in vegetables, and low in omega-3 fatty acids, accounted for more than 2% of global deaths (GBD 2017 Diet Collaborators 2019: 1967). It is important to note that healthier food options can often cost up to 60% more than unhealthier options; thus, measures to make affordably priced healthier food options available to the masses, may have an impact on redirecting and shaping population behaviour. In South Africa, from 1994 to 2012, there has been a steady increase in energy intake from sugar-sweetened beverages, processed and packaged foods, animal source foods, and added calorie sweeteners, while the consumption of fruit and vegetables, decreased. The consumption of a wide variety of processed and packaged foods, sugary drinks, sauces, dressings and condiments, and sweet and savoury snacks experienced the highest increase (>50%). It is worth noting that moderate obesity can incur an increase of up to 11% in healthcare costs while severe obesity can lead to a 23% increase in healthcare costs (Department of Health 2019a: para. 2 line 3).

2.5.2 PHYSICAL ACTIVITY

About 1.6 million deaths annually can be attributed to insufficient physical activity and unhealthy diet; however, these statistics can be changed (Lee *et al.* 2012: 229). Research indicates that engaging in physical activity has many valuable benefits, including increasing longevity. Physical activity in South Africa is gaining momentum as more people realise the benefits associated with preventative health measures and the gains from improved physiological well-being (Pandey *et al*. 2018: 18).

The World Health Organisation describes physical activity as any bodily movement produced by skeletal muscles that requires energy outflow (WHO 2021c: para. 1 line 1). Physical activity includes walking, cycling, jogging and active recreation to include all movement, both moderate and vigorous intensity physical activity, contributing to health improvement. It is recommended that consistent physical activity be recognised as a means to aid the management of NCDs such as heart disease, stroke, diabetes and several cancers, and helps prevent hypertension, aids maintenance of a healthy body weight, and improves mental health, quality of life and well-being. The WHO advocates that adults aged 18–64 year should engage in 150–300 minutes of moderate-intensity aerobic physical activity weekly, muscle-strengthening activities at moderate or greater intensity that involve all major muscle groups twice a week, and to substitute inactive time with physical activity of somewhat moderate intensity (WHO 2021c: para. 2 line 3).

In South Africa, the Department of Sports and Recreation hosts an annual Big Walk, which is the South African version of the World Walking Day. This event is held in all provinces annually, and since inception in 2012, and has achieved optimum participation. In 2014, the Cabinet of South Africa also declared the first Friday of October as the National Recreation Day, and the resulting national campaign targets all South Africans to take responsibility to be physically active (Department of Sport and Recreation 2012).

2.5.3 ALCOHOL AND NON-COMMUNICABLE DISEASES

Alcohol has been negatively associated with NCDs. In 2015, governments worldwide, through the adoption of the United Nations 2030 Agenda committed themselves to strengthen the prevention and treatment of substance abuse, including narcotic drugs and the harmful use of alcohol (WHO 2017: 6). Alcohol abuse has damaging health and social consequences in society and is directly linked to adverse health outcomes. It is one of the world's foremost risk factors for illness, disability and death, and the main cause of more than 200 diseases and injuries worldwide. Alcohol abuse results in nearly 3.3 million deaths annually, more than HIV/AIDS, violence or tuberculosis (WHO: 2021d para 2. line 3). Globally, alcohol consumption is estimated to cause more than 10% of the burden of NCDs, including cirrhosis of the liver, pancreatitis, cancers, (oral and pharynx, larynx, oesophagus, liver, colorectal), haemorrhagic stroke and hypertension (WHO 2021d para 3. line 3).

The Coronavirus pandemic has impacted many people, their lives and health status. A global survey revealed that many people increased alcohol consumption during the COVID-19 pandemic. When not consumed in moderation, alcohol can have a lethal impact, it is an addictive substance and impacts many organs and systems in the human body; it is also a fundamental contributor to many chronic NCDs. Alcohol exacerbates mental health issues and health conditions, weakens the immune system and makes an individual more vulnerable to infections. An additional concern is the domestic violence triggered by excessive alcohol consumption. With the long-haul duration of the COVID-19 pandemic, alcohol is being used as coping strategy to survive the monotony, tension and other damaging emotions associated with the virus (Chong *et al.* 2020: 3).

Well-documented interventions call for accelerated action to reduce alcohol harm and its contribution to the overall burden of disease (WHO 2020a para. 1 line 6). The implementation of an alcohol policy best-buy is an intervention that is not only extremely cost-effective, but also culturally acceptable in many situations. According to Gruenwald 2011, the alcohol policy best-buy restrictive measures that are well supported. These include increasing excise taxes, regulating legal purchase times and days, as well as legal consumption age, governmental monopoly of retail sales and restricting exposure to marketing of alcoholic beverages (Gruenewald 2011: 248).

2.5.4 TOBACCO AND NON-COMMUNICABLE DISEASES

Statistics indicate the following tobacco induced deaths in Africa: 58% from lung cancer, 37% from chronic obstructive pulmonary disease, 20% from tuberculosis, and 23% from cardiovascular deaths, all due directly to smoking (WHO 2010: 100). The death rate with regards to smoking-related tuberculosis fatalities is high in South Africa, as this stems from a vulnerability to HIV and tuberculosis exposure (WHO 2013: para. 3 line 2). The 2019 South African Health Demographic Survey indicated that 37% of men and 8% of women smoked tobacco products daily or occasionally. Those who smoke daily, the majority being (75% women and 64% men), therefore most people who smoke daily, smoke less than 9 cigarettes a day, while 12% of women and 18% of men smoked 15 or more cigarettes daily (South Africa Department of Health 2019a: para. 2 line 3).

2.6 INTERVENTIONS TO REDUCE RISK FACTORS FOR NON-COMMUNICABLE DISEASES IN SOUTH AFRICA

In the past 20 years, a number of interventions have been introduced to reduce morbidity and mortality from NCDs in South Africa. The National Strategic Plan directs the actions that will be undertaken between 2020 and 2025, across sectors, to redress and reverse the escalating risk harm posed by NCDs (South Africa Department of Health 2013). The prevailing aim of this plan is that South Africa reaches the SDGs to reduce, by one-third, premature mortality from NCDs through prevention and treatment, and to promote mental health and well-being by 2030. In signing this declaration, South Africa has committed to increased efforts to reduce NCDs. However, these need to be supported and additional interventions introduced, to reinforce and maintain the process (South Africa Department of Health 2013).

Prevention efforts from the Department of Health in South Africa (2019b) include legislative and regulatory initiatives, awareness, education and information to the public, social and behaviour change programmes, community-based programmes, increased screening and health promotion such as secondary interventions by health practitioners. Non-governmental organisations (NGOs) in the health sector also have an essential role with regard to promotion and prevention of NCDs, as they work in and with communities (South Africa Department of Health 2019b). A key objective of the strategic plan is to allow for the explicit inclusion of the risk factors associated with NCDs when health system plans and services are drafted and

implemented. This means that health promotion and prevention of disease, and effective treatment and care should be included as a standard part of all National Health Insurance (NHI) plans.

The World Health Organisation (2021d) estimates that the annual cost for addressing NCDs in an upper middle-income country like South Africa, is approximately R1 billion, around R150 million for population-based interventions, and R1 125- billion for individual-based measures. Support for addressing the four common risk factors is demonstrated in "Best Buys". The World Health Organisation's "best buys", is considered a gold standard and a strategic response to the worldwide surge of NCDs. Several interventions aimed at risk factor reduction and treatment of NCDs is related to the cost of implementation and health impact. Interventions related to reducing tobacco use, the harmful use of alcohol, improving diet and increasing physical activity, are possible low-cost actions (Bakhtiari *et al.* 2020). Early detection, screening, and treatment of NCDs, as well as palliative care, are key components of the response to NCDs (Pastakia *et al.* 2017: 247). Early detection and interventions can reduce and manage the burden of NCDs in South Africa, thus creating a community of healthier citizens (Freeman *et al.* 2020: 3).

An important measure to control NCDs is to focus on this group of diseases. Inexpensive solutions exist for governments and other stakeholders to reduce the common modifiable risk factors (WHO 2020c). In an effort to reduce the major modifiable risk factors for NCDs, such as tobacco use, harmful use of alcohol, unhealthy diets and physical inactivity, it is critical to reduce the burden on health that NCDs create for countries throughout the world. In an effort to prevent and control NCDs, the WHO encourages and creates awareness of a healthier world population making improved health choices that benefits the global nation (WHO 2020c). Existing information confirms that these interventions are valued economic investments as they provide preventative tools to patients, which can subsequently reduce the need for expensive treatment at a later stage (Srivastava and Bachani 2011: 7).

Active population-based strategies to prevent NCDs have already been implemented and includes legislation for the reduction of sodium in processed foods, taxation of sugar-sweetened beverages and alcohol, and the continued tightening of anti-tobacco regulations (Schutte 2018: e177).

2.6.1 PREVENTATIVE MEASURES

The political and economic marginalization and inequalities from the previously disadvantaging apartheid era policies continue to impact many communities in South Africa (Cesare *et al.* 2013: 587). The enabling of healthy behaviours and the control of metabolic risk factors should be cultivated and encouraged earlier, from childhood to adult lifestyle dietary interventions and education (Cesare *et al.* 2013: 587). When compared to a disease-oriented approach, focusing on interventions for a single condition; a life course approach considers the critical stages, transitions and settings where large differences can be made in promoting or restoring health and wellness. More importantly, this considers the social determinants of health, gender, equity, and human rights issues. This has been emphasised in numerous frameworks and initiatives in the past decade, but more work is needed to give the approach more importance. Well-planned and effective interventions, ultimately, save more lives in the process. Considering a life course approach requires improved health literacy through multisectoral work with individuals, institutions, communities, and countries. Planned interventions must extend beyond the health sector and be targeted within the natural settings that people are most comfortable in, throughout the various stages of their lives. This life course approach will assist the country to achieve SDG 3.4 and to reduce premature mortality by 30% before 2030 (Jacob *et al.* 2017: 5*).* When the national population is physically and mentally healthy, they learn and perform at an optimal level, incur less health care related costs and reduce pressure on the health care system.

2.6.2 NON-COMMUNICABLE DISEASES AND WORKSITES INTERVENTIONS

The workplace is now recognised as an important location for adult based health promotion, wellness and planned interventions for sustained wellbeing (Quintiliani *et al.* 2017: 14). As posited by Hill-Mey (2015: 2), primary prevention programs and nutrition promotion at the worksite has the potential to reach a large number of the adult population from different social backgrounds, who spend a substantial measure of time at workplace.

Effective workplace interventions include promoting healthy food options in staff eating facilities, initiating and supporting nutrition education tools and wellness programs, with consistent plausible opportunities and incentives regarded as return on investment (Whitmore *et al.* 2018). The worksite is rapidly becoming a significant setting for nutrition intervention

and health promotion efforts, and presents a large, accessible audience for health promotion and intervention initiatives. Moreover, workplace participants are exceptional candidates for primary prevention programs, the general intention of most health and nutrition interventions (Hill-Mey 2015: 2) Nutrition promotion at the worksite has potential to reach a larger number of the adult population from different social backgrounds, who spend a substantial measure of time at the workplace.

For optimal results, food-based interventions implemented at worksites must ensure dietary relevance, with due consideration to the community's social and cultural norms, and aspects of mindful eating. Enhanced nutritive diets are fundamental to the eating experience, well-being, improved function and quality of life and measure, in terms of effectiveness (Slimani *et al.* 2000: 900). The objectives of a food-based diet /nutrition intervention are depicted in Table 2.1.

Table 2.1: Nutrition intervention adapted from (SAMHSA 2020: 2)

PHASE 1	Formulation of a strategic plan that encompasses assessment of health issues to resolve and improve food based dietary findings, and integrated with the participant's knowledge, attitudes and behaviour.
PHASE 2	In this stage, testing, and screening is conducted and the data is recorded and analysed to identify and advise the optimal intervention to improve the nutritional status of staff at a university.
PHASE 3	The choice of measurable realistic intervention strategies and educational potential of food and nutrition resources are considered and the practice of healthy social norms are interrogated.
PHASE 4	The participant's need is personalized and a contextually-relevant nutrition intervention is implemented within the framework of a lifelong healthy nutrition model.
PHASE 5	This stage evaluates the intervention outcomes, in quantifiable terms, and provides feedback if needed, to re-enforce the message.

2.7 CARBOHYDRATE CONSUMPTION IN SOUTH AFRICA

South Africa's staple food is maize, and almost 13-15 million tons are produced annually, under favourable weather conditions (FAO 2021a: para. 1 line 4). The country consumes an average of 8.5 million tons of maize annually (Campbell 2020: para. 2 line 2).

Bread is a valuable staple and plays a very central role in the nation's diet (Food Advisory Consumer Service 2021). It is a ready-to-eat, convenience product, with no added resources needed. There is strong support for bread as a staple, the fat content is very low, and it is fortified with vitamins and minerals. Bread is also baked at high temperatures, removing some of the food safety hazards and that may present a concern to the consumer. It is an accompaniment to many other selections of foods and can be combined with a variety of foods to improve its nutritional value and contribute to satiety that provides a sense of fullness after eating. Even though the average consumption is three slices (100g) of bread per day, bread is the second most important staple food item after maize meal, in many households (Food Advisory Consumer Service 2021). According to the SA Chamber of Baking, white bread comprised 49.06% and brown and whole wheat bread 50.78% of total production, with speciality bread making up the difference in bread production (Food Advisory Consumer Service 2021).

The relationship and importance of household income in relation to food consumption, is well engrained in popular economic principles, and in improving the quality of health. Engel's seminal economic theory states when family income grows, the proportion of income spent on food drops on a comparative basis with luxury possessions and savings being escalated. (Grimmer-Solem, 2011), measuring levels of effectiveness, was considered ahead of its time, and helped to stimulate prompt intellectual leaps in the study of income to food consumption patterns, on a global scale. It is optimal to eat a healthful diet by including complex carbohydrates and limiting the intake of refined carbohydrates. Mindful carbohydrate choices can help give a person a good blood glucose balance and limit the risk of associated health conditions (Richards 2020: para. 2 line 4).

Patterns emerging from the review by the South African Medical Research Council (SAMRC), is that White, Coloured and Indian South Africans have a relatively low total carbohydrate intake (mean <50% of energy) and a high intake of added sugar (mean >10% of energy), with

reference to a cohort study in South Africa, participants in the North West Province, especially in rural areas have a higher intake of total carbohydrates, for example with regards to sucrose sweetened beverages men consumed 25% to 56% and women 33% to 63% with varying amounts of added sugar (Vorster *et al.* 2014:). Studies have also reported that with the urbanisation of growing populations in cities and towns of South Africans, this has therefore brought a rapid nutrition transition evidenced by a decline in carbohydrate consumption, along with a sharp rise in sugar consumption (Vorster 2013: S33).

2.8 THE CASE FOR UNREFINED CEREAL CONSUMPTION

Cereals, grains and whole grains are the seeds of grasses that are especially cultivated for food. They are available all shapes and sizes, from brown rice to large kernels of popcorn to quinoa, barley, buckwheat, millet, oatmeal and sorghum, to name a few. Whole grains refer to unrefined grains that have not had their bran and germ removed by the milling process; therefore, all of the nutrients remain intact (Laseter 2017: para. 3 line 5).

The case for unrefined consumption of cereals and grains in South Africa is constantly reinforced. The recommended adult portion of daily grain by the South African Food Based Dietary Guidelines is 48g (Vorster 2013: S35). The consumption of unrefined carbohydrate foods may be linked to the socioeconomic status of a family and can trace some of its history back to apartheid roots. People were often stigmatized for eating unrefined carbohydrates, as this was associated with being poor, and those consuming refined cereals and grains were classified as wealthy (Muhihi *et al.* 2012: 6). This food category association with its sociological interplay between the poor and the rich, resulted in the "white refined foods" of the rich being more sought after and desired than the "unrefined foods" of the poor (Muhihi *et al.* 2012: 6). In this vein, white bread and white rice was regarded as superior and therefore more desirable than brown bread and brown rice (Muhihi *et al.* 2012: 6). This conditioning has unfortunately not diminished over time.

The high cost including the unavailability of brown rice, are additional barriers to its daily consumption by more people. White refined maize meal and white rice are currently the most consumed staple foods in urban areas; however, there is a slow but steady incline towards unrefined cereal consumption, due to nutrition education and ongoing research on the benefits of unrefined cereals (Muhihi *et al.* 2012: 3).

While the availability of brown rice is limited both in urban and rural settings, the supply of unrefined maize and sorghum flour is abundant in rural settings but limited in urban areas. Previous studies in Tanzania have reported that the high cost of whole grain foods is a barrier to purchase and consumption. Unrefined maize and sorghum flour are relatively cheaper and widely available in rural settings (Muhihi *et al.* 2012: 3).

Nutrition education and intervention programmes may be designed, implemented and sustained to achieve desired outcomes (Pretorius and Sliwa 2017: 183). Networking with new collaborations and social responsibility groups may pave the way for improved of consumption unrefined cereals. Re-introducing wholesome foods that are varied, available, culturally acceptable and aligned to the South African Food Based Dietary Guidelines, with the emphasis on affordability, can be key towards stimulating food behaviour change (Pretorius and Sliwa 2017: 183).

2.9 RICE CULTIVATION IN STAGES

As depicted in Figure 2.6, rice cultivation in its various growth stages is a semi-aquatic monocot grass annual, with perennial abilities and endurance in the tropical regions (International Rice Research Institute 2017: para. 1 line 3). Rice varieties are able to acclimatise to various environmental conditions in three separate growth stages: in stage 1, the vegetative phase occurs with the germination to the panicle initiation, in stage 11 it is the reproductive phase which is the panicle initiation to the flowering stage (19-25 days) and finally in stage 111, it is the flowering to the mature phase in the plant where the grain filling and maturation stage (30-45 days) is reached.

More than 50% of the world's population depend on rice for most of their kilojoule requirements because they have limited or no access to a variety of healthy foods such as fruit, vegetables and animal protein. The lack of adequate dietary intake of iron, zinc, and vitamin A, this has become prevalent micronutrient deficiency in high rice-consuming countries, and these deficiencies affect the quality of life, placing mainly women and children, at risk (International Rice Research Institute 2017: 26).

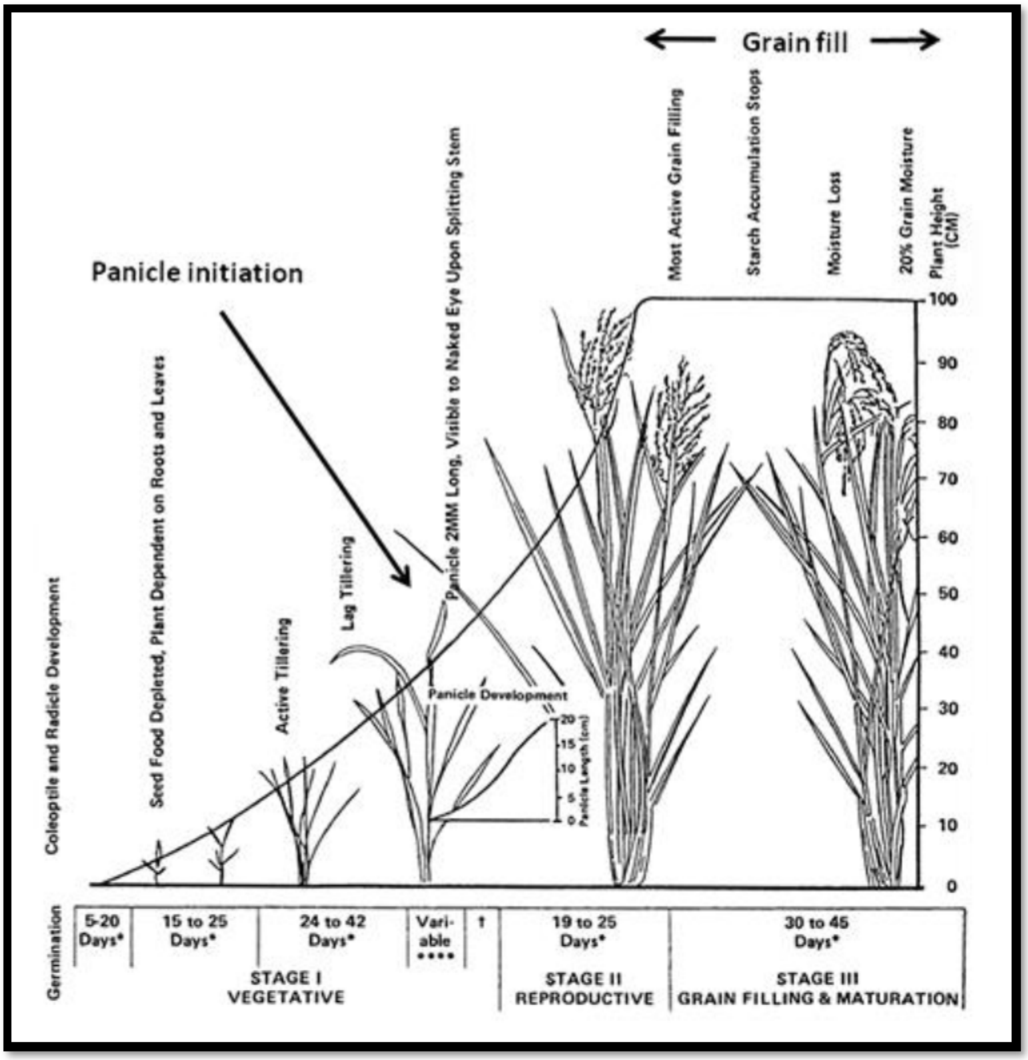

Figure 2.6: Rice Cultivation in Stages (International Rice Research Institute 2017)

Various cultural civilizations through the centuries have claimed evidence of early rice cultivation; however, many historians and early archaeological evidence confirm the Yangtze River Valley of southern China as the earliest rice growing belt region, going back to 5000 BC (Grossa and Zhaob 2013: 6190). Almost 90 percent of rice is grown in China, India, Indonesia, and Bangladesh, with a small percentage coming from Japan, Pakistan and the Southeast Asian countries. Rice cultivation is also evident in parts of the European North, South America and Australia. Rice was presented to Europe and the Americas by early explorers and travellers, who spread their cultural influences during travel. The first recorded cultivation of rice in the United States of Americas' coastal regions from South Carolina to Texas, started in 1685 (Ricepedia 2021a: para. 3 line 2).

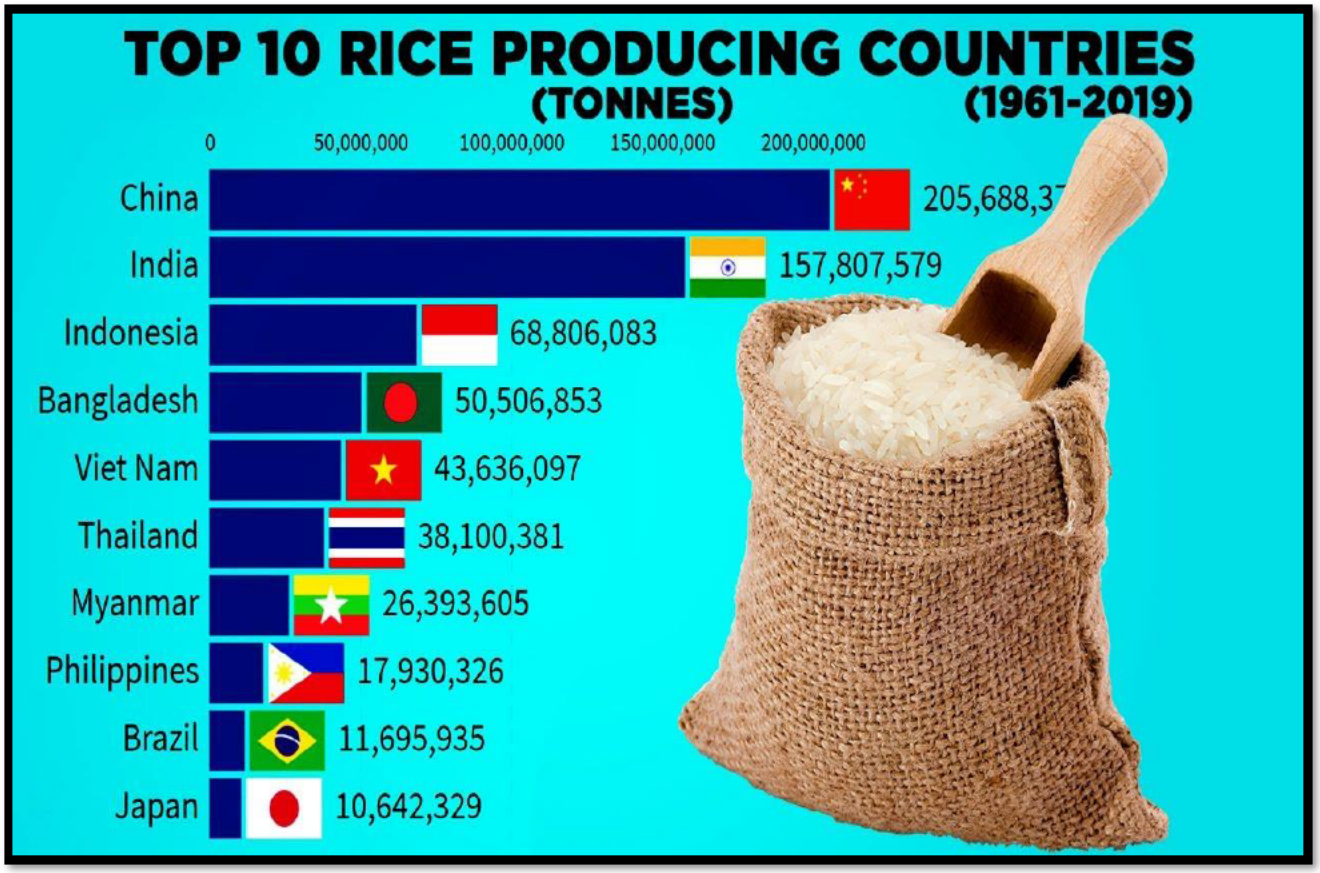

Figure 2.7: Top ten Rice Producing Countries in the World (1961-2019) (2020)

Between 1961 to 2019, China, India and Indonesia were the top rice producing countries globally (Figure 2.7). Currently, Thailand is the world's main exporter of all rice, including brown rice, trailed by Vietnam and India, where more than half of the Indian population depend on rice as a daily staple food. (Villanueva *et al.* 2020: 2). These top 10 rice importing countries represent less than 50% of global imports to meet worldwide consumption demands. The primary countries consuming brown rice are Indonesia, Philippines, Iran, Nigeria and some European countries, where there is a shifting preference towards healthy eating habits. The brown rice market is growing regarding the progress of rice trade among countries, and is anticipated to expand at a higher rate compared to the white rice market, due to this shifting preference and the growing awareness of the nutritive value of brown rice. There is a growing demand for brown rice from emerging markets in Middle-East and African countries, determined by health consciousness and the introduction of new products and flavours on the market (Anon 2020a: para. 3 line 3).

The global demand for rice is expected to increase alongside the world population growth, predominantly in Asia, where population is expected to increase 35% by 2025 (Nath *et al.* 2015: 5371). Throughout the world, the possibility for an increase of rice-growing areas is dwindling due to the expropriation of land by violence, loss of agricultural land through urbanisation and land conversion. According to Villanueva (2020: 929), the International Rice Gene Bank (IRGB) has the largest and most varied collection of rice genetic resources in the world. In 2018, this collection included 130 139 accessions, comprising of 123 837 Oryza sativa varieties called Asian rice or paddy rice which is a cultivar belonging to the family Poaceae, an ancient rice variety which is a significant staple food meeting more than 50% of the international market demand (Villanueva *et al.* 2020: 929). Cultivated rice plants come in over 40 000 different varieties. Over 90 000 samples of cultivated and wild rice species are stored at the International Rice Gene Bank (IRGB), to be utilised by researchers from all over the world in ongoing studies. To meet the demand for food security now and in the future, rice production will need to be more sustainable in the use of scarce natural resources, and production must be profitable, while using improved environmentally sustainable techniques. The dietary shift towards a higher consumption of meat, fruits and vegetables, and a comparatively lesser shift towards cereals, are placing an added burden on natural resources globally (Porter *et al.* 2014: 505).

With industrialisation, animal farming needs to meet the fast-food industry's demand for meat and the overwhelming effects of climate change. This means that the solution for sustained rice farming and production must come from improved crop yields and strengthened cropping, specifically within the wetted rice ecosystems (Norman and Kebe: 2004). Cultivated rice plants come in over 40 000 different varieties. Over 90 000 samples of cultivated and wild rice species are stored at the International Rice Gene Bank (IRGB), to be utilised by researchers from all over the world in ongoing studies. There are four key categories of rice: Indica, Japonica, aromatic and glutinous. The rice grains vary in shape, size, width, length, colour and aroma. Different varieties of rice are available: "drought-resistant, pest-resistant, flood-resistant, saline-resistant, tall, short, aromatic, sticky, red, violet, brown, or black; long and slender, to short and round grains" (Haifa Group 2020). Studies on the varieties of rice have confirmed their origin from the wild rice species. The domesticated varieties show substantially less variation in genetic rice polymorphism than the wild species (Haifa Group 2020).

The rice family can be divided into three main categories:

Long Grain: Approximately 6-8 mm long, 3-4 times longer and thick. The endosperm is hard and vitreous with a glassy exterior. The best long grain varieties are known to come from Thailand, Southern United States of America, India, Pakistan, Indonesia and Vietnam.

Medium Grain: Approximately 5-6 mm long, but thicker than long grain rice. The endosperm is soft and chalky. It releases about 15% starch into water during the cooking process. Medium grain rice is largely grown in China, Egypt and Italy.

Short Grain or **Round Grain**: Approximately 4-5 mm long, only 1.5-2 times longer than thick. The endosperm is soft and chalky. This variety is grown in subtropical areas like California, Egypt, Italy, Japan, Korea, Spain and Portugal (Haifa Group 2020: para.1 line 3).

According to study by Jewela *et al.* (2018:2), the emergence of the Green Revolution, which is an initiative intended to increase agricultural production of the new 'Super Rice' which was released in the year 2000, and featured a 35% yield increase potential. These new varieties of rice consist of fewer but stronger rice tillers, which is a specialized grain-bearing branch, this determines a higher seed yield, as it is carry more grains per inflorescence with enhanced nutrients. Previously, half of the plant's weight was grain and half straw, whereas the new Super Rice plant is 60% grain and 40% straw, rice varieties have now been deliberately enhanced to maximise nutrient absorption to produce higher yields, as the global rice production has to increase by about 25% by 2025 (Jewela *et al.* 2018: 2). There is an escalating demand for rice on a global scale and this is inevitably expected to increase mainly because of world population growth, predominantly in Asia, where population is expected to increase 35% by 2025 (Nath *et al.* 2015: 5371-5397).

Recent investigations suggest that the growth rates of rice yields vary vastly across ecosystems and countries. Where rainfall is sporadic and drainage is poor, farmers still grow traditional rice varieties relative to their native country and use minimal fertilizers to obtain adequate returns from investment inputs. Average yield growth in three out of four rice-producing countries, has been larger than the standard deviation of yield growth by provision over the last two decades (Kihara *et al.* 2020: 3015).

2.10 THE STRUCTURE OF THE RICE GRAIN

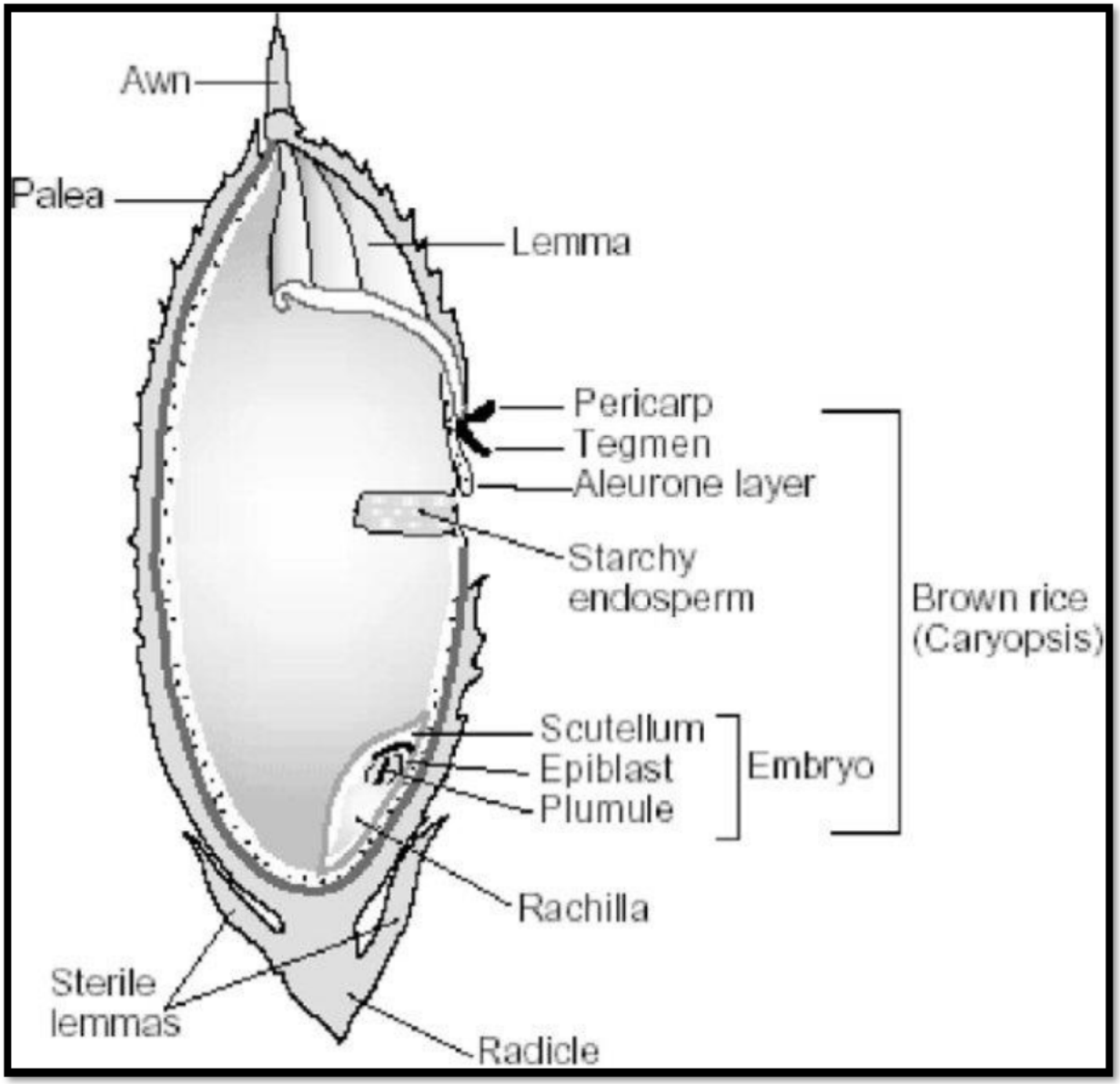

Figure 2.8: Structure of the rice grain (FAO 2019)

Figure 2.8 illustrates the cross section of a rice grain. A rice kernel comprises of a hull and a bran coat, that are removed during polishing. Each rice kernel has several layers. The rice shell is the hull or husk that encapsulates the bran coat, the embryo and the endosperm, and the bran coat being a thin layer of differentiated tissues. Fibre, vitamin B, protein and fat are all found in the bran coat and is the most nutritionally dense layer of the rice. The embryo, the innermost part of a rice grain, consists largely of starches called amylase and amylose pectin which when combined determines the texture of cooked rice (SA, DAFF 2014: 7). The structure of the rice

grain is made up of the following five main sections, the awn, lemma, caryopsis, aleuronic layer and the embryo.

- **Awn:** The tip of the rice grain, which is detached during processing.
- **Lemma:** There are 3 protective layers of "skin", brown and yellow that make up 20% of the grain's total mass.
- C**aryopsis**: This is what remains of the grain after processing, which is what most eat, it is composed primarily of starch and represents 60% of the grain's total weight.
- **Aleuronic (Bran) Layer**: It is the internal skin containing vitamins, minerals and fat.
- **Embryo:** Each grain of rice holds an embryo, from which a new shoot will sprout. Through the refining process, the embryo breaks away from the grain (Sebazco 2015).

2.11 RICE AND FOOD SECURITY

In developing countries, the availability of rice is associated with food security and is closely aligned to political, economic and social stability in the region (Mittal 2009: 1). Fluctuations in rice procurement and pricing are the backdrop to social strife and upheaval in numerous countries. This systemic origin was evident during the world food price crisis of 2007 and 2008, where the cost of rice tripled (Mittal 2009: 1). The World Bank (2020: 3) estimated that this triggered severe levels of poverty for 100 million impoverished people. Of the three major crops – rice, wheat and maize – rice is the most important food crop for people (FAO UN 2021b: 6). Rice is a commodity consumed by both rich and poor people worldwide, whereas the poorest people consume comparatively little wheat and other cereals due to high cost and accessibility.

Rice is vital and a generally irreplaceable staple in many Asian countries, especially for the poverty-stricken population in Asia (Kondhia *et al.* 2013). Comparatively, rice is to Asia what maize is to Africa: its heart and soul cereal. Pioneering research on these significant cereal grains plays a vital role in this new revolution for the continued betterment of the world's poorest people. Genetic engineering and biotechnology used on maize, rice, and wheat have contributed to global food security in the last five decades, mainly by boosting the crop yields, making them further drought-, flood- and pest-resilient. With more than 800 million people still living in abject poverty and suffering from inadequate diets, more time and energy needs to be invested in global food insecurity (Kropff and Morell 2019: para. 1 line 3).

The challenges are complex, given climate change, and widespread degradation of the ecosystems that sustain food production, rapid population growth and unequal access to resources that are vital for improved livelihoods (Kropff and Morell 2019: para. 1 line 4).

2.12 HEALTH BENEFITS OF BROWN RICE

Brown rice is less processed than white rice; the latter has the hull, bran and germ removed. With brown rice, only the hull, a hard-protective coating, is removed, leaving the nutrient-dense bran and germ. While similar in kilojoules and carbohydrate content, brown rice's nutritional profile is higher in vitamins minerals and antioxidants, as a fibre rich whole grain is a healthier choice than white rice which is a more refined grain (Kubala 2018 para. 3 line 1). Thus, brown rice retains the nutrients that white rice lacks such as vitamins, minerals, and antioxidants. Nevertheless, with trends towards low carbohydrate diets, many people tend to avoid eating rice (Kubala 2018 para. 3 line 3).

2.13 NURTITIONAL VALUE AND MEDICINAL BENEFITS OF BROWN RICE

The table below shows how vitamins and minerals compare in a cup (240ml) of cooked brown rice versus a cup (240ml) of cooked, enriched white rice, and the recommended daily amounts for an adult aged 19 years or over. Amounts vary by age and sex. Measurements are in either milligrams (mg) or micrograms (mcg).

Table 2.2: Nutritive value of 1 cup of cooked brown compared to 1 cup cooked white rice (Ware 2019 para. 6 line 4)

Nutrients	White rice	Brown rice	Recommended daily amounts
Iron (mg)	2.8	1.1	8–18
Thiamine (mg)	0.3	0.4	1.1–1.2
Niacin (mg)	3.4	5.2	14–16
Vitamin B-6 (mg)	0.1	0.3	1.3
Folate (mcg)	108	18.2	400 (with additional needs during pregnancy)
Phosphorus (mg)	68.8	208	700
Magnesium (mg)	24.2	78.8	310–420

Nutrients	White rice	Brown rice	Recommended daily amounts
Zinc (mg)	0.8	1.4	8–11
Selenium (mcg)	14	11.7	55
Copper (mg)	0.1	0.2	900
Manganese (mg)	0.7	2.0	1.8–2.3

With reference to Table 2.2 the nutritive value of 1 cup (240ml) of cooked brown is 0.190-195g the recommended serving size is 0.095g as compared to 1 cup (240 ml) cooked white rice is 195-200g and the recommended serving size is approximately 0.100g. Whole grains are a source of folate, riboflavin (vitamin B2), potassium, calcium and manganese. Manganese is essential for many key functions in the body, for example, bone development, wound healing, muscle contraction, metabolism, nerve function and blood sugar regulation (Kazemzadeh *et al.* 2014: 478). Manganese deficiency has been linked to a higher risk of developing metabolic syndrome, bone demineralisation, impaired growth, and low fertility. It is recommended the that 1 metric cup brown rice fulfils nearly all of an individual's daily requirement for this important nutrient as shown in Table 2.2 (Zhou *et al.* 2016: 853).

Brown rice is a rich source of magnesium, a mineral that is essential for heart health. Fang *et al.* (2016: 64) found that higher levels of dietary magnesium were linked to a 7-22% lower risk of stroke, heart failure and all-cause mortality. It was established through several studies that every 100 mg/day increase in dietary magnesium reduced heart disease mortality in women by 24-25%. Brown rice in addition to being a good source of fibre, contains lignans which is an antioxidant and magnesium, theses have positive effects on heart-related disease and risk factors and improving overall heart health (Fang *et al.* 2016: 64).

Selenium is an essential component of several major metabolic pathways, including thyroid hormone, metabolism, antioxidant defence systems, and immune function (Fang *et al.* 2016: 64). Brown rice is rich source of selenium with 9.8 mcg per 100g.This mineral strengthens the immune system and could be beneficial in a weight loss program (Fang *et al.* 2016: 64). The function of the thyroid is closely connected to proper bodily function and helps speed up metabolism. People who are diabetic or pre-diabetic will benefit from the switch to brown rice as it helps to regulate insulin levels by lowering blood sugar and decreasing the risk of diabetes.

For those who are already diabetic, selenium can help to regulate the blood sugar level, the recommended average daily dosage of selenium in adults 19 – 50 years (Sun *et al.* 2010: 961).

Collectively, brown rice is high in phenols and flavonoids, a class of antioxidants that support and protect the body from oxidative stress (Gong 2017: 433), heart disease, certain types of cancer, and premature aging. Antioxidants help prevent cell injury caused by unstable molecules called free radicals, and may reduce inflammation in the body (Wanders *et al.* 2011: 724). Research suggests that the antioxidants in brown rice may be the reason for a lower prevalence of chronic disease in regions where brown rice is a staple food (Goufo and Trindade 2014: 104).

It is long recognised that using a calorie-controlled diet and replacing more refined grains like white rice, white pasta and white bread with whole grains is more nutritionally dense, as the refined grains lack the fibre and nutrients. The consumption of fibre lowers the glycaemic index of foods, and helps to keep the body fuller for a longer period of time. This is an indicator that choosing fibre-rich foods may result in consuming fewer calories (Wanders *et al.* 2011: 724). It was noted in one of the largest studies consisting of 74.091 female participants from the US, aged between 38 to 63 those who consumed increased amounts of whole grains, including brown rice, weighed considerably less than those females who consumed fewer whole grains. Furthermore, in this study, the women who consumed brown rice had the highest fibre intake and in turn had a lower risk of weight gain than the women who consumed fewer whole grains (Liu *et al.* 2003: 920). The success of these studies can offer evidence-based data to encourage higher uptake and make a transition to brown rice consumption.

With reference to a study conducted in Iran with a sample size of 40 overweight women participants who consumed 150 grams of brown rice per day for six weeks, a significant decrease in body weight and waist circumference (WC) was reported, compared to women who consumed the same quantity of white rice. Making the transition from white rice to brown rice may enable the reduction of belly fat. Furthermore, the women who consumed brown rice experienced a substantial decrease in blood pressure and C-Reactive protein (CRP), a marker for inflammation in the body (Kazemzadeh *et al.* 2014).

Brown rice is recommended for good heart health as it contains a higher amount of fibre content; 100g of cooked brown rice provides 1.8g of fibre, and valuable bioactive compounds

that may help decrease the risk of heart disease (McDonell 2016). Using a large study sample of over 567 169 participants from the US, (Silva *et al.* 2015: 736). this study concluded that people who ate high amounts dietary fibre had a 24–59% lower risk of developing heart disease, cancer and respiratory diseases (Park *et al.* 2012: 1061). Likewise, a systematic review of 45 studies found that people who consumed the highest quantity of whole grains, including brown rice, had a 21% lower risk of coronary heart disease compared to those who the minimum quantity of whole grains. results for diets high in lignan-rich foods, such as whole grains, flax seeds, sesame seeds and nuts, have been linked to reduced cholesterol, lower blood pressure and decreased arterial stiffness (Peterson *et al.* 2010: 571).

Visceral fat is one of the most perilous body fats to possess. It builds up around the vital organs, and the higher the percentage of visceral, the more health risks one may encounter. Researchers found that making a transition to brown rice can help eliminate the dangerous visceral fat that builds up in the abdomen (Shimabukuro *et al.* 2014: 310). In this study conducted in Japan, 27 men participated in a 8 week study making the shift from white rice to brown rice had decreased visceral fat than those who chose to consume white rice.

Making an intended choice to eat foods with a lower glycaemic index like brown rice is a much healthier option for diabetics, as it is vital for a lower impact on blood glucose control (Silva *et al.* 2015: 735). The consumption of carbohydrates has a major impact on blood sugar levels. People with diabetes; who have insulin spikes, are therefore advised to eat fewer overly refined grains such as white rice. Taking a conscious decision to replace white rice with brown rice may reduce the chances of developing type-2 diabetes (Silva *et al.* 2015: 736). A systematic review found that brown rice has a lower glycaemic index of 55 compared to white rice with a GI of 64, lower GI foods results in slower digestion, thereby keeping one fuller for longer (Sun *et al.* 2010: 961). Research indicates that foods with a higher glycaemic index increase blood sugar, insulin and ghrelin, a hormone that drives hunger. The reduction of ghrelin levels may aid diabetics in controlling their hunger; this can reduce overeating and can improve blood sugar monitoring (Silva *et al.* 2015: 736).

Brown rice is thus a much healthier option for diabetics as it is vital for blood glucose sugar control. In a sample of 197 000 people in the US, a weekly substitution of 50 grams of brown rice for white rice per week, correlated to a 16% lower risk of developing type 2 diabetes (Sun *et al.* 2010: 961). Without reservation, rice is the most consumed food commodity for almost

half of the world's population (Sollid and Jabri 2013: 294). Consuming a significant amount of brown rice approximately 120g on a regular basis may be a practical way forward to adopting a more wide-ranging approach to reaping the benefits of brown rice (Sollid and Jabri 2013: 294).

The rice products used in medicinal remedies are made mainly from brown rice, and rice oil made from rice bran is the key ingredient. The traditional medicinal uses of rice are supported by a lifetime of indigenous knowledge and, in current times, are followed by scientific research globally (Kew Science 2021: para. 1 line 1). Ancient literature documents that rice was used as a common remedy for many therapeutic purposes in Asian countries, and this is an ongoing practice. The well-documented medicinal and remedial properties of rice are founded on the fact that rice bran contains a high percentage of fibre which may assist in the absorption of fats in the gut and decrease the levels of cholesterol in the blood. The regular consumption of brown rice may aid in digestion with a gentler natural laxative property (Ravichanthiran *et al.* 2018:71). A significant amount of vitamin E which is high in anti-oxidants is contained in brown rice. Scientific research has proven that rice products may have anti-cancer properties and enolic compounds are associated with multiple human health benefits, including anti-inflammatory anti-diabetic, anticarcinogenic, and gastrointestinal conditions (Ravichanthiran *et al.* 2018:71). Rakthashali, a red rice variety in India, is widely used by Ayurveda experts, as a functional food. Indigenous to India, Kullakar, is a medicinal rice with high thiamine also known as vitamin B1 content, while the Karikalaveya variety is high in riboflavin, commonly known as vitamin B2 and finally niacin which id vitamin B3, this is vital for optimum skin, muscle, brain and nerve function (Ravichanthiran *et al.* 2018:71).

Table 2.2: Nutritive value of 1 cup of cooked brown versus 1 cup cooked white rice

NUTRIENTS	MICRONUTRIENTS	WHITE RICE	BROWN RICE	RDA
Iron (mg)	Mineral	2.8	1.1	8-18
Thiamin (mg)	Vitamin	0.3	0.4	1.1-1.2
Niacin (mg)	Vitamin	3.4	5.2	14-16
Vitamin B-6 (mg)	Vitamin	0.1	0.3	1.3

NUTRIENTS	MICRONUTRIENTS	WHITE RICE	BROWN RICE	RDA
Folate (mcg)	Vitamin	108	18.2	400 (with additional needs during pregnancy)
Phosphorus (mg)	Mineral	68.8	208	700
Magnesium (mg)	Mineral	24.2	78.8	310-420
Zinc (mg)	Mineral	0.8	1.4	8–11
Selenium (mcg)	Mineral	14	11.7	55
Copper (mg)	Mineral	0.1	0.2	900
Manganese (mg)	Mineral	0.7	2.0	1.8–2.3

With reference to Table 2.2 the nutritive value of 1 cup (240ml) of cooked brown is 0.190-195g the recommended serving size is 0.095g as compared to 1 cup (240 ml) cooked white rice is 195-200g and the recommended serving size is approximately 0.100g. In addition, whole grains are a source of folate, riboflavin B2, potassium, calcium and manganese. Manganese is essential for many key functions in the body, for example, bone development, wound healing, muscle contraction, metabolism, nerve function and blood sugar regulation (Kazemzadeh *et al.* 2014: 478). Manganese deficiency has been linked to a higher risk of developing metabolic syndrome, bone demineralisation, impaired growth, and low fertility. It is recommended the that 1 metric cup brown rice fulfils nearly all of an individual's daily requirement for this important nutrient as shown in Table 2.2 (Zhou *et al.* 2016: 853).

Brown rice is a rich source of magnesium, a mineral that is essential for heart health. Fang *et al* (2016: 64) found that higher levels of dietary magnesium were linked to a 7-22% lower risk of stroke, heart failure and all-cause mortality. It was established through several studies that every 100 mg/day increase in dietary magnesium reduced heart disease mortality in women by 24-25%. Brown rice is high in fibre, lignans and magnesium, which all have positive effects on heart-related disease risks and overall heart health (Fang *et al.* 2016: 64).

Selenium is an essential component of several major metabolic pathways, including thyroid hormone, metabolism, antioxidant defence systems, and immune function (Fang *et al*. 2016: 64). Brown rice is rich source of selenium with 9.8 mcg per 100g.This mineral strengthens the immune system and could be beneficial in a weight loss program (Sun *et al.* 2010: 1479). The function of the thyroid is closely connected to proper bodily function and helps speed up metabolism. People who are diabetic or pre-diabetic will benefit from the switch to brown rice as it helps to regulate insulin levels by lowering blood sugar and decreasing the risk of diabetes. For those who are already diabetic, selenium can help to regulate the blood sugar level, the recommended average daily dosage of selenium in adults 19 – 50 years 55 (Sun *et al.* 2010: 1479).

Collectively brown rice is high in phenols and flavonoids, a class of antioxidants that support and protect the body from oxidative stress (Gong 2017: 433), heart disease, certain types of cancer, and premature aging. Antioxidants found in brown rice help prevent cell injury caused by unstable molecules called free radicals, and may reduce inflammation in the body (Wanders *et al.* 2011: 724). This whole grain is also a good source of folate, riboflavin B2, potassium and calcium.

Additionally, brown rice is remarkably high in manganese. This little-known mineral is vital for many important processes in the body, such as bone development, wound healing, muscle contraction metabolism, nerve function and blood sugar regulation (Fang *et al.* 2016:64-73). A deficiency in manganese has been linked to a higher risk of developing metabolic syndrome, bone demineralization, impaired growth and low fertility Just one cup of rice fulfils nearly all of an individual's daily requirement for this important nutrient (Zhou *et al.* 2016: 853-863). Research suggests that the antioxidants in brown rice may be the reason for a lower prevalence of chronic disease in regions where rice is a staple food (Goufo and Trindade 2014: 104). It is long recognised that using a calorie-controlled diet and replacing more refined grains like white rice, white pasta and white bread with whole grains is more nutritionally dense, as the refined grains lack the fibre and nutrients. The consumption of fibre lowers the glycaemic index of foods, and helps to keep the body fuller for a longer period of time. This is an indicator that choosing fibre-rich foods may result in consuming fewer calories (Wanders *et al.* 2011: 724). It was noted in one of the largest studies consisting of 74.091 female participants from the US, aged between 38 to 63 those who consumed more whole grains, included brown rice, weighed considerably less than those females who consumed fewer whole grains. Furthermore, in this

study, 49% of the women who consumed more fibre consistently, had a lower risk of weight gain than the women who consumed fewer whole grains and had a lower intake of fibre (Liu *et al.* 2003: 920). The success of these studies can offer evidence-based data to encourage higher uptake and make a transition to brown rice consumption.

With reference to a study conducted in Iran with a sample size of 40 overweight women participants who consumed 150 grams of brown rice per day for six weeks, a significant decrease in body weight and WC was reported, compared to women who consumed the same quantity of white rice. Making the transition from white rice to brown rice may enable the reduction of belly fat. Furthermore, the women who consumed brown rice experienced a substantial decrease in blood pressure and C-Reactive protein (CRP), a marker for inflammation in the body (Kazemzadeh *et al.* 2014).

Brown rice is recommended for good heart health as it contains a higher amount of fibre content 1.6 per 100g fibre, and valuable bioactive compounds that may help decrease the risk of heart disease. Using a large study sample of over 567.169 subjects from age 20-71 in the US this study concluded that people who ate high amounts dietary fibre had a 24–59% lower risk of developing heart disease, cancer and respiratory diseases (Park *et al.* 2012). Likewise, a systematic review of 45 studies found that people who consumed the highest quantity of whole grains, including brown rice, had a 21% lower risk of coronary heart disease compared to those who the minimum quantity of whole grains. Brown rice in addition to being a good source of fibre contains lignans which is an anti-oxidant may help to reduce heart disease risk factors. Research results for diets high in lignan-rich foods, such as whole grains, flax seeds, sesame seeds and nuts, have been linked to reduced cholesterol, lower blood pressure and decreased arterial stiffness (Peterson *et al.* 2010: 571).

Visceral fat is one of the most perilous body fats to possess. It builds up around the vital organs, and the higher the percentage of visceral, the more health risks one may encounter. In a study published in the *British Journal of Nutrition*, researchers found that making a transition to brown rice can help eliminate the dangerous visceral fat that builds up in the abdomen (Shimabukuro *et al.* 2014: 310). In this study conducted in Japan, 27 men participated in a 8 week study making the shift from white rice to brown rice had decreased visceral fat than those who chose to consume white rice.

Making an intended choice to eat foods with a lower glycaemic index like brown rice is a much healthier option for diabetics, as it is vital for a lower impact on blood glucose control (Sun *et al.* 2010: 1479).

The consumption of carbohydrates has a major impact on blood sugar levels. People with diabetes; who have insulin spikes, are therefore advised to eat fewer overly refined grains such as white rice. Taking a conscious decision to replace white rice with brown rice may reduce the chances of developing type-2 diabetes (Sun *et al.* 2010: 1479). Brown rice has a lower glycaemic index of 50 compared to white rice with a GI of 50, lower GI foods results in slower digestion, thereby keeping one fuller for longer. Research indicates that foods with a higher glycaemic index increase blood sugar, insulin and ghrelin, a hormone that drives hunger. The reduction of ghrelin levels may aid diabetics in controlling their hunger; this can reduce overeating and can improve blood sugar monitoring (Silva *et al.* 2015: 736).

Brown rice is thus a much healthier option for diabetics as it is vital for blood glucose sugar control. In a sample of 197 000 people in the US, a weekly substitution of 50 grams of brown rice for white rice per week, correlated to a 16% lower risk of developing type 2 diabetes (Sun *et al.* 2010: 1479). Without reservation, rice is the most consumed food commodity for almost half of the world's population. Considering that most of the rice that is consumed in South Africa is imported from Thailand and India contributing to 90% of the world's rice being cultivated in South, Southeast, and East Asia. Consuming a significant amount of brown rice approximately 120g on a regular basis may be a practical way forward to adopting a more wide-ranging approach to reaping the benefits of brown rice (Sollid and Jabri 2013: 294).

2.14 CUSTOMARY AND CULTURAL USE OF RICE IN ASIAN SOCIETY

Rice is not just a staple food; it is a food accorded great holy reverence as part of the framework of Asian society. It is an integral part of many religious rites, customary practices and ceremonial occasions. Present in most prayer rituals and served to God and devotees alike, most regional food cultures in India count rice as sacred. The annual calendar of festivals in Asian countries has many celebrations based on the harvest cycle of rice. According to the elders first rice harvested must not be consumed alone, so farmers will invite relatives to a communal meal to share their good fortune. Grains stuck to the pot are carefully collected and either eaten or put into the compost heap to foster new life. Rice has long gained the status as

a hallowed food, too valuable to waste even one grain. It is worth highlighting that rice is a thousand-year-old cultural tradition, some nations even acclaim rice cultivation with the progress of their civilization. and one of the most ancestral cereals on earth, hence it is revered by those who eat it, and over time, developed an ethos and symbolism of its own. In India, rice is known as 'dhanya' meaning “the sustainer of the human race” (Buddha Global Limited 2021: para. 3 line 3). This cereal has crossed all boundaries possible and even entered into a language of its own. In Mandarin, a traditional Chinese language, ‘rice’ and ‘agriculture’ are defined by the same word and the words ‘rice’ and ‘food’ are often interchanged. Instead of saying, "How are you?"' as a greeting, the Chinese ask, “Have you eaten rice today?” In the Japanese tradition reference is made to rice as their ‘mother’: it is a customary practice to soak rice before cooking as this is believed to release life energy and bequeaths the diner with a more powerful soul. As part of cultural tradition rice farmers are honoured as guardians of their culture and the countryside, and rice fields are even blessed with names of people (Novarroz 2021: para. 3 line 2).

In many Asian cultures rice is steeped in deep symbolism from birth to death and continues into the ancestral level. Recognising indigenous food systems and culturally indispensable foods is examined, which further validates why agricultural spiritual practices should be well-thought-out key elements of biocultural diversity and community identity. This study recommends the implementation of sustainable development that aims to represent the principles of food sovereignty, through local and indigenous ways, with tools of consultation and knowledge creation through sharing and community learnt holistic approaches, and indigenous and decolonizing practices (Castagnetti *et al*. 2021:16).

The worldwide practice of people showering newlyweds with rice as symbol of abundance and fertility, still remains. One of the first coming-of-age practices for young women in Asian culture is to learn the art of cooking perfect rice. Collective research indicates that 95 percent of the world’s rice crop is eaten by humans, as rice plays an indispensable role given its versatility (Rodriguez 2021: para. 1 line 3). The most basic method of using rice is cooked rice, by boiling, however, it can also be ground into a powdered form, to make flour. The gastronomic use of rice is diverse, ranging across main dishes, desserts, breakfast cereals, noodles, milk, syrups, soups, paper, alcoholic drinks and vinegars (Li 2021: para. 5 line 4). Rice by-products include rice flour, polished bran, rice starch, livestock feed, and rice oil,

which is processed from the bran, for both food and industrial applications for example, for use in the chemical furfural, brewing, distilling and as food additives (Bodie *et al*. 2019).

2.15 BROWN RICE AS A CULTURALLY ACCEPTABLE FOOD

The phenolics found in the germ and bran layers are intact as brown rice does not undergo any polishing or milling. Many food industries are improving their processed products by enrichment in ferulic acid, which is found in the bound form of the aromatic rice varieties, known collectively as "Basmati rice". Basmati rice is preferred by people from Asian and European countries, due to its aromatic qualities. Basmati rice has distinct cereal qualities such as long, supreme grains, a pleasing aroma, and a desirable texture when cooked. It has a high amylose 15-17% and a good amount of amylopectin ratio of 20:80 and a medium glycaemic index of 55-70, making it a good choice for the staple diets of diabetics (Ravichanthiran *et al.* 2018: 71).

The importance of cultural traditions and household perceptions on brown rice consumption patterns were clearly reflected in a study by Rojas *et al.* (2014: 200), where the traditional consumption of equal quantities of white rice and beans, as well as unfamiliarity with brown rice in the Costa Rican culture emerged. Rojas *et al.* (2014: 200) made the following recommendation to increase the consumption of brown rice and plant-based products in the Costa Rican culture: to reinforce from early childhood, the promotion of the associated ingredients health benefits and to simultaneously lower the cost thereof, while increasing availability and distribution, and most importantly, attracting women as facilitators of change for brown rice. This research highlights that innovative approaches are needed to persuade adults to adjust their food choices to healthier ones, within their cultural and sensory acceptability. It also highlights the importance and role of the food preparer and household food buyer to influence and shape the food consumption patterns of their families, presenting a strong case for targeted campaigns aimed at strategically including specific food ingredients into the diet, and thereby beginning the process of behaviour modification.

Some of the factors that may impact the acceptability of brown rice includes its appearance, longer cooking time, cost, limited availability, and a poor appreciation of its healthful benefits. As presented earlier, a common myth is that brown rice consumption is perceived as a sign of

poor living conditions (Adebamowo *et al.* 2017:1). Similar to South Africa, in Nigeria there is a historical association of white rice to privileged circumstances and wealth, thus making it seem more alluring and desirable to consumers. Creative recipe crafting may be called for, as proposed by Adebamowo *et al.* (2017:1), for example, by replacing brown rice with white rice in recipes and by including interesting and desired local and regional ingredients, to help disguise the appearance of brown rice and to help inspire a higher consumption and acceptance of brown rice (Adebamowo *et al.* 2017:1).

2.16 BROWN RICE INTERVENTION STUDIES

China's data markers show that it has the largest number of people with diabetes in the world, closely followed by India, Pakistan and then the US (Elflein 2020). Given that rice is one of the staple carbohydrates that is consumed in these countries, this is a good option for an intervention study targeting diabetes prevention and reduction. Well-planned interventions that are culturally and contextually suitable can be incorporated into national policy and could include the provision of brown rice as a replacement for white rice at government institutions and in food programs. This fairly modest dietary intervention has the probability to reduce the burden of diabetes globally. Successful implementation and adoption of such strategies has the scope to propel nutrition transitions specifically in urban settings, and could lead to a reduction in consumption of refined carbohydrates.

Such success would hinge on the potential to overcome barriers associated with the inclusion and consumption of brown rice in the diet and must be assessed for acceptability at national level within each country. The production of whole grains is supported by improving accessibility and regulatory expenses and is intended to be part of a larger global initiative to identify local, feasible and sustainable dietary interventions to reduce diabetes risk in countries experiencing epidemiological transition. The initiatives for the health benefits of whole-grains by improving the carbohydrate quality of staple foods was introduced in China, Tanzania, Nigeria, Puerto Rico and Mexico. Malik *et al.* (2019), predicts the efficacy of substituting brown rice, a whole-grain, for white rice in Chennai, India, are biomarkers of diabetes risk. The eventual objective of this research provides data for use in designing a dietary intervention aimed at reducing diabetes risk through a culturally appropriate, feasible and sustainable dietary change, which may be applied globally (Malik *et al.* 2019: 1387).

2.17 BROWN RICE CONSUMPTION IN SOUTH AFRICA

South Africa is reliant on rice imports to meet its national cereal needs, as the country's climate is not suited to the high-water demand for rice cultivation. Rice imports are duty free and local consumption is derived from import data as supplied by the Global Trade Atlas (GTA) (Esterhuizen 2018). The Global Trade Atlas (2018) forecasted that only a peripheral increase in South Africa's rice consumption would occur due to the continuance of comparatively low maize pricing in the country. It is a predictable fact that consumers usually interchange between rice, wheat and maize products with price and taste preferences and cultural patterns as selection markers. In South Africa, more than 90% the of rice that is consumed is parboiled, with the balance made up mainly of basmati rice. India, the world's second largest rice exporter, is having logistical hurdles in its exports reaching a standstill and not signing any new export contracts amid a nationwide COVID-19 lockdown, as labour shortages and global disruptions hinder the delivery of existing contracts (Mancombu: 2021 para. 1 line 4). Consequently, the demand for the functional food products with bioactive ingredients have increased. Food sustainability challenges have occurred in the age of global pandemic (Aday 2020: 3).

It is estimated that South Africa imports about 1 million tons of rice, in a year about 810 0000 tons of rice are imported from Thailand and India respectively, which constitute about 90 percent of South Africa's total rice demand (Table 2.3) (Esterhuizen 2018). Most people in South Africa eat a significant amount of rice daily. It is therefore recommended that a more wide-ranging approach to cereals and grains be adopted, indicating that rice is grown in more than a hundred countries with a total cultivation area of nearly 160 million hectares, producing more than 700 million tons annually (International Rice Research Institute 2017: para. 1 line 3).

Table 2.3: Consumption of rice in South Africa (Esterhuizen 2018)

MARKETING YEARS	ACTUAL 2016-2017	ESTIMATE 2017-2018	FORECAST 2018-2019
Consumption (1.000 tons)	860	840	860

2.18 INCOPORATING UNFAMILAR FOODS IN ONES' DIET

Making a food change in adults and children is a stressful process; to minimize stress and increase the opportunities for new food acceptance, foods must be introduced gradually, one new food type at a time (Janas 2019: para. 2 line 1). A familiar food substitution is another strategy, for example, whole-wheat pasta for white pasta and searching for interesting alternatives, which can help to make the switch from one food to another easier to adopt (Janas 2019: para. 2 line 1). It must be noted that a fear of unfamiliar foods or food neophobia, often impacts negatively on the dietary intake of both children and adults thus people with higher levels of food neophobia consume less diverse diets with a reduced quantity and variety of vegetables, fruit and meats making it harder to facilitate shifts in consumption patterns. Potential influence of neophobia on dietary intake may render unhealthy weight consequences in children (Perry *et al.* 2015:2).

In a study conducted in Finland people who were open to trying new foods consumed more protein, healthy fats, and magnesium than people who did not. Women are more inclined to be explorers and eat 50 percent more vegetables (Zickgraf *et al.* 2018). Being more adaptable to a diverse range of food experiences, rather than following fastidious eating habits and sticking to a few foods, brings innovation into everyday meals with a choice of interesting flavours, textures, and combinations of ingredients.

A survey of more than 1300 adults showed that 18 percent of participants qualified as picky eaters, rather than exploring different ingredients and flavours, one might be missing on health benefits that makes one healthier and stronger. In one study, people who were open to trying new foods consumed more protein, healthy fats, and magnesium than people who did not (Swartz 2020). Adventurous women also tend to eat 50 percent more vegetables, according to the Finnish study (Swartz 2020).

2.19 PROMOTING A NEW FOOD

Promoting a new food to impact positive dietary habits is motivated by many social and economic factors that shape a person's lifestyle choices (WHO 2020c). These aspects include income, food prices, accessibility and affordability, individual predilections, beliefs, cultural traditions, geographical and environmental aspects relating to climate changes, education level

and consumer awareness (WHO 2020c). Promoting a healthy food environment, including food systems that encourage a diversified, balanced and healthy diet, requires the involvement of multiple sectors and stakeholders from government to public and private sectors, to adopt and maintain healthy dietary practices. Public health is promoted through co-operative actions by policy makers to create a healthy food environment and they must create coherence in national policies and investment plans including trade, food and agricultural policies. Promoting consumer mindfulness of a healthy diet should include (WHO 2020c):

- Developing school policies and programmes that motivate children to adopt and maintain a healthy diet;
- Cultivating a culture of knowledge and information for children, adolescents and adults about nutrition and healthy dietary practices;
- Promoting culinary skills in young adults;
- Supporting point-of-sale material, through nutrition labelling for precise, consistent and logical information on nutrient contents in foods;
- The addition of front-of-pack labelling to enable consumer understanding; and
- Providing nutrition and dietary counselling at primary health-care facilities.

Founded on the benefits of brown rice consumption, a new trend is currently emerging as in germinated brown rice (GBR), which is brown rice that has been soaked, drained, and sprouted for a few days, to enhance its nutritive value. Germinated brown rice or gamma-aminobutyric acid (GABA) rice, contains increased levels of GABA (Coconuts Bangkok 2019). Unpolished brown rice that is germinated is heightened in flavour, texture and nutritional value. Germinated brown rice is said to support and protect the brain from harmful amino acids connected to Alzheimer's disease (Kaewsorn and Sirisomboon 2014). It is also a powerful neurotransmitter, boosting the central nervous system's ability to support good sleep and reduce stress. Furthermore, in additional to GABA, germinated brown rice has gamma oryzanol, an antioxidant, that has anti-dyslipoproteinemia and cholesterol lowering effects for healthy cells; also, pre-germinated brown rice is said to increase mental health and immunity (Kaewsorn and Sirisomboon 2014). Reviews of brown rice have highlighted that it contains bioactive phytochemical compounds that may be associated with vital nutrigenomic implications. Hence, brown rice has captured the attention of health-conscious consumers and presents an ideal opportunity for brown rice new product development. The bran in brown rice is rich in γ-oryzanol, which has many pharmacological properties, including cholesterol

lowering, anti-inflammatory, anti-cancer, anti-diabetic and antioxidant activities (Ravichanthiran *et al.* 2018: 71).

2.20 SENSORY ELEMENT OF BROWN RICE

Sensory analysis indicates that brown rice is harder to chew and has low taste acceptability; therefore, pre-germinated rice is preferred (Slogrove 2014: 218). As mentioned earlier, brown rice can be soaked for 2-3 days in water to begin the germination process and to maximise the nutritional content (Ravichanthiran *et al.* 2018: 71). The different sensory qualities of cooked brown rice must meet the requirements of consumers with different cultural and preference backgrounds. Pang *et al.* (2016) indicated that different rice varieties can be matched to best meet the expectation of consumers and to help overcome initial resistance to the sensory attributes of brown rice. To escalate brown rice consumption, growers, importers and marketers of brown rice require a better understanding of the sensory properties that drive brown rice consumption, as well as a greater appreciation of the opinions, attitudes and perceptions of consumers. After thorough investigation in a study by Slogrove (2014: 218) based in South Africa, it was concluded that no data is readily available, specifically detailing the development of final product specifications for the long-grain parboiled rice, Oryza sativa. More specific research is needed in South Africa to address the element of sensory acceptance in rice varieties (Slogrove 2014: 218).

Although outcomes of numerous studies have found that the consumption of whole brown rice is healthier than that of white rice, the culinary application of brown rice is restricted. The limitation of brown rice consumption can be ascribed to some cultural influences and traditions. (Rojas *et al*. 2014: 200). The most important challenge is the lower consumer acceptability of brown rice when compared to the polished white rice, polished rice denotes to rice which has been milled to eliminate the husk, bran, germ, and the altering amounts of the nutrients it contains, leaving a starch-rich grain. The difference is that rice from which the husk has been removed with the bran partially or entirely left intact is unpolished rice or brown rice. Polished rice has a reduced amount of moisture, mineral, biotin, niacin, protein and fatty content than brown or lightly milled rice, in comparison to unpolished brown rice in which the bran is partially or entirely complete within the rice grain (Thomas 2019: para. 2 line 1).

Innovative strategies must be identified to motivate transformation in eating behaviour based on tradition and family trends, as opposed to only health and nutrition. Providing flavoursome, culturally-acceptable, healthy meal ideas such as brown rice and beans in school lunch programs and in the family home, could encourage the development of healthy eating habits among the younger generations. Furthermore, the introduction and promotion of dishes prepared with brown rice in work site cafeterias and in the casual dining restaurants, could underpin the adoption of novel eating habits (Rojas *et al.* 2014: 200).

The lower sensory acceptability of brown rice can be attributed to its harsh taste and nutty flavour caused by phenolic and volatile compounds, and dietary fibre, which are largely concentrated in the outer bran layer. The fibre-rich bran in brown rice gives it a chewy resistant texture and darker colour, compared to the soft, fluffy mouth feel and light, bright colour of white rice. There is also concern that the shelf-life of brown rice is shorter than white rice, at ambient temperature. This is attributed to the oil which is highly concentrated in the bran layers. Naturally occurring lipase enzyme in brown rice breaks down the oil in the bran layers, and causes rancidity and spoilage by hydrolytic and oxidative elements. Therefore, conventional technologies in germination, a combination of germination and selenium enrichment, modified atmospheric packaging, and the treatment with essential oil vapour, will be useful for improving the quality brown rice during storage and handling, to extend shelf-life and to improve its sensory qualities. However, the effectiveness and application of these technologies as well as other processing methods at commercial scale, need further investigation. Moreover, these processed products are recommended as functional and healthy foods (Saleh *et al.* 2019: 1070).

2.21 COOKING APPLICATION OF BROWN RICE

The cooking time of rice is determined by the temperature at which the crystal-like structures of the starch begin to dissolve, referred to as gelatinisation temperature (GT), and it ranges from 55 to 85°C (Miura *et al.* 2018:2). Rice with high GT takes a longer time to cook and the cooked rice has an unacceptable texture; low-GT rice takes a shorter time to cook, and the cooked rice is more palatable, thus increasing acceptability levels. A key gene affecting GT, identified as the enzyme Starch Synthase IIa (SSlla), acts in a catalytic and regulatory role as it influences the functional properties of the cereal (Miura *et al.* 2018: 2). This important finding allows for new rice varieties with a lower GT, where there will be a decrease in the

average cooking time by up to 4 minutes. This finding may initially seem inconsequential, but when calculating the number of times rice is cooked in any one day by the millions of households worldwide, a decrease of 4 minutes for each cooking event could save more than 10 000 years of cooking time each day. This epitomizes the enormous possibility for global energy and environmental conservation (Ricepedia 2021b: para. 3 line 4). There is shift in the modern consumer practice activities bases on health consciousness and therefore mindfulness, people who are interested in the nutritional quality of food, will appreciate improved brown rice varieties with excellent nutritional value, which can simultaneously offer excellent energy saving benefits (Rebeira *et al.* 2014: 570).

2.22 PRE AND POST-PRANDIAL BLOOD GLUCOSE

The following terms are commonly used in relation to blood glucose levels: the word 'prandial' relates to a meal; 'pre-prandial' relates to before a meal, and 'post-prandial' means measurement after consuming brown rice. The human body responds to sugar and starch after consuming a meal. Within two hours of eating, insulin and blood glucose levels should return to 4-6 mmol/L, if blood glucose levels remain raised at is over 7 mmol/L, this may be an indicator of diabetes (Diabetes 2019: para. 2 line 3).

In pre- and post-prandial testing, one is able to see how the intake of a meal affects blood glucose levels. In post-prandial tests, blood glucose measurements are normally taken two hours after a meal is consumed. The recommended post-prandial glucose reading is between 4.0 to 5.4 mmol/L, and a pre-prandial plasma glucose reading is 4-6 mmol/L. These test results may vary, depending on age, gender, health history, the method used for the test, and other factors such as smoking, extreme stress, snacking before or after the testing, exercise, and not finishing the entire meal before testing (Haldeman-Englert 2021: para. 3 line 2).

In pre-post prandial testing, the participant is required to fast for 12 hours before the test and then to eat a meal with at least 75 grams of carbohydrates. After the meal, the participant must not eat anything else before having the post-prandial test. It is advised to rest during the two-hour waiting period, because exercise can cause blood sugar levels to rise (American Diabetes Association 2018: S13).

Glycaemic regulation is a vital aspect in the management of diabetes mellitus. It is foundational in reducing the morbidity and mortality caused by diseases associated with raised glycated haemoglobin (HbA1c), fasting plasma glucose (FPG), and post-prandial plasma glucose (PPG) (Ketema and Kibret 2015). Yet, the measurement of HbA1c level remains the gold standard for assessment of glycaemic control at follow up. Concerning day-to-day disparities, numerous findings suggest that several determinations of glucose over a period of several weeks offer a more reliable indicator of glycemia and are better correlated with HbA1c, than a single measurement or a few measurements in a day (Ketema and Kibret 2015). According to the American Diabetes Association (2018: S13), 86 million people in the US are prediabetic and this can lead to diabetes in the absence of a healthy lifestyle change. Therefore, to keep pre-diabetes from becoming diabetes, a dietary modification plan and exercise regime must be introduced and maintained.

2.23 CONCLUSION

This chapter presented an overview of a variety of literature findings relating to the proposed research in this study. The literature indicates that NCDs are the root cause of almost 70% of all deaths on a global scale. With recent studies from the WHO and the United Nations (UN) confirming that people suffering from NCDs are more prone to becoming severely sick and dying from COVID-19 (WHO 2020b: para. 2 line 3), interventions and strategies must be planned, implemented, and measured for effectiveness within different sectors of the population, from conception, infancy, early childhood, and adolescence to adulthood, to combat the prevalence of death from NCDs (Department of Health 2013).

The South African population have many challenges around over and under nutrition. Undernourished children progress into adulthood facing the increased burden of overweight, obesity and NCDs, this as a consequence of over-exposure to an unhealthy food environment as well as cultural factors. Obese individuals are micronutrient-deficient, amplifying their risk to NCDs (Medical Brief: 2016). South Africa faces a conflict in nutrition on two fronts: firstly, considerable escalation in overweight and obesity rates, and secondly, a collective nutrition deficiency battle commonly known as the double -burden of malnutrition. A study conducted by the Human Sciences Research Council in 2014 (Shisana *et al.* 2014) provides comprehensive insight into the state of nutrition in South Africa.

The National Health and Nutrition Examination Survey (HSRC) asserts that over 40% of South Africans in rural and informal urban areas face nutritionally deficiency with poor dietary diversity and increasingly low food security status. For many South Africans, food security is one of the biggest issues when it comes to diverse nutrition, and the research also revealed an opposing problem: in urban areas, in the higher income regions where food diversity was high, the foods eaten were high in fat, and sugar and was accompanied by obesity and health problems (Writer 2016; Govender *et al*. 2017: 1). In a summary of this chapter the following; topics were covered, carbohydrate and unrefined cereal consumption in SA, and the cultivation and structure of rice. Addressing the challenges of food security, the benefits of brown rice consumption, and the nutritional and medicinal value of brown rice. The customs and cultural status of rice was also presented. The incorporation of unfamiliar foods in one's diet and promoting a new food, the cooking application and sensory element of brown rice was explored. Further, the importance of brown rice intervention studies was presented with pre and post-prandial blood glucose measurements. The basis of this chapter is an understanding of a variety of literature relating to the study being undertaken. In the following chapter, the procedures used in the research design and methodology are presented.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to outline and explain the research design and methodology adopted in this study. It will also describe and explain the data collection procedures used to gather information for this study. A selection of measuring tools and techniques were utilized, namely, FGDs, SFFQ, sensory acceptability tests of brown rice cooked using various methods, sensory acceptability of brown rice paired dishes, anthropometric measurements, and lastly, pre-prandial and 2-hour post-prandial blood glucose measurements.

3.2 RESEARCH STUDY DESIGN

This study used a mixed methods approach. Qualitative methods were used to assess the barriers and facilitators of brown rice consumption through FGDs. Cross-sectional methods were used to determine the starch food frequency questionnaire, sensory acceptability of meals paired with brown rice and brown rice using various cooking methods, anthropometric measurements and pre-prandial and 2-hour post-prandial blood glucose to determine the effect of brown rice consumption on blood glucose levels among participants.

3.3 STUDY POPULATION

Participants in this study were recruited from the Durban University of Technology. The Durban University of Technology is one of seven universities of technology in South Africa. It was formed in 2002 with the merger of ML Sultan Technikon and Natal Technikon, to form a successful amalgamation in higher education in KZN. After 1994, the country's true development infers issues concerning transformation, Africanization of the curricula for higher education, open-minded leadership, and neo-liberal policies in human potential for the emergence of higher education in a democratic South Africa. All these matters have been under critical scrutiny since democracy. Such scrutiny was deemed necessary to realize the objectives of higher education through a sustained and inclusive transformation strategy (Karodia *et al.* 2015: 326).

The Durban University of Technology is located in Durban and Pietermaritzburg, KZN. It has a staff complement of 841 academics and 2 647 administrative staff (DUT 2021). In 2019,

DUT had approximately 33 932 students across seven campuses, five in Durban (City Campus, ML Sultan Campus, Ritson Campus, Steve Biko Campus and Brickfield Campus) (Figure 3.1) and two in Pietmaritzburg (Indumiso Campus and Riverside Campus).

Figure 3.1: Google Earth Map of DUT (Google Earth (2018) shows the building locations for DUT)

3.4 PARTICIPANT ELIGIBILITY CRITERIA

In order to participate in this study subjects had to be non-diabetic permanent and contract staff, both men and women from DUT, who were based at the Steve Biko, Ritson and ML Sultan campuses, and consumed rice and meat. Outsourced company staff within DUT and students were excluded from this study. All staff members who did not consume rice and who were vegetarians were excluded from the study. Gatekeeper permission to conduct the study at DUT was obtained from the Directorate for Research and Postgraduate Support (Appendix A).

3.5 SAMPLE SIZE

It was projected that Focus Group Discussion (FGDs) would continue until meaning saturation of core codes was reached. It was anticipated that there would be two to three FGDs, with 8-10 participants in each, totalling 24-30 participants for all FGDs. Sixty participants were recruited for the SFFQ, sensory evaluation and the pre-prandial and 2-hour post-prandial blood glucose tests. Using sensory analysis sample size estimation as a guide, through reference to a study conducted by Gacula and Rutenback (2006: 129), the sample size ranging from 20 to 200 was used to detect a difference ranging from 0.0 to 1.0 on a 9-point hedonic scale. A significant difference was first observed at a difference of 0.60, when n = 40, confirming the widely cited sample size of 40–100 in sensory analysis (Gacula and Rutenback 2006: 129).

3.6 MEASUREMENT TOOLS

3.6.1 FOCUS GROUP DISCUSSIONS

Notice of the study and recruitment of participants for the FGDs was posted on the staff intranet, from May to July 2020 inviting eligible participants to contact the researcher via email (Appendices B and C). Participants were recruited through convenience sampling. A letter of information (Appendix D) on details of the study and informed consent was shared via email (Appendix E). The second step of recruitment involved the sharing of several dates for FGDs with interested eligible participants. Participants selected a compatible date, and received a reminder of this date both one week before week and on the day of the FGD interview.

Focus group discussions continued until meaning saturation of core codes were reached. All the FGDs were conducted by the researcher, who was assisted by the supervisors as note-takers. Prior to conducting the FGDs, the researcher received training on moderating and how to facilitate a focus group. Each FGD lasted approximately one hour and was conducted in English. Two FGDs were conducted face-to-face and one online on MS Teams during the first COVID-19 lockdown in 2020. The face-to-face FGDs were held in a private space to ensure anonymity and open sharing of opinions. At the start of each FGD, participants completed a short demographic questionnaire (Appendix F). For the online FGD, the MS Teams platform which allows for synchronous meetings, with recording facilities was used. This platform was familiar to all employees as they had used it previously to conduct their job online during the COVID-19 lockdown.

Consent to participate in the online FGD was obtained through email. Verbal consent to record the session was obtained at the start of the online session. The note-taker's role was extended to manage written chats and questions during the online call. For the online FGDs, a link was shared with participants to complete the demographic questionnaire at the start of the session. At all sessions, the moderator briefly introduced the study and outlined the ethical considerations and procedures for protecting participants confidentiality at each session. The moderator posed open-ended questions and probed for additional information (Table 3.1) (Appendix G). A debriefing session was held by the researcher and supervisors after the completion of each FGD, to assess the quality of data.

Table 3.1: Focus Group Discussion interview guide

QUESTIONS
1. What do you understand by healthy foods?
2. What do you understand by unhealthy foods?
3. What are the factors that determine your food choice?
4. What influences you to choose healthy food?
5. What prevents you from choosing healthy food?
6. Which type of rice do you and your families frequently eat? Why?
7. What type of qualities you would look for when you buy rice?
8. What do you think of brown rice?
9. Why do you think people prefer white rice rather than brown rice?
10. If I were to tell you that there are several scientific studies that show that eating brown rice is healthier than eating white rice, would you replace white rice with brown rice? Why or why not?
11. What factors would influence your willingness to change from white rice to brown rice?
12. What suggestions do you have to make brown rice more appealing to people?

3.6.2 STARCH FOOD FREQUENCY QUESTIONNAIRE

The SFFQ (Appendix H) was used to assess how often starchy foods were consumed by university staff. The SFFQ was designed by the researcher and piloted among ten staff members in the Department of Food and Nutrition at DUT, to check for comprehensiveness and ease of flow. Feedback from the piloted questionnaire was used to assess and revise the SFFQ in terms design, layout, categories of starch items and recommendations for improvement of the questionnaire before administrating to the 60 participants.

3.6.3 BROWN RICE COOKING METHODS TRIALS AND SENSORY EVALUATION

Brown rice was cooked using four different heat application methods: microwave, electric stove solid plate, gas cooker, and oven, with salt and without salt, and lastly, soaking overnight in cold water and then cooking. To draw a comparison, two brands of brown rice were used: Woolworths brown basmati rice and Tastic brown rice. Both were prepared using the same set of cooking applications. Three cooking trials were conducted using a ratio of 50g brown rice to 250 ml cold water. Both the rice was cooked using the manufacturer's instructions on the packaging as a guide the cooking time and conditions were documented, and changes effected to obtain the optimal cooked brown rice. Each participant was presented with four samples of Basmati brown rice and four samples of brown, each with coded samples of 60g each using the four different cooking methods. Participants received a letter of information and consenting participants then completed a preference test (Appendices I and J). The cooked rice samples for tasting were presented in transparent tasting cups at a temperature of over 60-degree Celsius.

3.6.4 PAIRED MEALS PREPARATION AND SENSORY EVALAUTION

Using a validated 9-point hedonic scale (Lawless and Heyman, 2010: 12) (Appendix K), two commonly consumed dishes that pair well with white rice, butter chicken and lamb curry were prepared and photographed with recipes; as presented in Appendices L and M. The decision to select these dishes was based on sales data and the fact that these two dishes were the most popular among staff and students in the Rendezvous Restaurant at DUT, which caters for staff and student lunches. Sensory evaluation was conducted among 60 participants to determine if the selected meals, when paired with brown rice, were sensorially acceptable and palatable, by

using a 9-point hedonic scale (Lawless and Heyman, 2010: 12). Traditionally, the 9-point hedonic scale is a valid and reliable tool that is reassigned as numbers and is widely used in sensory evaluation to measure food preference and food acceptability. It is a suitable tool for adults and has been in use for over six decades for statistical analysis and modelling (Nicolas *et al.* 2010: 1008).

All sensory evaluation trials took place in the Rendezvous Restaurant at the Steve Biko Campus during November and December 2020, where each participant was explained the details of the sensory evaluation trials by the research team. In the rare case, if a participant could not attend the sensory evaluation tasting session, the researcher together with two research assistants (RAs) delivered the samples to the participants office. In this case, sample trays (consisting of a cup of water, samples, a spoon, and serviette) were delivered to the participant's office and the procedure for the sensory evaluation was explained by RAs.

3.6.4 SELECTION OF A BREAKFAST DISH

In order to determine the most appropriate breakfast dish to be served to the participants in the pre- and post-prandial blood glucose phase of the study, recommended dishes from the FGDs were piloted and trialed for acceptance. Two dishes, breakfast muesli rice (Appendix O).and an egg fried rice-stir fry (Appendices M and N), were piloted trialed and evaluated among staff in The Department of Food and Nutrition Consumer Science for acceptability, using a 9-point hedonic scale. Feedback from the piloted breakfast items was used to revise the recipe, until the breakfast dishes were pronounced acceptable by the sensory panel using the 9-point hedonic scale. These two breakfast dishes were used at the pre- and post-prandial blood draw.

3.6.5 SAMPLE PREPARATION AND SENSORY EVALUATION CONDITIONS

All sensory samples were prepared in the Masters' Food Laboratory while adhering to COVID-19 guidelines, and standard operating procedures (Appendix P). A serving tray was set for each participant. This included 250ml potable still water, a serviette, a spoon, product samples at a serving temperature of 60-degree Celsius, the sensory evaluation sheet with the 9-point hedonic scale, a pencil and an eraser. Sanitizing and social distancing were followed strictly during the sensory evaluation sessions and the process was closely monitored by the supervisors.

3.6.6 ANTHROPOMETRIC MEASUREMENTS

According to Casadei and Kiel (2020: para 1. line 1), anthropometric measurements are a selection of numerical quantitative attributes of the muscle, bone, and adipose tissue used to determine the composition of the body. The four main dimensions of anthropometry are height, weight, body mass index (BMI), and body circumferences. These measurements are vital as it represents diagnostic indicators for obesity, which notably increases the risk for cardiovascular disease, hypertension, diabetes mellitus, and many other conditions. Furthermore, anthropometric measurements are used as a baseline for physical fitness and to formulate a plan for health fitness status.

Body weight, height and WC were measured for all 60 participants before the pre-prandial blood glucose test (Appendix Q). Body weight and height were measured with the participant bare foot and wearing minimum clothing, and after removing head gear where necessary. Weight was measured using a calibrated electronic scale (Scales 2000) and recorded to the nearest 0.1 grams. The scale was placed on a flat, even surface and adjusted to zero, then recalibrated after each participant, using a 1kg brown rice weight, for accuracy. The standing height was measured using a standard portable stadiometer, with the participant not wearing shoes, and standing against a wall in an upright position, and recorded to the nearest 0.1cm. Waist circumference was measured using a non-stretch tape measure and was taken at the midway area and the lower circumference of the rib cage, with the participant breathing at a normal rate. The researcher, supervisors, and trained RAs were responsible for administrating and recording the anthropometric measurements. The anthropometric measurement procedure was done in duplicate to eliminate any margin of error, and recorded on the data sheet.

3.6.7 PRE-PRANDIAL AND POST-PRANDIAL BLOODS GLUCOSE MEASUREMENTS

Blood glucose is produced from dietary carbohydrates to supply the body's cells with energy. Usually, the body controls blood glucose levels so there's continuously enough to fuel cells. Pre-prandial blood glucose refers to the level of sugar in the bloodstream before eating a meal, and post-prandial blood glucose refers to blood sugar levels within an hour or two after consuming a meal (Manzella: 2021 para. 5 line1).

Stage 1 - Finger prick blood glucose measurements were taken by a registered nurse for all 60 participants, assisted by the researcher, supervisors and two research assistants. The participants were instructed to fast overnight, and participants chose a time slot for the following morning, when the pre-prandial blood glucose test was administered at their offices. Participants were instructed to continue their day as normal. All the breakfast was freshly prepared in the Masters Food Laboratory by trained RAs, following strict COVID-19 standard operating procedures (Appendix P) and food safety guidelines. Participants were then given a prepared sensory tray with a brown rice breakfast meal of their choice that was pre-ordered the day before by the participant. The breakfast dishes weighed 195g for the muesli rice and 180g for the egg fried rice-stir-fry (Appendices N and O). The breakfast was prepared in advance and the temperature was maintained using a Wonder bag before serving. After 2 hours, the research team went back to the staff members' office for the 2-hour post-prandial blood glucose measurement. The following method presented in Figure 3.2 was adhered to. Stage 2 - All medical waste (lances, cotton swabs, gloves) were disposed through a medical waste company.

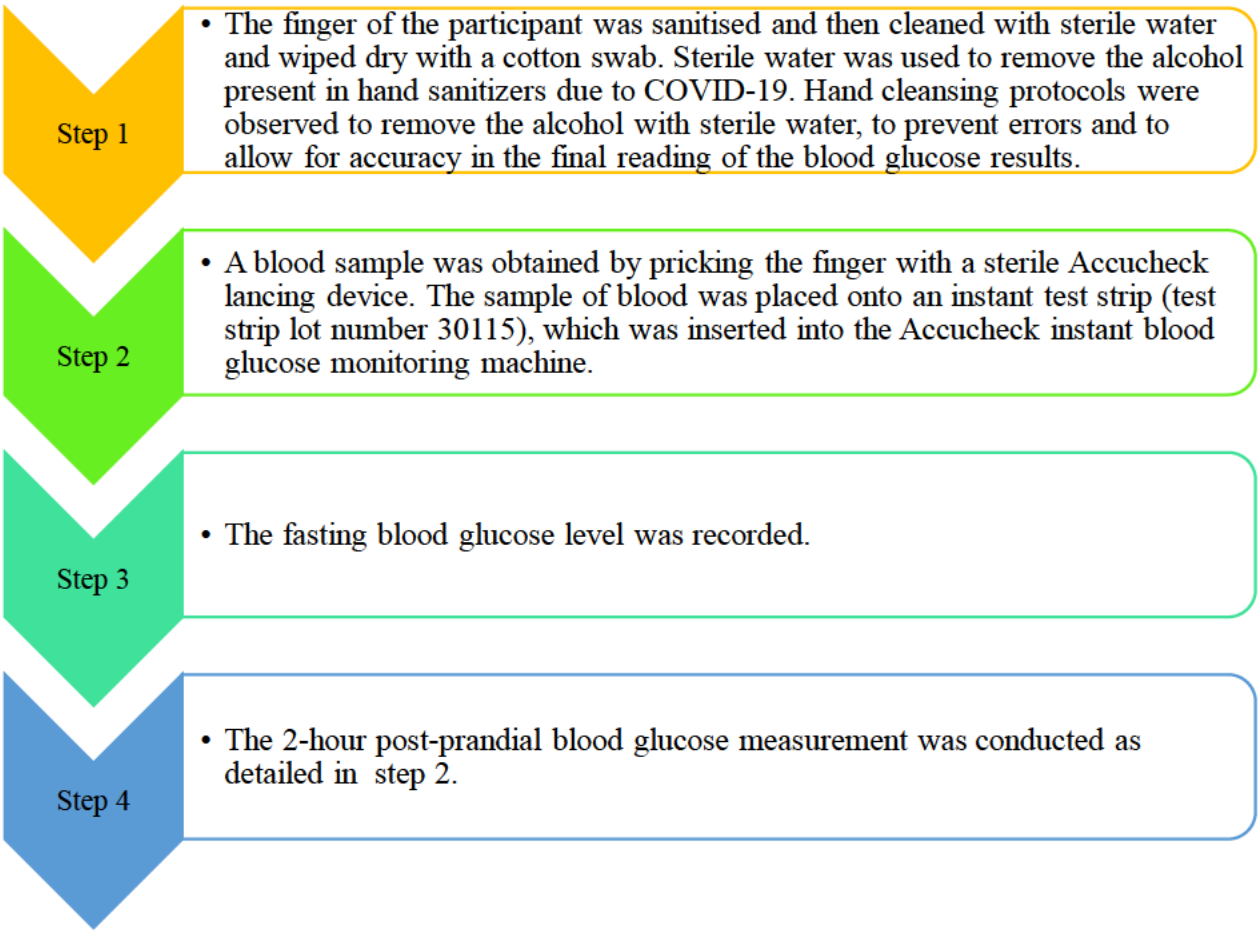

Figure 3.2 Stages in the pre-prandial and post-prandial measurement.

3.8 STATISTICAL ANALYSIS

Qualitative data consisted of translated verbatim transcripts of the FGDs. To ensure quality control, two investigators independently reviewed the transcripts against the audio recording for potential discrepancies or incomplete data. Textual data was managed using ATLAS ti. The interview transcripts were coded inductively by two independent coders to enhance the validity of the data. The coders then compared the coding schemes and resolved any differences. Following this the code book was finalised. Inductive coding was used to allow findings to emerge from the frequent, dominant, or significant themes inherent in the data. A codebook for each set of qualitative data was created, tested for inter-coder reliability, and used to code the transcripts to identify emergent thematic elements. A thematic analysis approach was used for data analysis, using Braun and Clark's (2006: 77) six-phase framework of thematic analysis. This process involves familiarizing oneself with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Quantitative data collected was captured on a Microsoft Excel® spread sheet, analysed using the Statistical Package for Social Sciences (SPSS®) version 25IBM Corp, Armonk, NY, US). Captured data was checked for correctness by a research assistant. Descriptive statistics were used to define the proportion of responses for each question and frequencies are represented in tables or graphs. The Chi-square goodness-of-fit test was used for categorical variables to test whether any of the response options were selected significantly more or less often that the others. Other statistical methods included the Binomial test, one sample t-test, paired samples t-test and the Wilcoxon signed ranks test. Statistical significance was accepted as $p < 0.05$.

3.9 ETHICAL APPROVAL

The research proposal was submitted, reviewed, and approved by the Institutional Research Ethics Committee (IREC) at the DUT, prior to the commencement of the study. Full approval from the Head of Department and DUT gatekeeper was obtained on the 29 January 2020, ethical clearance was granted for the research proposal (IREC139/19) (Appendix R). All potential participants were made aware that their participation was on a voluntary basis and that they were free to withdraw at any time. Recruitment of participants was done in two stages. In stage one, which involved staff recruitment, the aims, objectives, methods and benefits were explained using a verbal and written format with a letter of information per stage to each participant. In stage two, consent was obtained from interested participants. The data

management and de-identification of all data, and this electronic datum were password protected.

3.10 TRAINING AND THE ROLE OF RESEARCH ASSISTANTS

The purpose for training the RAs was to provide them with sound knowledge and understanding of the research tools and administration, and to adhere to COVID-19 protocols. The RAs were trained to make the participants comfortable during data collection, to remain neutral on all aspects of the data collection, and to manage verbal and non-verbal communication so as not to influence the participants' response in any way during the completion of the assessments. The research team adhered to strict COVID-19 protocols in the preparation of meals and the execution of sensory evaluation, using a validated 9-point hedonic scale. To reinforce training, the RAs were briefed with a practice run prior to the session and debriefed with recommendations for the next data collection session. The researcher and supervisors actively participated in the data collecting sessions with the RAs, as a quality measure.

3.11 CONCLUSION

In this chapter, the researcher presented the study design and offered a detailed description of the research methodology used. The researcher further acknowledges that all attempts was made to retain the validity and reliability of research findings and the elimination of any possibility of bias that may exist in this study. In chapter four, the findings, interpretations, correlations, and results will be critically analysed and discussed, with reference to similar brown rice studies conducted internationally.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter reports on the data that were collected, processed, analysed, interpreted and correlated, then converted into comprehensible results, using tables and graphs, according to the specific objectives of this study. A total of 94 participants engaged in different but relevant stages of the data collection process. It should be noted that some participants exercised their ethical rights and chose not to take part in aspects of the study, for example, in providing information and their BMI measurements and weight, during the pre- and post-blood tests, or divulging their age. Another factor that influences data collection was the impact of the COVID-19 pandemic on subject participation, some participants who commenced the study at stage one in the FGDs were unable to progress to all the stages of the study. This was due to staff working remotely during the different levels of the lockdown; staff keeping varied working hours. The staff having comorbidities; the over 60 age group who left the study; the unavailability of many staff on campus, and finally, the staff members refrained from any involvement in the data collection process, alluding to concerns with the COVID-19 pandemic. The results in this chapter will be presented in accordance with the objectives of the study.

4.2 RESULTS

Three focus group discussions were conducted until meaning saturation was reached, two face-to-face and one in the online mode. Table 4.1 depicts the participant characteristics of the FGDs. The total number of participants in the three FGD groups consisted of 24 participants comprising 25% (n=6) of male and 75% (n=18) of female participants. The mean age of the participants was recorded at 44 years (± SD 12). The analysis of participants by race included 42% (n=10) African staff members, followed by 33% (n=8) Indian and 25% (n=6) White, who participated in the FGDs. In terms of occupation, 54% (n=13) were academic staff, while 46% (n=11) were administrative staff. All participants' quotations are attributed to a participant number identifier, belonging to FGD group 1, FGD group 2 or FGD 3 (for example, P1-2: P=Participant, 1=participant number, 2=focus group discussion group 1; Table 4.2).

2.1 FOCUS GROUP DISCUSSION

Objective 1: To explore the perceptions, barriers and facilitators of brown rice consumption among staff at a university in South Africa

Table 4.1: Demographic characteristics of FGD participants

Number of FGDs

Characteristics	n	(%)
Number of FGDs		
FGD 1	10	(41)
FGD 2	9	(38)
FGD 3	5	(21)
Gender		
Men	6	(25)
Women	18	(75)
Age (Mean ± SD)	44	(12)
Race		
African	10	(42)
Indian	8	(33)
White	6	(25)
Occupation		
Academic	13	(54)
Administration	11	(46)

In summary the three focus group discussions were conducted until meaning saturation was reached, two face-to-face and one in the online mode. Table 4.1 depicts the participant characteristics of the FGDs. The total number of participants in the three FGD groups consisted of 24 participants comprising 25% (n=6) of male and 75% (n=18) of female participants. The

mean age of the participants was recorded at 44 years (± SD 12). The analysis of participants by race included 42% (n=10) African staff members, followed by 33% (n=8) Indian and 25% (n=6) White, who participated in the FGDs. In terms of occupation, 54% (n=13) were academic staff, while 46% (n=11) were administrative staff. All participants were assigned to a participant number identifier, belonging to FGD group 1, FGD group 2 or FGD 3 (for example, P1-2: P=Participant, 1=participant number, 2=focus group discussion group 1 (Table 4.2).

Table 4.2: Themes and associated sub-themes with descriptions emerging from thematic analysis of FGDs

THEME	SUB-THEME	DESCRIPTIONS
Understanding of healthy foods versus unhealthy foods	Healthy foods types	• P1-1: Foods that help one lose weight with it. • P2-1: Foods that are not harmful. • P3 & P4-1, 3: Low fat, low starch, low GI. • P5-1: If food has a dull look, it is healthy. • P6 & P4-1, 3: Fruit and vegetables. • P1 & P5-2: Healthy foods have all the right nutrients in it and are not processed foods. • P2 & P5-2: Less oil, sugar, salt – fresh as possible. • P3-2: Something where you get all your nutrients…required by the body. Something that does not affect the heart.
	Unhealthy food types	• P4-2: Foods that are not genetically modified. • P1, P3, P4-1, 2, 3: Fried food and processed, sugar. • P2 & P1-1, 2: Sweets, chocolate, cooldrink, cake, chips. • P4-1: Anything that is nice that we like, junk. • P7-1: White starch is bad, for example, potatoes.

THEME	SUB-THEME	DESCRIPTIONS
Factors that determine food choice	Education, mood, availability, affordability	• P3 & P5-1, 2: Mood. For example, if sad/depressed - Junk food and healthy foods if happy. Substances/textures – feeling for something salty – stir fry. • P4-1: Depends where you at (location). For example, home versus work. The company you have (type of people around you). • P5 & P2-1, 2: Budget. • P7 & P5, P2-1, 2, 3: Family references: eat around the child (foods that they like). • P8 & P6-1, 2: Availability – seasonal (global location). • P1, P9 & P5-1, 1, 2: Fundamentals – that is, education on food types better for you; you [are] aware of what is good for you. • P2, P5 & P4-1, 2, 3: Affordability. • P4-2: Taste – understand the benefits of healthy food. • P5-2: My health- Hypertensive + cholesterol + look at labels.
Factors that influence rice choice	Taste and texture, availability, cost, culturally acceptable	• P1-1: Soft, clean, no stones. • P2-1: Fluffy and loose when cooked. • P3-1: Soft, not sticky. • P5 & P6-1: Colour: must be white. Colour – turmeric – yellow rice. Turmeric is healthy. • P1 & P2-2, 5: Quick to cook.

THEME	SUB-THEME	DESCRIPTIONS
		• P3 & P3-1, 3: I grew up with it, culturally white. • P4: White rice is dyable, colour it with food colour. • P6, P7, P2-1, 2, 3: Cost of it. 2kg is the maximum one can buy of brown rice, unlike 10kg in white rice.
Perceptions of brown rice consumption	Barriers	• P1-1: It is terrible. • P4 & 5-1: Eating with curry – it is not so tasty with curry. Brown rice only with certain dishes – not with curry. • P6-1: Forced to eat brown rice due to health-conscious family. • P4-2: Expensive. • P5, P4, & P1-1, 2,3: Takes long to cook. • P4-2: Don't know how to prepare brown rice. • P2 & 4-2, 3: Person shopping at home only buys white rice. • P1 & P3-2: Family members preferences.
Perceptions of brown rice consumption	Facilitators	• P2, P8 & P9, P3-1, 2: Healthy. Taste nice, like the nuttiness. Good texture – not soft, crunchy texture. Has crunchiness if cooked correctly. • P1 & P3-1: Healthy and high in fibre. • P8-2: Not sticky. • P4, P5-2: Like the smell and flavour. Earthy.

The analysis revealed five broad themes: perceptions of healthy food and unhealthy foods; factors that determine food choice; factors that influence rice choice; barriers, and facilitators of brown rice.

Regarding the understanding of healthy foods versus unhealthy foods outlined in the FGDs, participants could clearly differentiate between healthy and unhealthy foods. According to Plasek *et al.* (2020: 1881), health practitioners refute the so-called healthy or unhealthy food claim, and as an alternative, there are only appropriate or inappropriate diets, since consumers still ponder about certain foods as healthy, and some as unhealthy. It thus become imperative to know how they make this distinction by using the term 'perceived healthiness', from their perspective. In the current study participants perceived the following to be healthy: foods that provide weight loss assistance to low fat, low starch, low GI, low salt and low sugar foods. Furthermore, some participants perceived healthy food as dull, nutrient-dense, including fruit and vegetables, that are not genetically modified, are heart-friendly and harmless to one's well-being. Food marketers capitalize considerably with inventive and persistent advertisements intended to boost widespread purchase of unhealthy foods. These foods are defined in the literature by Pettigrew *et al.* (2017) as being energy-dense and nutrient poor (EDNP). Several terms exist for EDNP foods, including unhealthy food, fast food, junk food, discretionary food, convenience food, party food, extra foods, treats, and snacks, and it is probable that they have diverse connotations for different people, which will vary according to the demographics and health status of the population group (Pettigrew *et al.* 2017: para. 5 line 1). It was apparent in the FGDs that junk food was clearly identified as unhealthy, but the liking for junk food justified its consumption.

Factors that determine food choices have evolved with the changes of natural and physical environment, lifestyle changes, and progress in technology. In today's South African society, due to growing national wealth and urbanized living, people consume more animal proteins and processed food. At the same time, consumption of whole food or minimally processed foods like whole grains, legumes, and other sources of fibre, has decreased sustainable healthy diets and dietary patterns in individuals in favour of a more refined diet of food choices (Chen and Antonelli 2020: 1898). Similarly, the FGDs detailed the following aspects in determining food choices: educational awareness, availability, accessibility, affordability of healthy foods, family influence, comfort eating and working from home during the COVID-19 pandemic.

According to a study by Sasananan and Ruekkasaem (2017) in Thailand, investigating rice purchasing patterns, participants bought the same type of rice (37%), including the same brand (25%), followed by rotational purchases of various types (20%), purchases without consideration for branded rice products (10%), and finally, in addition, had preference for well-known brands (8%). Rice was purchased in supermarkets as high priority and was placed on its convenience and accessibility. The FGD choice of rice was based on cultural determinants of food choice acceptance; colour; white rice being preferred in terms of a shorter cooking time; bulk purchase, which is more affordable compared to brown rice that is available in smaller packaging, and adding turmeric, which is considered as healthy. The choice of rice was further emphasised by its sensory properties: it is soft and fluffy, with loose grains and not sticky.

Numerous barriers to the consumption of whole-grain foods occur. Although the availability of brown rice is limited in urban and rural areas, brown rice is primarily obtainable in supermarkets and shopping malls and is sold at a higher price (Adebamowo *et al.* 2017:1). Another barrier to the consumption of brown rice is a lack of awareness and knowledge of the health benefits of brown rice, cultural preference, and perceived hunger versus nutritional value (Muhihi *et al.* 2012: 6). In a study by Mohan *et al.* (2017), barriers to brown rice consumption, similarly, were its availability, cultural preferences, cooking characteristics, sensory attributes, shelf-life storage and finally, side effects. The FGDs outlined the following barriers: brown rice is not as tasty as white rice; it requires longer cooking time; some of the participants had limited preparation skills; brown rice is expensive, and the designated family shopper purchases only white rice.

Brown rice has a reputation for being extremely nutritious; it is a naturally gluten-free grain containing a notable number of vitamins, minerals and with valuable beneficial compounds. According to Amore *et al.* (2019), the main facilitator of brown rice is individual nutrition knowledge gain; guidelines of parental influence; the social environmental impactive measures; including an institutional environment with reliable healthy meal choices; a conducive physical environment, and social media and a macrosystem that supports better food choices (Amore *et al.* 2019). The FGD participants enlisted enablers to sensory attributes such as mouthfeel, the nutty, crunchy texture, non-sticky, earthy smell and flavour elements.

4.2.2 DEMOGRAPHICS OF STUDY PARTICIPANTS AGE AND GENDER

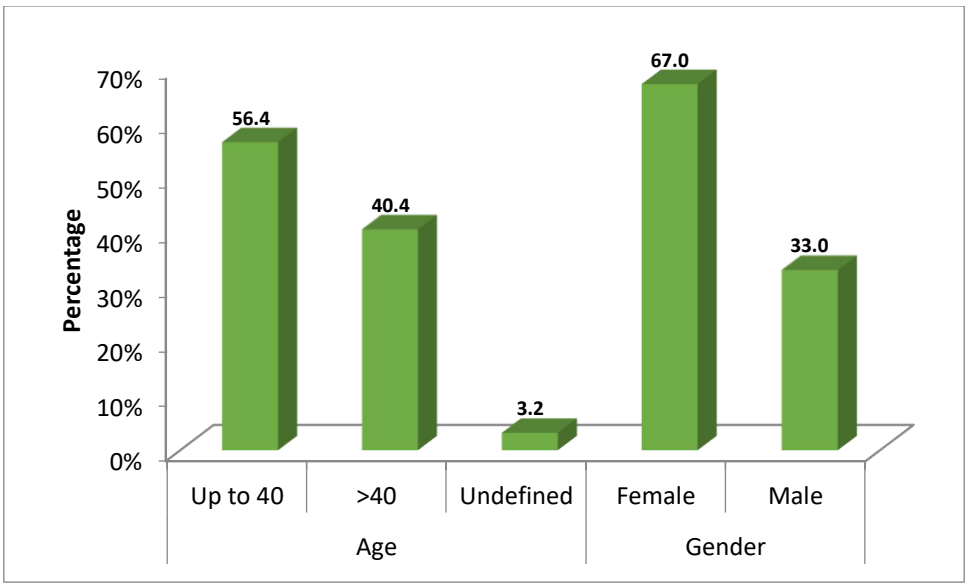

Figure 4.1: Age and gender of study participants

There was a higher level of women participation at 67.0%, compared to men at 33%. In terms of the mean age of the participants, 56.4% were >40 years, 40.4% were <40 years, and the remaining 3.2% did not disclose their age (Figure 4.1). With reference to the 2019 DUT annual report, there were 1 899 (48.25%) women and 2 037 (51.75%) men employed at the university, totaling 3 936 employees (DUT 2019). The increased participation of women staff can be attributed to many reasons.

Women have a known tendency to be more responsive to participate in research studies. According to Kamuya *et al.* (2017:2), decision-making and engaging processes by women are often not supported, with many women using their intervention skills to control household decisions, with purchasing and food preparation. The gender narrative suggests a shifting landscape in a once socially prescribed role with men at the helm, changing levels of education and financial independence for women, and the ability to access and control resources in a more female empowered environment. With reference to the age of the participants in the workplace, outdated views of retirement are changing patterns globally. People live longer, and are healthier, and the life expectancy for both men and women in the developed world has increased (Volini *et al.* 2020: 37).

4.2.3 STARCH FOOD FREQUENCY INTAKE

Objective 2: To assess the starch food intake of participants through a starch food frequency questionnaire

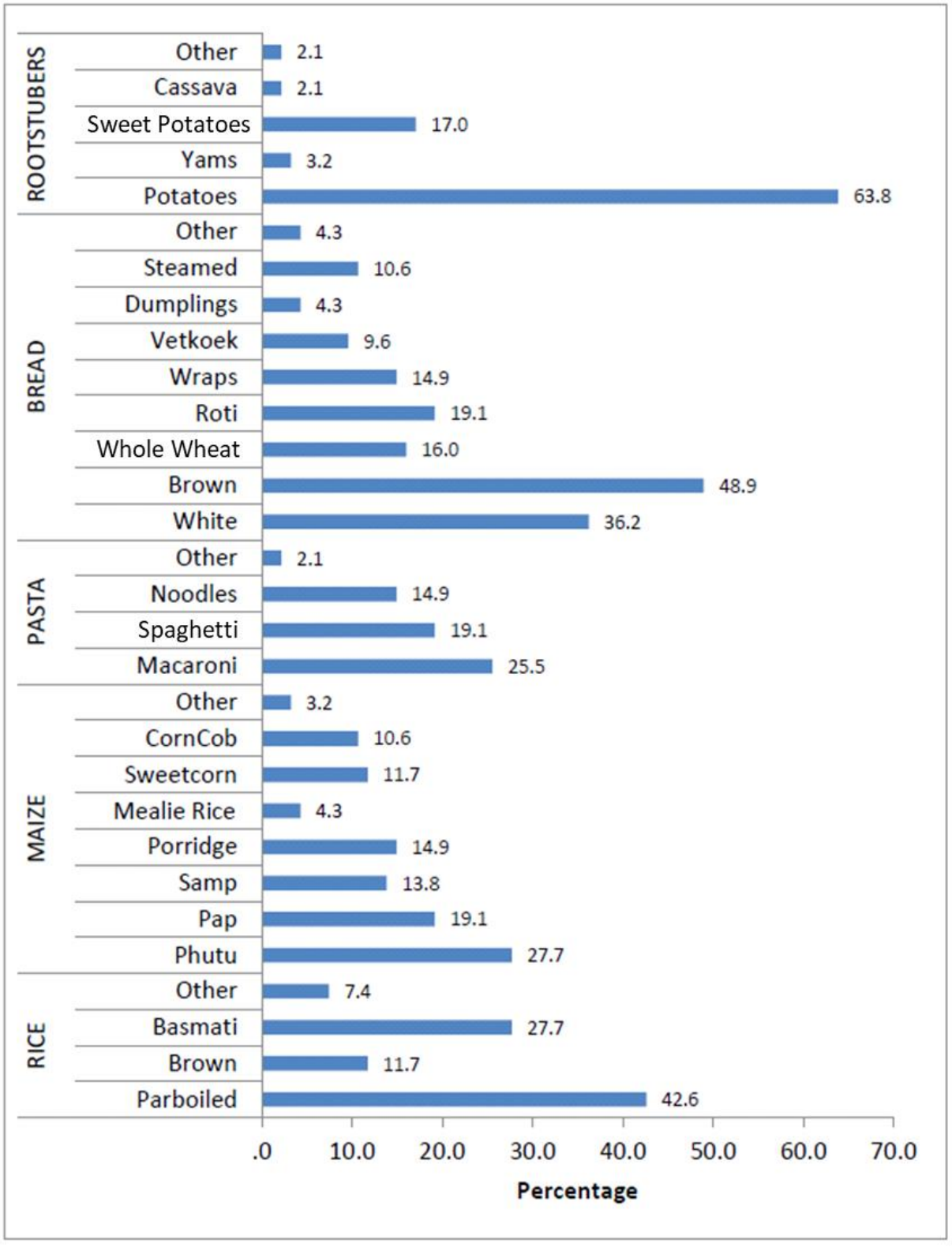

Figure 4.2: Frequency of starch food consumption

To assess the starch consumption of participants in the previous 7 days, a starch food frequency was conducted among the 94 DUT employees (Figure 4.2). The most frequently consumed starch was potatoes. Over a seven-day period, 63.8% of the study population consumed potatoes. This was followed by brown bread (48.7%) and white parboiled rice (42.6%). In the total rice category, 89.4% of participants reported consuming rice, and brown rice was the least consumed (11.7%). For the bread category, the most frequently consumed starch was brown bread (48.9%), followed by white bread (36.2%). For the maize category, phutu featured at 27.7 % and pap at 19%. With regard to the pasta category, macaroni featured at 25% followed by spaghetti at 19.1%.

In the root and tuber category, potato was consumed most frequently. This can be attributed to its all-year availability and the ability of the crop to thrive in most climatic regions in South Africa. The total value of potato production accounts for 43% of major vegetables produced in the South Africa (SA DAFF, 2013). South Africans tend to find comfort in potato chips which are served with most fast-food meals (Van Zyl *et al.* 2012: 124) also, potatoes are added to an array of dishes like curries, stews and soups to extend quantity for larger families and portion size for others. Furthermore, the younger generation has repositioned potatoes in favour of other starches, potato called “slap chips” (Muller *et al.* 2017: 88). The high carbohydrate value of potatoes is a contributing health marker that causes the blood glucose level to rise and relates to the high prevalence of diabetes. This has an impact on the glycaemic load, as the amount of carbohydrate in food is in relation to its effect on blood sugar levels. It is determined by multiplying its glycaemic index by the amount of carbohydrate the food contains (Anon 2015: para. 8 line 1).

The reasons for the higher consumption of brown bread compared to white bread could be attributed to previous nutrition education efforts focusing on its high fibre benefits; the ready to eat nature of the product; its purchasing and storage convenience; its versality of application as a meal accompaniment; its affordable price and the fact that brown bread is a zero-rated food to benefit the underprivileged in South Africa. Moreover, over a period of time, white bread was overly stigmatised for being too processed and unhealthy, yet it differs little from the nutritive composition of brown bread (Foster *et al.* 2020: 2170). Removing the negative stigma connected with carbohydrate foods has an important bearing for future progress in grain and cereal consumption to enable healthier food choices (Foster *et al.* 2020: 2170).

There are marked possibilities for increased brown rice consumption among participants, given the total rice consumption pattern noted in this study. Possible reasons for the high white parboiled rice consumption indicated by the FGD are mostly cultural elements, convenience, price and familiar eating habits. On the other hand, possible reasons for low brown rice consumption could be attributed to low availability, lack of promotion, dislike of the taste, extended cooking time (Mohan *et al.* 2017). Furthermore, this finding is supported by the results of the FGDs, where participants shared the view that parboiled white rice was their main rice starch choice as they were culturally accustomed to it. Many reasons can be attributed to the low consumption of brown rice in South Africa. The country has very diverse population groups who traditionally consume a wide variety of different starches that they are accustomed to, these are readily available on the market, whereas brown rice is a relatively new grain with which most consumers are not entirely familiar. However, according to Ronquest-Ross *et al* (2015: 3), rice and oats showed substantial growth in consumption levels of 48% and 83.3% in 2015, compared to other cereals. Making a shift from parboiled rice to brown rice consumption in South Africa will be affected by many factors such as food availability and accessibility. New food adoption patterns are subjected to many influences as indicated by the participants in the study, and there is a need for consumer awareness to increase brown rice consumption on a national and global scale.

Phutu is made from finely ground maize and is a traditionally consumed starch staple in South Africa. Historically, the shift from traditional staple of white maize-based product consumption to white parboiled rice equated the status and affluence of white rice with consumers. The gradual shift from predominantly maize-based meals in Africa is good for the population, as more nutritious foods will feature more prominently, encouraging the use of a variety of cereals for example, millet, sorghum, cassava, and sweet potatoes (Fihlani 2019). Likewise, the cultural preference for parboiled white rice was evident during all three FGDs, compared to other starches.

The International Pasta Organisation (IPO) data noted that the most dynamic movement in growth markets for pasta are Asia and Africa. South Africa is the second major pasta market on the continent after Tunisia. Furthermore, with urbanisation there is a stronger shift towards convenience foods teamed with new product innovation this has motivated the growth of the pasta category in recent years (Food Review 2019). Collectively, the pasta consumption in this study was indicated at 44.6% of starch consumption. The more frequent consumption of

macaroni and spaghetti was well noted by the study participants. These two pasta varieties are cost-effective, widely available on most supermarket shelves, and more familiar to the consumer compared to other varieties of pasta. On a ranking of the top 10 popular pasta types that people purchase and consume globally, spaghetti ranks at number 1, as the most frequently cooked pasta worldwide whilst macaroni ranks at number 4 (CBS 2021). Therefore, South Africa needs to make a shift in removing the negative stigma connected with carbohydrate foods, as this will be essential for future progress in grain and cereal consumption, enabling healthier choices (Foster *et al.* 2020: 2170).

Table 4.3: Binomial test on starch food frequency consumption (n= 94)

Item	Frequency (%)		p-value
	Yes	No	
Rice, White parboiled	40 (43)	54 (57)	.180[a]
Rice, Brown	11 (12)	83 (88) *	.000[a]
Rice, Basmati	26 (28)	68 (72) *	.000[a]
Rice, Other	7 (7)	87 (93) *	.000[a]
Maize, Phutu	26 (28)	68 (72) *	.000[a]
Maize, Pap	18 (19)	76 (81) *	.000[a]
Maize, Samp	13 (14)	81 (86) *	.000[a]
Maize, Porridge	14 (15)	80 (85) *	.000[a]
Mealie Rice	4 (4)	90 (96) *	.000[a]
Maize, Sweetcorn	11(12)	83 (88) *	.000[a]
Maize, Corn on the Cob	10 (11)	84 (89) *	.000[a]
Maize, Other	3 (3)	91 (97) *	.000[a]
Pasta, Macaroni	24(26)	70 (74) *	.000[a]
Pasta, Spaghetti	18(19)	76 (81) *	.000[a]
Pasta, Noodles	14(15)	80 (85) *	.000[a]

Item	Frequency (%)		p-value
	Yes	No	
Pasta, Other	2(2)	92 (98) *	.000[a]
Bread, White	34(36)	60 (64) *	.000[a]
Bread, Brown	46(49)	48 (51)	.000[a]
Bread, Wholewheat	15(16)	79 (84) *	.000[a]
Bread, Roti	18(19)	76 (81) *	.000[a]
Bread, Wraps	14(15)	80 (85) *	.000[a]
Bread, Vetkoek	9(10)	85 (90) *	.000[a]
Bread, Dumpling	4(4)	90 (96) *	.000[a]
Bread, Steam bread	10(11)	84 (89) *	.000[a]
Bread, Other	4(4)	90 (96) *	.000[a]
Roots & Tubers, Potatoes	60(64)	34 (36)	.010[a]
Roots & Tubers, Yams	3(3)	91 (97) *	.000[a]
Roots & Tubers, Sweet Potato	16(17)	78 (83) *	.000[a]
Roots & Tubers Cassava	2(2)	92 (98) *	.000[a]
Roots & Tubers, Other	2(2)	92 (98) *	.000[a]

* Indicates significance at the 95% level

The binomial test showed that a significant 64% of participants ate potatoes in the previous seven days (p=.010) (Table 4.3). Potatoes have gained popularity over time as a widely obtainable and available starch in many convenient pre-packaged options for the consumer. On the other hand, the SFFQ reflected that a significant number of participants did not eat many starches like cassava, yams, corn on the cob and sweet potato, due to availability, seasonal crop, price, awareness of product uses, food application, and cooking methods, little or no preparation intensity, and cultural acceptance. There is a marked shift towards convenience-based health and nutrition, and the convenience market is gathering new momentum as Generation Z swings into adulthood. Food trends based on cravings and comfort shifts food

consumption patterns, and this is concerning as they relate to increased fat, sugar and salt which have negative effects on health and wellness (Sterk 2020).

4.2.4 SENSORY ACCEPTABILITY AND PALATABILITY OF PAIRED MEALS WITH BROWN RICE

Objective 3: To determine the sensory acceptability and palatability of paired meals with brown rice by means of sensory analysis

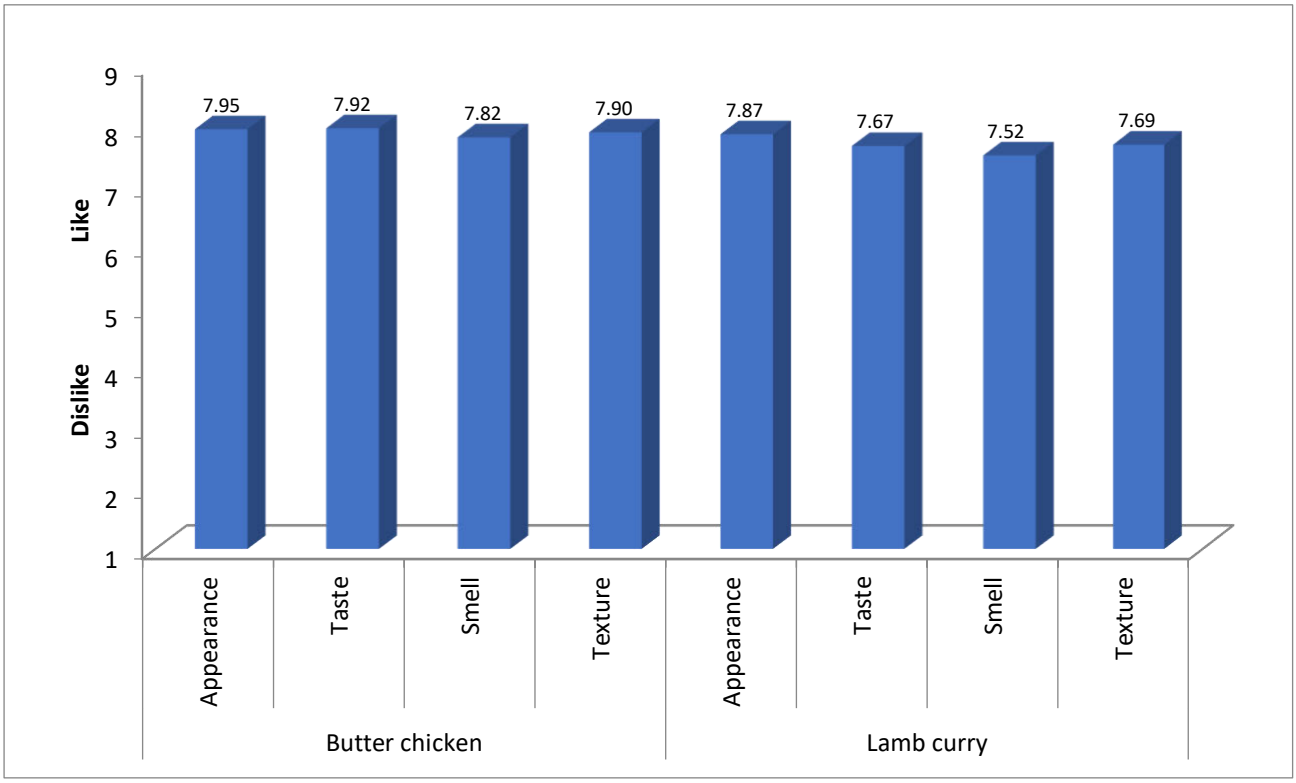

Figure 4.3: Sensory acceptability of paired meals (butter chicken and lamb curry) with brown rice

Butter chicken and lamb curry are two popular dishes selected from the many dishes prepared, following high sales figures of these menu items in the Rendezvous Restaurant at DUT. This restaurant which caters for both staff and students has high sales figures of these two menu items. Butter chicken and lamb curry were prepared according to the recipes provided by the restaurant and revised by the researcher and served with the brown rice. Participants completed the sensory evaluation of the paired meals on a 9-point hedonic scale (Figure 4.3). Sensory attributes comprising appearance, taste, smell, and texture were evaluated. The sensory evaluation of butter chicken paired with brown rice showed that taste had the highest ranking of 7.97, followed by appearance at 7.95, texture at 7.90 and smell at 7.82. The sensory

evaluation of lamb curry paired with brown rice showed that appearance had the highest ranking at 7.87, followed by texture at 7.69, taste at 7.67 and smell at 7.52. Noteworthy, was the liking shown for butter chicken and lamb curry when examining all sensory attributes (appearance, taste, smell, and texture).

Table 4.4: Binomial test on sensory acceptability and palatability of paired meals with brown rice

	Item	Responses as Frequency (%)						n	Mean (SD)	t	df	p-value
		Dislike moderately	Dislike moderately	Neither like or dislike	Like slightly	Like very much	Like extremely					
BUTTER CHICKEN	Appearance	0	14 (23.30)	2 (3.30)	3 (5.0)	18 (30.0)	23 (38.30)	60	7.95 (1.06)	21.4	59	.000
	Taste	0	0	6 (10.20)	8 (13.50)	27 (45.80)	18 (30.50)	59	7.97 (0.92)	24.5	58	.000
	Smell	2 (3.30)	2 (3.30)	6 (10.0)	7 (11.60)	21 (35.0)	22 (36.70)	60	7.82 (1.30)	16.6	59	.000
	Texture	2 (3.39)	2 (3.39)	2 (3.39)	10 (16.95)	18 (30.51)	25 (42.37)	59	7.90 (1.42)	15.6	58	.000
LAMB CURRY	Appearance	1 (1.67)	2 (3.33)	3 (5.0)	12 (20.0)	21 (35.0)	21 (35.0)	60	7.87 (1.21)	18.2	59	.000
	Taste	1 (1.72)	2 (3.45)	3 (5.17)	15(25.86)	20 (34.48)	17 (29.31)	58	7.67 (1.36)	14.8	57	.000
	Smell	4 (6.67)	2 (3.33)	6 (10.0)	11(18.33)	20 (33.33)	17 (28.33)	60	7.52 (1.47)	13.1	59	.000
	Texture	2 (3.39)	1 (1.69)	7 (11.86)	11(18.64)	18 (30.51)	20 (33.90)	59	7.69 (1.39)	14.8	58	.000

The mean 'like' score was calculated and used in analysis to test for significant *like/dislike* of the food, according to the four sensory attributes: appearance, taste, smell and texture. Table 4.4.1 reflects the use of a one-sample t-test to test if the average score is significantly different from *neither like nor dislike*. For all sensory attributes for both butter chicken and lamb curry paired with brown rice, the results were significant, with all mean scores >5 (p =0.000). Both butter chicken and lamb curry are two distinctive, well-known, high in demand, sauce- based, liquid in consistency, one-pot menu items that are popular choices in KZN. The acceptance of these dishes is influenced by the predominant Indian culinary influence and foundational food culture in the province (South Africa 2021).

4.2.5 PREFERENCE OF BROWN RICE PREPARED USING VARIOUS COOKING METHODS

Objective 4: To determine the preference of brown rice prepared using various cooking methods through sensory analysis paired preference tests

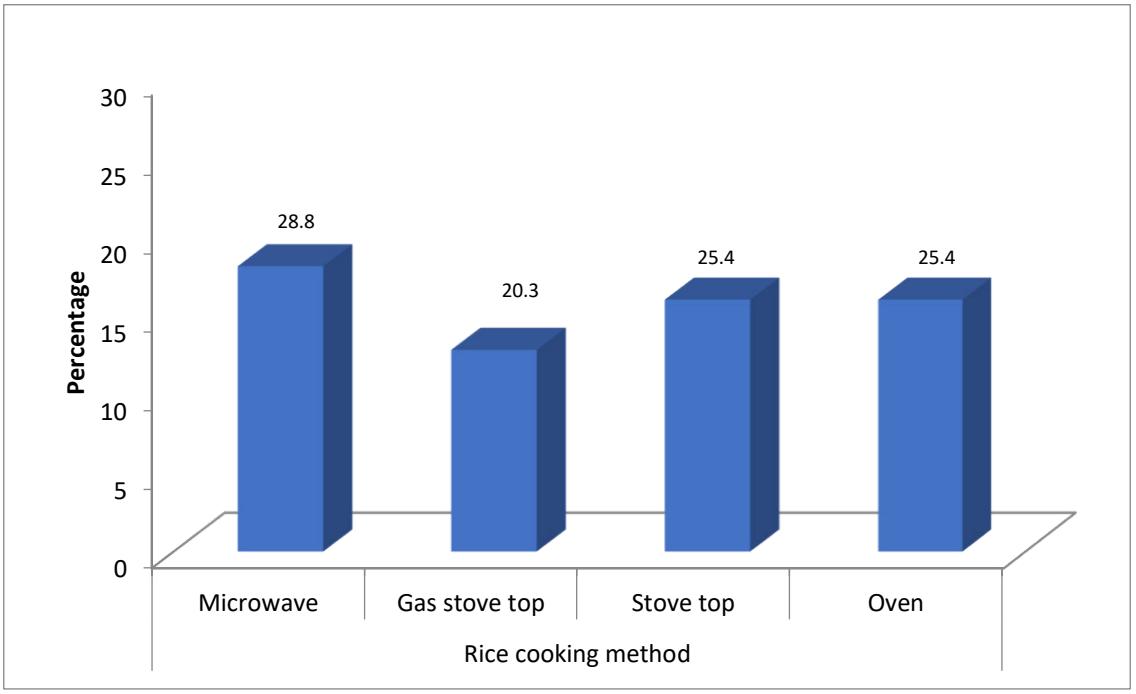

Figure 4.4: Preference of brown rice cooked using various cooking methods

Using the chi-square goodness-of-fit test to test if any cooking method was significantly preferred to others, the results showed that the four cooking methods were equally preferred (p=.834) (Figure 4.4). The brown rice prepared through microwave cooking indicated a slightly higher selection than the other methods (28.8%). A possible reason for this preference

was that the microwaved rice was moist, and the rice grain was moist, and in addition to no stirring, the starch grain was intact with the benefit of condensation in the microwave. It is a more popular mode of cooking, being a novel technological method of cooking, with added convenience and speed for the working individual (Shaheen *et al.* 2012). From a convenience point of view, this method of cooking requires limited cooking resources with reduced clean-up and need to oversee the process once the cooking times are established. The brown rice cooked on the conventional stove top and gas top was selected by 25.4 % of participants, respectively. Gas cooking is a relatively newer method of cooking in most households, but there is a noted increase in gas cooking due to the unpredictability of electricity load shedding in the country. The stove top and gas top cooking methods resulted in a less moist, cooked rice grain, possibly due to more evaporation of moisture from an open pot. All four methods of cooking the brown rice used the manufacturers instruction with guidance from by the researcher.

4.2.6 ANTHROPOMETRIC STATUS

Objective 5: To determine the anthropometric status of participants

Table 4.5: Mean weight, height, and waist circumference of participant

	Weight (kg) (SD) (n =58)	Height (cm) (SD) (n=59)	WC (cm) (SD) (n=51)
Women	75.15 (17.96)	1.60 (0.66)	87.56 (15.33)
	Weight (kg) (SD) (n =30)	**Height (cm) (SD) (n=30)**	**WC (cm) (SD) (n=24)**
Men	82.01 (14.74)	1.71 (0.75)	95.33 (13.16)

Table 4.5 represents the mean weight, height and WC of the participants. The women (n=58) recorded a mean weight of 75.15 kg (17.96); the men (n=30) displayed a higher mean weight of 82.01kg (14.74). The mean height of women participants (n=59) was 1.60 m (0.66), and for men it was 1.71m (0.75) (n=30). The recommended weight of women at 1.60 m is 64 kg and the difference are 11.15 kg/14.84%; for men at 1.71m, it is 70.00 kg, and the difference is (12.01kg/14.64 %).

The mean WC for women (n=51) was 87.56cm and for men (n=24) was 95.33cm; the difference between men and women regarding their waist circumference 7.77cm. According to the World Health Organisation (WHO 2021a), the frequency of metabolic syndrome among men and women using the new cut-off points is validated using WC cut-off points (≥ 94 cm in men and ≥ 80 cm in women). A high WC places men and woman at a greater risk of diseases and WC is a reliable predictor of adverse cardiovascular and metabolic outcomes of obesity. Alarmingly, the findings of the mean WC for both men and women in this study are higher than the recommended WC cut-off points.

Anthropometric measurements signify diagnostic norms for obesity, which pointedly raises the risk for cardiovascular disease, hypertension, diabetes mellitus, and other metabolic syndrome conditions. Moreover, anthropometric measurements are used as a baseline for physical fitness and nutritional status guide.

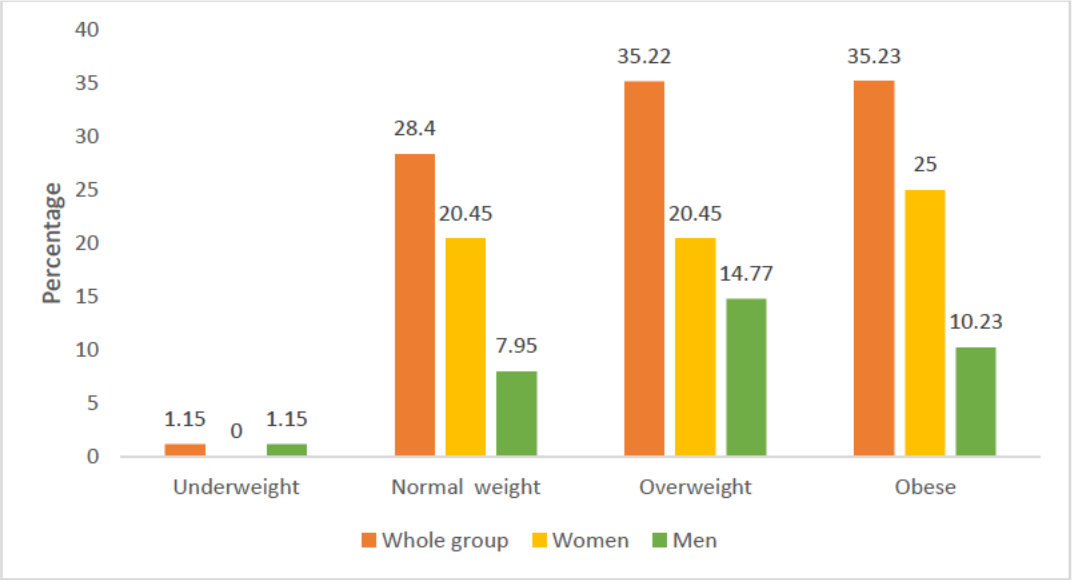

Figure 4.5: BMI classification for the whole group, men and women (n=88)

The data reflected in Figure 4.5 illustrates the BMI results for the whole group (n= 88), of women (n=58) and men (n=30). Six participants declined to have their weight, height or WC measurements taken. From the whole group, one participant was underweight (1.15%), 28.4% (n=25) participants were normal weight, 35.22% (n=31) were overweight, and 35.23% (n=31) were obese. No women were underweight; 20.45% women were normal weight (n=18) and overweight (n=18), respectively, and 25% (n=22) were overweight. One man was underweight (1.15%), 7.95% (n=7) men were normal weight, 14.77% (n=13) were overweight, and 10.23% (n=9) were obese, from the total sample size.

According to the WHO (2018), the cut-offs for the BMI range are underweight <18.50 kg/m^2, normal weight 18.50-24.99 kg/m^2, overweight ≥ 25 kg/m^2, and obese ≥ 30 kg/m^2. According to Weir and Jan (2020), the crucial topic of concern in respect to BMI includes the growing connection between the obesity epidemic and the growing population with high BMI statistics. Obesity is associated with changeable behaviours, including a sedentary lifestyle and increased caloric consumption. Conditions related to overweight, and obesity include premature death, cardiovascular diseases, high blood pressure, osteoarthritis, cancer and diabetes. Thus, a higher BMI and the correlation between waist circumference and body fat range strongly indicate a higher risk of disease and death in individuals (Weir and Jan:2020).

4.2.7 PRE-PRANDIAL AND POST-PRANDIAL BLOOD GLUCOSE LEVEL

Objective 6: To determine the fasting pre-prandial blood glucose level and the 2-hour post-prandial blood glucose level of participants after consuming a brown breakfast rice of either egg rice or muesli rice

Table 4.6: Pre-prandial and post-prandial bloods

	Whole group Mean mmol/L (SD)	Men Mean mmol/L (SD)	Women Mean mmol/L (SD)
Pre-blood (n=60)	5.54 (1.001)	5.75 (0.679)	5.50 (1.082)
Post-blood (n=60)	5.45 (0.565)	5.65 (0.582)	5.37 (0.536)

Analysis was done to test for significant change in blood pre-prandial to post-prandial eating. The mean value for pre-blood (n=60) was 5.549 mmol/L and the post-blood was (n=60) 5.458 mmol/L (Table 4.6). Analysis from a Wilcoxon signed ranks test showed that there was no significant difference in blood pre to post eating, (p=.771). Analysis using a paired t-test shows that there was no significant difference in blood values before and after eating, (p=.431), meaning that blood glucose levels were maintained after consuming the brown rice breakfast. This study sample comprised non-diabetics, people whose blood sugar should return to a normal range within 1-2 hours after eating, between 4.0 to 5.4 mmol/L, and a pre-prandial plasma glucose reading is 4.0 to 6.0 mmol/L because of the effect of insulin. In a non-diabetic,

blood sugar levels characteristically do not rise as high as people with diabetes, as insulin is directly carried into their circulatory system while eating is taking place (Gdanietz 2018). In summary, there were no notable changes in the fasting pre- and post- blood glucose levels after the participants consumed a breakfast of brown egg rice or brown muesli rice. The findings of this result indicate the healthful benefits of brown rice, as it is widely evidenced in existing literature that brown rice reduces insulin spikes and aids in the stabilisation of the body's blood sugar levels due to its low glycaemic index. Testing of pre- and post-prandial blood is an important tool to manage blood glucose levels among prediabetics and one can adjust accordingly with dietary modification.

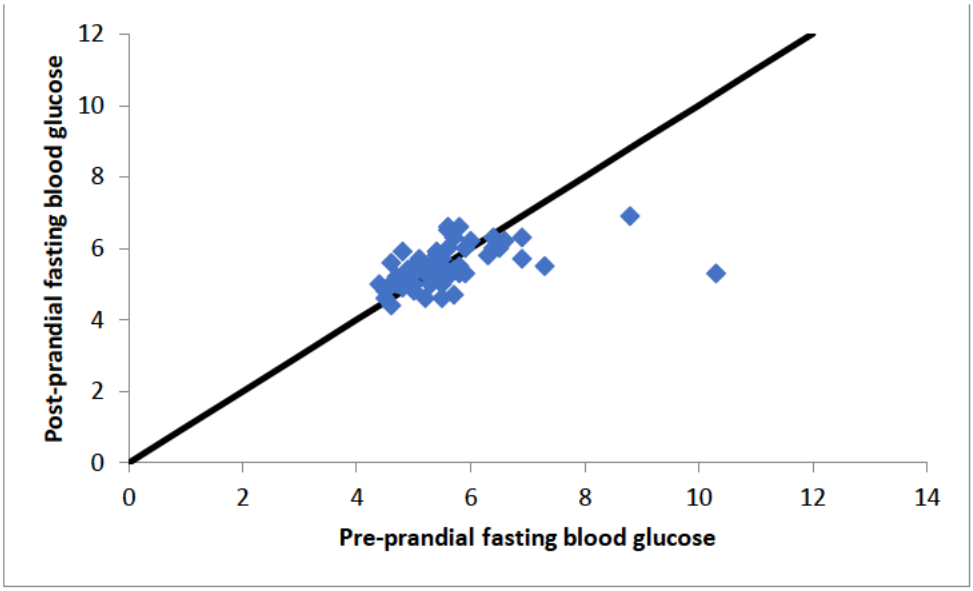

Figure 4.6: Pre-prandial and post-prandial blood scores

Figure 4.6 shows pre-prandial and post-prandial blood scores of the participants. Those below the black line indicate the subjects for which pre-scores greater than post scores (Figure 4.6). Those above the line indicate pre-scores less than post scores. Those on the line show no significant change; they float around the line, further confirming that the results have no significant change and that no pre- to post-shift has occurred. A few values appear scattered below the line, indicating low significance to prove the drop-in blood glucose after consuming a brown rice breakfast meal.

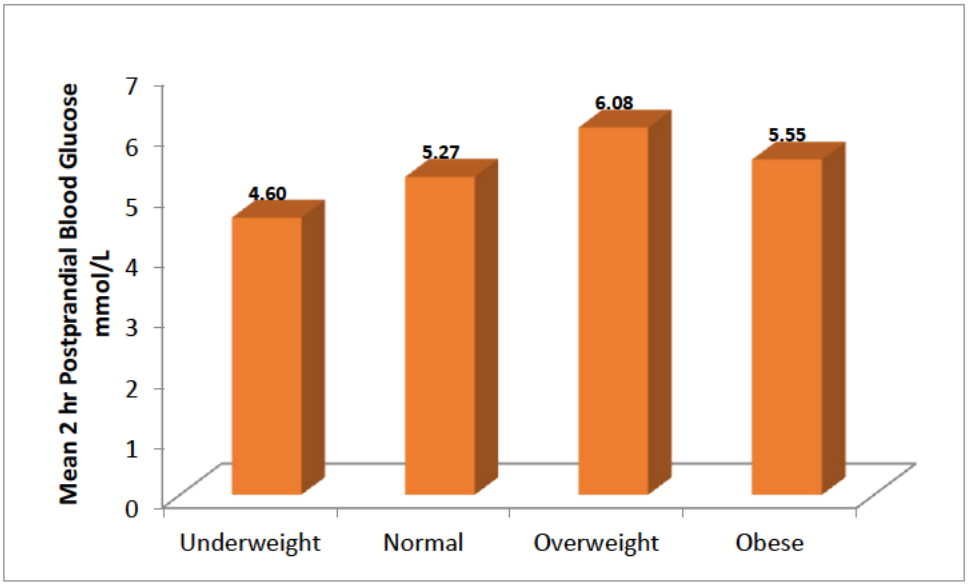

Figure: 4.7: Relationship between BMI and the mean 2-hour post-prandial blood glucose

No significant differences in post blood were found across the BMI categories, F (3, 51) = .970, p=.414 (Figure 4.7). Excluding the one person with the high value, the following means (mmol/L), 4.6, 5.2, 5.5, 5.5, 5.4, were noted. No significant differences in post-blood was found across the BMI categories, with F (3, 50) = 1.961, and p=.132. The glycaemic alternations in the non-diabetic population are closely controlled by physiological factors. Dietary aspects also influence glycaemic breaks, especially during the post-prandial period. Therefore, dietary interventions signify an imperative approach to reduce these fluctuations and improve post-prandial glycemia (Rodríguez *et al.* 2019).

Table 4.7: Pearson's Correlation between waist circumference and the mean 2-hour post-prandial blood glucose

		WC	Post-prandial blood
WC (cm)	Pearson Correlation	1	.365*
	Sig. (2-tailed)		.011
	N	48	48
Post-prandial blood	Pearson Correlation	.365*	1
	Sig. (2-tailed)	.011	
	N	48	60

*. Correlation is significant at the 0.05 level (2-tailed)

There was a significant moderate positive correlation (r=.365) between WC and post-blood scores, p=.011 (Table 4.7). This may be linked to the fact that many white-collar employees have reduced their activities to more restricted deskbound tasks and working online from home during the current corona virus pandemic, and the lack of physical activity due to over 10 months of lockdown restrictions, where many social and recreational facilities have not been available for use (Füzéki *et al.* 2020). Current physical activity recommendations advise the general population to engage in 150–300 minutes of moderate or 75–150 minutes of vigorous physical activity weekly (Füzéki *et al.* 2020). Therefore, it is essential for community knowledge and awareness programs to be facilitated for people to decrease waist circumference, and consequently reduce body weight to prevent the development of diabetes mellitus.

4.3 CONCLUSION

The objective of Chapter Four was to present and analyse the results of the study. This included a health status of staff at a university, using anthropometric data such as height, weight, waist circumference and pre- and post-prandial glucose levels, as an appropriate measure to the physical status of the study sample. In Chapter Five, conclusive interventions and discussion will be presented with recommendations based on the relevant results gathered in this chapter.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter draws conclusions from the core results and findings in Chapter Four and the relevant literature reviewed in Chapter Two of the study and will subsequently articulate conceivable recommendations. The strengths, limitations and recommendations are also discussed to support and provide guidance for impending studies and planned intervention strategies within this field of research.

5.2 SUMMARY OF FINDINGS

The summary of findings is presented according to the specific objectives of the study.

Objective 1: To explore barriers and facilitators of brown rice consumption among participants through focus group discussions

The outcome of the qualitative approach to the FGD was an important foundational tool to explore the available barriers and facilitators and for brown rice consumption. The FGDs created an opportunity to discover and share a wide range of ideas and suggestions that link the research problems and findings. Data analysis revealed five broad themes: perceptions of healthy and unhealthy foods; factors that determine food choice; factors that influence rice choice; barriers and enablers of including brown rice in the diet.

Objective 2: To assess the starch food intake of participants through a starch food frequency questionnaire

The starch food frequency questionnaire (SFFQ) was adapted and piloted from the FFQ, and then administered to participants, to be used as a dietary instrument to reflect starch food behaviour patterns and to measure frequency of starch consumption. The SFFQ was conducted among 94 DUT employees. The starch reported to be consumed by most participants starch was potatoes at 63.8%, brown bread at 48.9% and parboiled rice at 42.1%. Brown rice featured at 11.7%.

Objective 3: To determine the sensory acceptability and palatability of paired meals with brown rice by means of sensory analysis

The paired meals prepared in this study were butter chicken and lamb curry, two popular dishes, that were selected from the Rendezvous Restaurant menu at DUT. A strong liking was shown for both these paired meals when examining all sensory attributes (appearance, taste, smell and texture*)* with brown rice. Paired meals go back to early culinary practices in history, from traditional staples of rice and dhal in India, red beans and rice in Spanish cuisine, and samp and beans in South Africa. Familiar food pairings can elevate health benefits and enhance the eating experience of people. In this case, the two popular dishes butter chicken and lamb curry, normally paired with white rice, were found to be suitable when paired with 12.5 g of cooked brown rice for the sample tasting, thus increasing the likelihood for acceptance of the accompanying starch.

Objective 4: To determine the preferred cooking method of brown rice through sensory analysis

Four different cooking methods were used, namely, stove top, gas, microwave and oven. The highest-ranking result was the preference for microwave cooking; the oven method of cooking resulted in a risotto style dish that was texturally more acceptable with the participants, which may be attributed to the dry cooking technique, where the moisture is retained in the rice grain, thereby creating a nuttier, crunchy texture, which contributes to the sensory properties of brown rice.

Objective 5: To determine the anthropometric status of participants

The anthropometric status denotes the mean weight, height and WC of the participants in this study. The findings of the mean WC for both men and women were higher than the recommended WC cut-off points recommended by WHO (2011). The anthropometric status in this study denotes that a high WC places men and woman at a greater risk of diseases and WC is a reliable predictor of adverse cardiovascular and metabolic outcomes of obesity. The mean WC for women (n=51) was 87.56cm and for men (n = 24), 95.33cm; the difference between men and women regarding their waist circumference was 7.77cm. The findings of the mean WC for both men and women in this study were higher than the recommended WC cut-off points. The results for the BMI for women (n = 58) and men (n = 30). Six participants declined to be measured or share their weight, height or WC measurements. One participant was underweight (1.15%), 28.4% (n = 25) participants were normal weight, 35.22% (n=31)

participants were overweight, and 35.23% (n = 31) participants were obese. Cardiometabolic diseases is known to be the leading cause of death in the world. Participants who are at risk include those with cardiovascular disease, diabetes mellitus and chronic renal failure. Cardiometabolic diseases is primarily caused by an unhealthy lifestyle, and the major risk factors are physical inactivity, smoking and an unhealthy diet.

Objective 6: To determine the fasting pre-prandial blood glucose level and the 2-hour post-prandial blood glucose level of participants after consuming a paired meal with brown rice

The analysis was conducted to test for significant change in pre- and post-prandial blood after eating a breakfast meal. No significance was noted; however, the mean pre-prandial was 5.54 (1.001) and mean post-prandial was 5.45 (0.565), which shows that the blood glucose levels was maintained after eating brown rice, with no rise and fall in the glucose levels of the participants. The normal blood sugar levels in a healthy person are between 4.0 to 5.4 mmol/L (72 to 99 mg/dL) and when fasting, up to 7.8 mmol/L (140 mg/dL), 2 hours after eating. Testing of pre- and post-prandial blood is an important tool to manage blood glucose levels and one can adjust accordingly with dietary modification or medication.

5.3 LIMITATIONS OF THE STUDY

- The COVID-19 restriction was an unpredicted limitation to the study, which impacted on the data collection process as the study participants resorted to working remotely in response to the lockdown levels.
- Another COVID-19 induced limitation (Appendix T) was that participants who commenced the study at stage one in the FGDs, were unable to progress to all the stages of the study because of the shift to blended teaching and learning, and staff working flexi-hours, having comorbidities, being in the over 60-age group (some left the study), and being unavailable on campus.
- The number of men in the study was not equitable to the women, so the researcher had to send out many requests for male members of staff to join the study sample. Recruitment of more male participants in the study was done on the DUT intranet noticeboard, email, WhatsApp® and Facebook®
- The exclusive use of brown rice without a white rice control.
- The exclusion of vegetarians, non-rice consumers and diabetics from the study was noted.
- Only four methods of cooking were investigated.

- Some participants exercised their ethical options and chose not to participate in all aspects of the study: for example, with respect to disclosure of BMI, weight, age or consenting to the pre- and post-blood draw.
- The meal pairing was done exclusively with brown rice. Using white rice as control could produce different results.

5.4 STRENGTHS OF THE STUDY

- COVID-19 protocols were successfully followed and implemented in all aspects of the study.
- The SFFQ was adapted from the FFQ and piloted, which proved to be a valuable tool for starch data collection.
- All four recipes in this study were first piloted for acceptability and prepared in the Masters Food Laboratory.
- The third FGD was conducted successfully online using MS Teams. This took place during the peak of the first national lockdown. The researcher and supervisors adapted training materials for the online FGD, and the full research team was present for the online session.
- There were many follow-up requests for the two recipes used in the paired brown rice sensory evaluations, as well as for the two the breakfast rice recipes.
- Many participants also requested more recipe solutions to substitute brown rice for white rice.
- The possibility of increased availability and accessibly with brown rice marketing and promotional campaigns was noted.
- This study provided a window into the starch preferences of staff at a university.

5.5 RECOMMENDATIONS

- The health benefits associated with brown rice consumption as outlined in this research, warrant further research on the acceptance of brown rice among consumers in South Africa.
- Studies should also be conducted to determine the impact that the marketing and promotion of brown rice can have on the acceptance of brown rice.

- Brown rice consumption should be encouraged through targeted community and school awareness campaigns and via school feeding schemes, to stimulate a smoother acceptability and transition from white rice to brown rice consumption.
- Brown rice can be introduced at workplace canteen interventions, as part of a targeted approach to lower blood glucose levels.
- The agricultural sector should become proactive in consumer support and cooperation-programs in rice production.
- The consumption of brown rice should be encouraged by compiling a brown rice recipe booklet with other paired meals and added rice uses, including recipes that incorporate germinated brown rice (GBR).
- The findings of this study should be reported to key stakeholders, including government and industry.
- Various media platforms should be engaged to change the outlook of the consumer on brown rice, including National health programs, nutrition societies and mass media communications.
- Suppliers and manufacturers of brown rice should be encouraged to include on-pack recipes, and serving suggestions for brown rice, to encourage higher consumer buy-in.
- There should be a reduction in the cost of brown rice, with industry and government collaboration towards long term health promotion in South Africa.

5.6 CONCLUSION

The results of the study clearly emphasize the necessity for additional research to build on the current body of evidence. Initiatives to simultaneously increase demand while removing barriers to brown rice consumption will enable the mainstreaming of brown rice into the diets of South Africans. The study recommends that there should be a collective effort by all stakeholders to successfully facilitate the transition from white rice to brown rice, in so that the health benefits of brown rice can be fully appreciated.

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LIST OF APPENDICES

Appendix A: Letters requesting Gatekeeper and Head of Department Permission

A. Gatekeeper Letter
Directorate for Research and Postgraduate Support

Permission to Conduct Research at DUT

Dear XXX

My name is Anjellah Reddy a staff member at DUT in the Department of Food and Nutrition. I am hereby seeking consent to conduct research to determine the acceptability, appropriateness and feasibility of brown rice consumption at a university in South Africa.

I have attached supporting documentation, which includes the proposal, copies of the data collection tools, letter of information and consent forms to be used in the research process and a copy of the approval letter from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me on ext. 2372 anjellahr@dut.ac.za Thank you for your time and consideration in this matter.

Yours sincerely,

Anjellah Reddy

……

B. Letter to HOD

HOD Food and Nutrition
Dr H. Grobbelaar

Permission to Conduct Research in the Department of Food and Nutrition

Dear Dr H. Grobbelaar

I am hereby seeking consent to conduct research to determine the acceptability, appropriateness and feasibility of brown rice consumption at a university in South Africa

I have attached supporting documentation, which includes the proposal, copies of the data collection tools, letter of information and consent forms to be used in the research process and a copy of the approval letter from the Institutional Research Ethics Committee (IREC). I request permission to use a venue in the Department of Food and Nutrition to conduct the focus group discussions, sensory analysis and clinical measurements.

If you require any further information, please do not hesitate to contact me. Thank you for your time and consideration in this matter.

Yours sincerely,

Anjellah Reddy

Appendix B: Staff Intranet Recruitment Advert

Dear Staff,

I am seeking research study participants for a brown rice research study. The purpose of this research study is to explore the acceptability, appropriateness and feasibility of brown rice consumption to lower blood glucose levels among staff at DUT. The first part of the study involves focus group discussions on the barriers and facilitators of brown rice consumption. For this we require 30 participants. The second part of the study involves sensory analysis of brown rice meals and bio clinical measurements and for this I require a total of 60 participants. You can decide to be part of both parts of the study or just the first part.

TO PARTICIPATE IN THIS RESEARCH STUDY, YOU MUST:

- ✓ Be a permanent or contract staff member
- ✓ Eat rice
- ✓ Non-vegetarian
- ✓ Non-diabetic

NOTE: PARTICIPATION IN THIS STUDY DISCUSSION INVOLVE A TIME COMMITMENT OF TWO HOURS

For more information about this study, please contact Anjellah Reddy:

Phone: 0824650137\ 031-373 2372

Email: anjellahr@dut.ac.za

Appendix C: Flyer

SEEKING FOCUS GROUP DISCUSSION VOLUNTEERS FOR A RESEARCH STUDY

The purpose of this research study is to explore
the acceptability, appropriateness and feasibility of brown rice consumption to lower blood glucose levels among staff at DUT

TO PARTICIPATE IN THIS RESEARCH STUDY, YOU MUST:

- ✓ **Be a permanent or contract staff member who:**
- ✓ **eats rice regular**
- ✓ **is not a vegetarian**
- ✓ **has not been diagnosed as a diabetic**

NOTE: PARTICIPATION IN THIS STUDY DISCUSSION INVOLVES A TIME COMMITMENT OF ONE HOUR

For more information about this study, please contact Anjellah Reddy:
Phone: 0824650137\ 031-373 2372
Email: anjellahr@dut.ac.za

Research Study: FGD Contact: Anjellah
Research Study: FGD
Research Study: FGD Contact: Anjellah
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Research Study: FGD Contact: Anjellah

Appendix D: Letter of Information (FGDs)

LETTER OF INFORMATION (FGD)

Title of the Research Study: Acceptability, appropriateness and feasibility of brown rice consumption to lower blood glucose levels among staff at a university

Principal Investigator/s/researcher: Anjellah Reddy

Co-Investigator/s/supervisor/s: Ashika Naicker /Evonne Singh

Brief Introduction and Purpose of the Study:
The aim of the study is to determine the acceptability, appropriateness and feasibility of brown rice consumption, to lower blood glucose levels among staff at DUT. Given that the prevalence of lifestyle diseases has increased alarmingly in South Africa and the quality of diet has a large impact on this prevalence, measures to modify diet are sought such as increasing the consumption of unrefined cereals. White rice remains a staple in South Africa after maize, but little is known about why brown rice consumption has not taken off in South Africa despite its numerous health benefits. The purpose of this research is to determine barriers and facilitators of brown rice consumption, the sensory acceptability of brown rice paired with typical South African dishes and its effect on blood glucose levels among staff at DUT.

Outline of the Procedures:
The study will use a mixed methods approach; the first part of the study involves qualitative methods to assess the barriers and facilitators of consuming brown rice through focus group discussions (FGDs). The FGDs will assess your current thoughts and feelings about the facilitators and barriers of eating brown rice. You will be required to sign a consent form should you wish to take part in the FGD. FGDs will take place at a venue in the Department of Food and Nutrition at a mutually agreed time and date by all participants. The FGD should not take up more than 1hour of your time. You will be recorded via the use of a tape recorder for recollection purposes only.

Risks or Discomforts to the Participant:
There will be no risk or discomfort to you in participating in the FGD.

Benefits:
The outcome of this study can lead to the promotion of brown rice which would impact positively on the South African diet. This study will result in the completion of a Masters in Applied Science Consumer Science: Food and Nutrition. The research project will be measured scientifically, presented at conferences, and published in accredited journals.

Reason/s why the Participant May Be Withdrawn from the Study:
Withdrawal from the study is optional at any time if you feel the need to.

Remuneration:

You will be asked to participate voluntarily and there will be no financial gain.

Costs of the Study:
No costs will be expected to be covered by you if you choose to volunteer to participate in the FGD.

Confidentiality
Ongoing informed consent will be collected from you at each stage of data collection. You will be given a letter of information and consent will be sought for your participation FGD.

Research-related Injury:
The FGD is of such, where is there is no room for any possible injury.

Persons to Contact in the Event of Any Problems or Queries:
(Supervisor and details) Please contact the researcher (tel no.), my supervisor (tel no.) or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

Appendix E: Informed Consent

CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, _____ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: _____,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

_____	_____	_____	_____
Full Name of Participant	**Date**	**Time**	**Signatur**

Appendix F: Focus Group Demographic Details Questionnaire

FOCUS GROUP: DEMOGRAPHIC DETAILS QUESTIONNAIRE: STAFF

Please answer the following questions in the spaces provided, circle or tick the most appropriate options.

1. Age_____
2. Are you: (please tick as necessary) □ Male □ Female
3. What is your job title? _____
4. How many years of experience have you had in this current job?
   - □ <1 Year □ 1-2 Years
   - □ 2-5 Years □ 5-10 Years
   - □ >10 Years

Thank you for taking the time to complete this questionnaire

Appendix G: Focus Group Discussion Guide

FOCUS GROUP: DISCUSSION GUIDE

Welcome and thank you for volunteering to take part in this focus group. You have been asked to participate as your point of view is important. I realize you are busy and I appreciate your time.

Introduction: This focus group discussion is designed to assess your current thoughts and feelings about the facilitators and barriers of eating brown rice. The focus group discussion will take no more than one hour. May I tape the discussion to facilitate its recollection? (if yes, switch on the recorder)

Anonymity: Despite being taped; I would like to assure you that the discussion will be anonymous. The tapes will be kept safely in a locked facility until they are transcribed word for word, then they will be destroyed. The transcribed notes of the focus group will contain no information that would allow individual subjects to be linked to specific statements. You should try to answer and comment as accurately and truthfully as possible. I and the other focus group participants would appreciate it if you would refrain from discussing the comments of other group members outside the focus group. If there are any questions or discussions that you do not wish to answer or participate in, you do not have to do so; however please try to answer and be as involved as possible.

Ground rules

- The most important rule is that only one person speaks at a time. There may be a temptation to jump in when someone is talking but please wait until they have finished.
- There are no right or wrong answers.
- You do not have to speak in any particular order.
- When you do have something to say, please do so. There are many of you in the group and it is important that I obtain the views of each of you.
- You do not have to agree with the views of other people in the group.
- Does anyone have any questions? (answers).
- OK, let's begin.

Warm up

- First, I'd like everyone to introduce themselves. Can you tell us your name?

Introductory question

I am just going to give you a few minutes to think about your perceptions of eating brown rice.

Guiding questions

- What do you understand by healthy foods?
- What do you understand by unhealthy foods?
- What are the factors that determine your food choice?
- What facilitates you to choose healthy food?
- What obstructs you form choosing healthy food?
- Which type of rice do you and your families frequently eat? Why?
- What type of qualities you would look for when you buy rice?
- What do you think of brown rice?
- Why do you think people prefer white rice rather than brown rice?

- If I were to tell you that there are several scientific studies show that eating brown rice is healthier than eating white rice, would you replace white rice with brown rice? Why or why not?
- What factors would influence your willingness to change from white rice to brown rice?
- What suggestions do you have to make brown rice more appealing to people?

Concluding question

- Of all the things we've discussed today, what would you say are the most important issues you would like to express about this checklist?

Conclusion

- Thank you for participating. This has been a very successful discussion
- Your opinions will be a valuable asset to the study
- We hope you have found the discussion interesting
- If there is anything you are unhappy with or wish to complain about, please contact the local PI or speak to me later
- I would like to remind you that any comments featuring in this report will be anonymous
- Before you leave, please hand in your completed personal details questionnaire

[Stop the recorder].

Appendix H: Starch Food Frequency Questionnaire

STARCH FOOD FREQUENCY QUESTIONAIRE

PLEASE INDICATE STARCH FOODS YOU ATE DURING THE PAST SEVEN (7) DAYS BY AN (X)

GROUP: CEREALS, ROOTS AND TUBERS DIVERSITY	Y	N
RICE:		
Parboiled		
Brown		
Basmati		
Any other variety		
MAIZE:		
Phutu		
Pap		
Samp		
Porridge		
Mealie rice		
Sweet corn		
Corn on the cob		
Any other variety		
PASTA:		
Macaroni		
Spaghetti		
Noodles		
Any other variety		
WHEAT BREAD:		
White		
Brown		
Whole wheat		
Roti		
Wraps		
Vetkoek		
Dumpling		
Steamed bread		
Any other variety		
ROOTS, TUBERS:		
Potatoes		
Yams		
Sweet Potato		
Cassava		
Any other variety		

Appendix I: Letter of Information (Sensory and Bio Clinical Tests)

LETTER OF INFORMATION (Sensory and bio clinical tests)

Title of the Research Study: Acceptability, appropriateness and feasibility of brown rice consumption to lower blood glucose levels among staff at a university

Principal Investigator/s/researcher: Anjellah Reddy

Co-Investigator/s/supervisor/s: Ashika Naicker /Evonne Singh

Brief Introduction and Purpose of the Study:
The aim of the study is to determine the acceptability, appropriateness and feasibility of brown rice consumption, to lower blood glucose levels among staff at DUT. Given that the prevalence of lifestyle diseases has increased alarmingly in South Africa and the quality of diet has a large impact on this prevalence, measures to modify diet are sought such as increasing the consumption of unrefined cereals. White rice remains a staple in South Africa after maize, but little is known about why brown rice consumption has not taken off in South Africa despite its numerous health benefits. The purpose of this research is to determine barriers and facilitators of brown rice consumption, the sensory acceptability of brown rice paired with typical South African dishes and its effect on blood glucose levels among staff at DUT.

Outline of the Procedures:
The study will use a mixed methods approach; the second part of the study involves quantitative methods to assess sensory acceptability, appropriateness and palatability of paired meals with brown rice, sensory acceptability of brown rice cooked using various methods and anthropometric and clinical measurements of participants. The study will be explained to you in detail before sensory analysis, anthropometric and clinical measurements takes place. You will to be required to sign a consent form agreeing to take part in the study on a voluntarily basis. For the sensory acceptability, appropriateness and palatability of paired meals with brown rice and the sensory acceptability of brown rice cooked using various methods you will be given the food product to taste on three possible designated dates at the Department of Food and Nutrition Research laboratory. This will take you no more than 30 minutes to evaluate. During the sensory evaluation you will be required to complete a starch food frequency questionnaire. Once the sensory analysis is complete you will be required to undergo an overnight fast and will be expected to report to Food and Nutrition Research Laboratory for a fasting finger prick blood glucose test from 7:00 to 8:00 am. Your height, weight and waist circumference will be measured at this session as well. Thereafter, you will be given a brown rice breakfast and then after two hours will be required to report back for a post prandial finger prick test.

Risks or Discomforts to the Participant:
There will be no risk or discomfort to you in participating in the sensory analysis and anthropometric measurements. Minimal discomfort is expected from the finger prick fasting blood glucose test which will be administered by a registered nurse.

Benefits:
The outcome of this study can lead to the promotion of brown rice which would impact positively on the South African diet in particular on blood glucose levels. This study will result in the completion of a

Masters in Applied Science Consumer Science: Food and Nutrition. The research project will be measured scientifically, presented at conferences, and published in accredited journals.

Reason/s why the Participant May Be Withdrawn from the Study:
Withdrawal from the study is optional at any time if you feel the need to.

Remuneration:
You will be asked to participate voluntarily and there will be no financial gain.

Costs of the Study:
No costs will be expected to be covered by you if you choose to volunteer to participate in the study.

Confidentiality
Ongoing informed consent will be collected from you at each stage of data collection. You will be given a letter of information and consent will be sought for your participation in the sensory analysis, anthropometric and clinical measurements.

Research-related Injury:
The the sensory analysis, anthropometric and clinical measurements is of such, where is there is no room for any possible injury.

Persons to Contact in the Event of Any Problems or Queries:
(Supervisor and details) Please contact the researcher (tel no.), my supervisor (tel no.) or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

Appendix J: Paired Preference Sensory Test

PERSONAL DATA

GENDER

MALE		**FEMALE**	

AGE

20 -30		**31-40**		**41-50**		**51-60**		**61-65**	

In front of you there are four brown rice samples with different codes. Taste all four samples. Which sample do you prefer overall?

154	**267**	**382**	**461**	**No preference**

Thank you for your participation!"

Appendix K: Sensory Evaluation and validated 9-Point Hedonic Scale

PERSONAL DATA

GENDER

MALE		**FEMALE**	

AGE

20 -30		**31-40**		**41-50**		**51-60**		**61-65**	

In front of you is a coded sample. Taste the sample and tick how much you like or dislike it. You can taste the sample more than once.

	Appearance	Taste/Flavour	Smell/Odour	Texture
Like extremely				
Like very much				
Like moderately				
Like slightly				
Neither like nor dislike				
Dislike slightly				
Dislike moderately				
Dislike very much				
Dislike extremely				

Appendix L: Lamb Curry and Butter Chicken Photographs

Lamb Curry

Butter Chicken

Appendix M: Lamb Curry and Butter Chicken Recipes

Recipe: Lamb Curry

RECIPE/PRODUCT: Lamb Curry
NUMBER OF PORTIONS: 10
TOTAL RECIPE YIELD: 1.280 Kg
PORTION YIELD: 200g
COST PER PORTION: R18.74

QTY	UNIT	PERCENTAGE	INGREDIENT	STEP	METHOD
15	ml	1.17	Oil	1.	Heat oil in a pot.
40	g	3.13	Onions	2.	Sweat chopped onion.
2.5	g	0.20	Turmeric powder	3.	Add turmeric, garam masala and curry powder and stir.
2.5	g	0.20	Garam masala powder	4.	Add ginger and garlic paste, allow to simmer for 30 seconds.
2.5	g	0.20	Curry powder	5.	Add cubed lamb meat and stir well. Allow to cook for 30 minutes on medium heat.
2.5	g	0.20	Ginger and garlic paste	6.	Replenish with hot water to cook the meat till tender, a further 30 minutes.
1000	g	78.13	Lamb cubed	7.	Add tomato paste and salt, mix well and cook for an additional 5 minutes
150	g	11.72	Water-hot	8.	Garnish with coriander and serve hot.
30	g	2.3	Tomato - paste		
10	g	0.78	Salt		
25	g	1.96	Fresh coriander		

Recipe: Butter Chicken

RECIPE/PRODUCT: Butter Chicken
NUMBER OF PORTIONS: 10
TOTAL RECIPE YIELD: 1.110Kg
PORTION YIELD: 100g
COST PER PORTION: R 7.78

QTY	UNIT	PERCENTAGE	INGREDIENT	STEP	METHOD
25	ml	2.23	Oil/butter	1.	Heat oil or butter in a pan.
15	g	1.34	Onions	2.	Sauté onion till translucent.
2.5	g	0.22	Turmeric	3.	Add turmeric, garam masala, curry powder and stir.
2.5	g	0.22	Garam masala	4.	Add ginger and garlic paste and simmer for 30 seconds.
2.5	g	0.22	Curry powder	5.	Add cubed chicken and cook on low heat.
2.5	g	0.22	Ginger and garlic paste	6.	When the chicken is almost done add tomato paste and fresh cream.
1000	g	89.53	Chicken breasts cubed	7.	Garnish with coriander and serve hot.
2.5	g	0.22	Tomato paste		
50	g	4.48	Fresh cream		
15	g	1.34	Coriander		

Appendix N: Photos and Recipes of Breakfast Egg Fried Rice

RECIPE: EGG FRIED RICE

RECIPE/PRODUCT: Egg Fried Rice
NUMBER OF PORTIONS: 10
TOTAL RECIPE YIELD: 2,617 Kg
PORTION YIELD: 190g
COST PER PORTION: R9.17

QTY	UNIT	PERCENTAGE	INGREDIENT	STEP	METHOD
25	ml	0.96	Oil	1.	Heat 15ml oil in a pan on medium temperature.
290	g	11.08	Cherry tomato	2.	Slice cherry tomatoes in half and pan fry on low, cook for 3 min, season and remove of the heat.
2.5	g	0.10	Salt	3.	In a separate pan heat the remaining 10 ml oil and butter on high heat.
2.5	g	0.10	Pepper	4.	Sauté the chopped onion until translucent.
100	g	3.82	Butter	5.	Add the grated carrots and peppers and cook till al Dante.

105	g	4.01	Red onion	6.	Whisk eggs and add to the vegetable mix, top with shallots and cook for a few minutes.
120	g	4.59	Carrots, grated	7.	Season with salt and pepper.
205	g	7.83	Green pepper	8.	Add the cooked brown rice to the egg and veg mixture and combine well.
467.5	g	17.86	Eggs	9.	Serve with cherry tomatoes.
1.300	g	49.68	Cooked brown rice		

Appendix O: Photos and Recipes of Breakfast Muesli Rice

RECIPE: BREAKFAST MUESLI RICE

RECIPE/PRODUCT: Breakfast Muesli Rice
NUMBER OF PROTIONS: 3
TOTAL RECIPE YIELD: 587g
PORTION YIELD: 195g
COST PER PORTION: R13.76

QTY	UNIT	PERCENTAGE	INGREDIENT	STEP	METHOD
335	g	57.06	Cooked brown rice	1.	Add nutmeg powder and butter to the cooked rice and combine well.
1.5	g	0.26	Nutmeg powder	2.	Then add cranberries, sunflower seeds and dried or fresh bananas to the brown rice mixture.
25	g	4.26	Butter	3.	Combine all ingredients well.
50	g	8.52	Cranberries dry	4.	Garnish with sliced almonds.
55	g	9.37	Sunflower seeds		
60	g	10.22	Dried/fresh bananas		
60	g	10.22	Almonds sliced		

Appendix P: Standard Operating Procedures to prevent the transmission of COVID-19

Standard Operating Procedures (SOPs) for Practical's, Recipe and Product Development

Viral illness can spread from person to person through small droplets from the nose or mouth which are spread when an infected person coughs or exhales. These droplets land on surfaces and survive for a long time on some surfaces. By touching a contaminated surface, then touching your eyes, nose, or mouth, the virus can be transferred. The virus can also be transferred when people breathe in droplets from a person with a viral infection who coughs, sneezes or exhales droplets. When infection rates rapidly increase across a very large region, it is considered a pandemic. Preventative measures are taken to protect public health and safety (Insititute of Child Nutrition 2020).

Please adhere to the following preventative measures when working in the food laboratory:

1. Always wear your mask and face shield.
2. Wash hands immediately upon entering the lab following the correct procedure- refer to image below.
3. Maintain a 1.5m distance from your peers always. You must use separate workstations.
4. Clean and disinfect work surfaces before and after use using a 70% alcohol-based disinfectant.
5. Wash and sanitize hands regularly when working in the lab.
6. Handle food waste properly.
7. Avoid touching eyes, nose, or mouth. Follow appropriate coughing and sneezing etiquette. Cough or sneeze in a disposable tissue or elbow, always followed by proper hand washing.
8. Only approved staff and students are allowed in the lab.
9. If you get any cuts, burns and bruises please inform the lab staff for assistance in first aid.
10. If you are feeling unwell, please report to staff in charged.
11. For sensory evaluation, no sharing of individual portions is allowed.

Clean and disinfectant your unit at the end of the practical.

Appendix Q: Anthropometric and Bio Clinical Measurements Form

FOOD AND NUTRITION CONSUMER SCIENCES

Anthropometric and Biochemical Measurements Form

1.Name of the Participant	

2. Date of birth	Year	Month	Day

3. Gender	Male	Female

4. Body weight (kg)	5. Height (cm)	6. Waist Circumference (cm)

7. Pre-prandial Fasting Blood Glucose (mmol/L)	8. Post-prandial Fasting Blood Glucose (mmol/L)

Appendix R: Full Approval and Ethical Clearance to Conduct Research

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

26 October 2020

Mrs A Reddy
P.O. Box 4323
Durban
4000

Dear Mrs Reddy

Acceptability, appropriateness and feasibility of brown rice consumption and impact on blood glucose levels among staff at a university
Ethical Clearance number IREC 139/19

The Institutional Research Ethics Committee acknowledges receipt of your Safety Monitoring and Annual Recertification report.

I am pleased to inform you that the study has been approved to continue.

Please note that ethical approval has been extended till **15 November 2021** if the research is not complete within this time, you will be required to apply for recertification three months before the expiry date.

Yours Sincerely

Professor J K Adam
Chairperson: IREC