



**Development and acceptability of a cost-effective,
energy-dense snack suitable for the National School
Nutrition Programme**

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Declaration

I, Saffia Hassanally, hereby declare that the research work presented by this thesis is my original work and all the materials used are appropriately acknowledged and explicitly reference. 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

I dedicate this thesis to:

My parents (Razia and Riyaz Hassanally)

My brothers (Naeem and Mohomed Hassanally)

For always being there for me, no matter what.

And

My son (Muhammed Zulfikaar Gaffoor)

“It is the quality of one’s convictions that determines success, not the number of followers.” –

Remus Lupin

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Abstract

Background: The National School Nutrition Programme (NSNP) was established in South Africa (SA) to ensure that hunger will not be a barrier to learning among school learners attending quintile one to three schools and aims to provide a free, nutritious meal for all 189 school days. The NSNP currently does not have a solution to ensure that all learners are suitably sustained, until the main NSNP meal can be served. With the increase in food insecurity levels, the need for the development of an energy-dense snack item for school learners is critical, in the effort of combatting hunger and ensuring learners have the necessary energy to sustain their concentration until their next meal.

Aim: This study aimed to develop a suitable, cost-effective, energy-dense snack item for learners as a supplement to the NSNP, to assist learners in reaching their recommended dietary requirements.

Methodology: The snack product development was informed by a cross-sectional snack preference survey, as well as a scoping review of the literature on school feeding programmes and past snack interventions that have shown success in South Africa and other developing countries in Africa. Through informed consent, 85 primary school learners between the age group of nine to thirteen that were part of the NSNP from two quintile three schools in KwaZulu-Natal participated in the snack preference survey whilst 81 learners participated in the consumer sensory evaluation.

The snack preference survey and scoping review of past snack development interventions were conducted, to decide on a suitable, cost-effective snack for development, for the learners of the primary schools. The developed snack product then went through sensory evaluation, using trained personnel and, thereafter, for microbiological testing, to deem the product safe for consumption. The product then underwent nutritional analysis, to determine the nutritional properties of the snack item and shelf-life testing. Lastly the product was presented to the learners for final sensory analysis, to determine sensory acceptability of the developed snack, using a 7-point facial hedonic scale.

Results: Analysis of the reviewed articles inferred that the most appropriate snack product to develop for this study was a biscuit. Results from the snack preference survey showed that muffins were the most preferred snack (57.1%) by both girls and (55.8%) boys, respectively. Biscuits were the second most preferred snack (32.6%) by both girls and (33.3%) for boys, respectively. There was no significant relationship between gender and choice of snack ($p=1.000$) and no significant relationship between age and choice of snack ($p=0.141$). The literature results showed biscuits to have a longer shelf life than most other snacks. It can be emulated with ease and can carry many nutrients, while being cost-effective. Trained sensory panellists, comprising of consenting Food and

Nutrition staff and students, were used to evaluate the sensory acceptability of the trial recipes, during development. Following the systematic steps of food product development, at the end of the trained sensory tests, a crispy, flavourful biscuit was developed. The final recipe yielded 20 portions of 22g biscuit dough, of which the final weight of the biscuit was reduced to 20g, due to moisture loss during baking. The microbial analysis deemed the product to be safe to consume, as total counts of coliform bacteria were zero, showing no bacterial growth. The nutritional analysis showed that fat contributed the most energy (61.0%). The Recommended Dietary Intake (RDI) percentage values of the biscuit amounted to 14.3% for girls and 14.2% for boys, which is in-keeping with the first objective of creating an energy-dense product. When compared to two other products of a similar nature on the market, the developed biscuit was found to be the most cost-effective (R0.79 for 20g portion). The shelf stability of the product proved that the product is highly shelf stable, remaining fresh for five weeks and can last up to five months, under proper storage conditions. Following the consumer sensory evaluation, a significant number (69.1%) of children found the snack to be 'Super good' ($p<.0005$), 14.8% rated the product as 'Good' and 12.3% rated the product as 'Really good'. There was no significant difference in sensory scores across age groups ($p=0.706$).

Conclusion: It is well established that school feeding programmes create a positive impact on school children, as it enriches their lives and provides them with much needed nutrients. In SA, the well-established NSNP does have challenges one of which is the shortfall of -providing 30.0% of the Recommended Dietary Allowances (RDA) to learners. Although there are existing snack development studies, this study is unique, in the sense that it is designed to assist the NSNP to fill the current gap in the RDA for the children of SA. All objectives of this study were reached, and a suitable, cost-effective, energy-dense snack biscuit was developed in a systematic process. This snack can be a potential solution to sustain children that come to school hungry. This study will be brought to the attention of NSNP stakeholders, in the hope of the programme adopting this solution, to fill the RDA gap in the NSNP.

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List of Abbreviations

AI	Adequate Intake
AMDR	Acceptable Macronutrient Distribution Ranges
AOAC	Association of Analytical Chemists International
ASTM's	American Society for Testing and Materials
BMI	Body Mass Index
CSI	Corporate Social Investment
DoE	Department of Education
DUT	Durban University of Technology
FAO	Food and Agriculture Organisation
FBDG	Food Based Dietary Guidelines
FIES	Food Insecurity Experience Scale
GCNF	The Global Child Nutrition Foundation
GI	Glycaemic Index
HEB	High Energy Biscuit
HGSF	Home-Grown School Feeding
IDF	International Dairy Federation
IFAD	International Fund for Agricultural Development
IOM	Institute of Medicine
IREC	Institutional Research Ethics Committee
KZN	KwaZulu- Natal
NCD	Non-communicable Disease
NFCS	National Food Consumption Survey
NSNP	National School Nutrition Programme
PEM	Protein-energy Malnutrition
PPE	Personal Protective Equipment
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
QPM	Quality Protein Maize
RDA	Recommended Dietary Allowance
RDI	Recommended Dietary Intakes
SA	South Africa
SABER	Systems Assessment for Better Education Results
SANAS	South African National Accreditation System
SANHANES	South African National Health and Nutrition Examination Survey
SDG	Sustainable Development Goals
SPSS	Statistical Package of the Social Science

SSA	Sub-Saharan Africa
USAID	United States Agency for International Development
WFP	World Food Programme

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1. CHAPTER 1

1.1. Introduction:

The introductory chapter will provide an overview and summary of the research study and explains the importance of the study, problem statement, aim, objectives, assumptions, delimitations and lastly, provides an outline of the research study and structure of the thesis.

1.2. Importance of the study:

The NSNP was established in South Africa to ensure that hunger will not be a barrier to learning among school learners, attending quintile one to three schools and aims to provide a free, nutritious meal for all 189 school days (South Africa, Department of Basic Education 2016: 1). The 2016 report on the NSNP stated that many challenges were faced when implementing the school feeding programme, such as not serving the required quantities of the major food groups (higher levels of starch and lower levels of protein and vegetables), dilatory feeding each month, due to delays in funding, or late deliveries by suppliers, inadequate space and storage for food, poor cleanliness, poor access to water and unsafe storage of gas (South Africa, Department of Basic Education 2016: 3). Factors that caused delays in feeding by the stipulated time (10:00am) were due to certain schools being closed early in the morning, volunteers not having transport to the schools- and too short time to prepare, cook and serve the large quantity of food (South African Department of Basic Education 2016: 79).

Regional challenges were also found, such as certain provinces (Gauteng and Western Cape) having a poor uptake of the meal, whereas Limpopo and Eastern Cape had learners that were most likely to “always” consume the meals provided. Moreover, it should be noted that Gauteng and Western Cape are the only two provinces that have some schools with breakfast provisions (South African Department of Basic Education 2016: 78). However, these provinces that serve breakfast, are not the provinces with the highest prevalence of hunger (South African Department of Basic Education 2016: 164), which infer that provinces with a high prevalence of hunger and not having a breakfast provision, are more likely to be in need of it.

To counter these challenges, recommendations for the improvement of the programme are reported. One of them is the inclusion of a highly nutritious snack before the start of the school day, to provide learners with energy until the lunch meal can be served (South Africa, Department of Basic Education 2016: 7). Serving a snack to children upon arrival to school can curb hunger, as more than a fifth of children sometimes or frequently go to bed hungry and approximately 5.5 million children experience hunger in SA, every day (Timæus, Simelane and Letsoalo 2013: 275; Remmelzwaal 2018: 3). The prevalence of hunger was reported to be between 16.4% and 36.2% in South Africa with child hunger ranging from 3.8% to 33.5% in every province (Hall *et al.* 2007:

820; Shisana *et al.* 2013: 10). In 2018, approximately 2.1 million children experienced hunger with North West and KwaZulu-Natal (KZN) provinces affecting 19.0% and 18.0% of children living there, respectively (Shung-King *et al.* 2019: 234; Statistics South Africa 2019). Child hunger among race differed significantly with 12.0% of children being from African households, 7.0% from Coloured households and less than 1.0% from Indian and White households (Shung-King *et al.* 2019: 235). Currently, the NSNP does not have a solution to ensure that all provinces have learners, who are suitably sustained, until the main NSNP meal can be served. With the increase in food insecurity levels, the need for the development of an energy dense snack item for school learners is critical, in the effort to address the issue of food insecurity in SA, by combating hunger and ensuring learners have the necessary energy to sustain their concentration until their next meal (Labadarios *et al.* 2011: 891; Lawson 2012: 1). It was found that South African school children eat a mainly carbohydrate-rich diet- henceforth, it was recommended that the NSNP meal should include a variety of food groups, providing the children with essential nutrients (South African Department of Basic Education 2016: 67). The report also highlighted that children in SA receive 18.0% of their RDA- from the NSNP meals (South African Department of Basic Education 2016: 40).

Specific criteria, for the snack being developed, should aim to fill the gap, if not amalgamate, to provide at least 30.0% of the energy of the RDA of primary school children, sustaining energy levels of the children from the morning until the lunch meal can be served (Buhl 2010: 8). Issuing of such a snack item should also not delay the school programme by being cumbersome- i.e., need to be dished out, provide utensils etc., -hence, an easy to consume, on-the-go snack would be an optimal solution for the NSNP (Bundy *et al.* 2009: 56).

1.3. Problem statement:

There are many challenges faced by the NSNP and one of the recommendations for the improvement of the programme states that an energy-dense snack can be served in the morning to provide learner's with energy, until the lunch meal can be served. According to (Zuydam 2014: 1, Boonyasirikool and Charunuch 2000: 1, Hoskin 2016: 1, Kumar *et al.* 2018: 836 and Gunert *et al.* 2016: 82), there are many snacks currently on the market; however, an energy-dense snack that is specifically designed for the NSNP has not been addressed. The South African Department of Basic Education concurs that this snack will serve as a potential solution for the improvement of the NSNP's effectiveness, by being time-efficient, to distribute at schools for the NSNP, thus, enabling minimum disruption to commencement of the morning classes (South African Department of Basic Education 2016: 175).

1.4. Aim of the study:

This study aims to develop a suitable cost-effective, energy-dense snack item for learners, as a supplement to the NSNP, to assist learners in reaching their recommended dietary requirements.

1.5. Objectives:

- To determine a suitable snack item for development, by conducting a literature review and by conducting a snack preference survey, with a sample of the target market.
- To develop a cost-effective, energy-dense snack item, using the steps of product development.
- To determine the macronutrients and micronutrients of the snack, through nutritional analysis.
- To determine food safety of the snack item developed, using microbiological tests.
- To determine shelf-life stability of the snack, by conducting shelf-life analysis.
- To determine sensory acceptability and palatability of the snack item, using a sensory evaluation survey, with a sample of the target population.

1.6. Assumptions:

- It is assumed that all children attending the two primary schools are part of the NSNP.
- It is assumed that children, attending the two primary schools, do not bring a lunch pack.
- It is assumed that the responses and data, collected from primary school learners for the snack preference survey and sensory evaluation, were of an unbiased and honest nature.
- It is assumed that all primary school learners, involved in the research, could comprehend English, which was the language used to communicate, and where required, a translated snack preference survey and sensory evaluation sheet was given to learners, who preferred isi-Zulu.

1.7. Delimitations

- The study was limited to the KwaZulu-Natal province.
- Only two primary schools that were part of the NSNP were used for this study.
- 85 learners for the snack preference survey and 81 learners for the sensory evaluation were used for this study.
- Each learner received one sample of the snack which equates to one portion.

1.8. Outline of the project:

The outline of the study, as depicted in Figure 1.1, was developed together with the research supervisors.

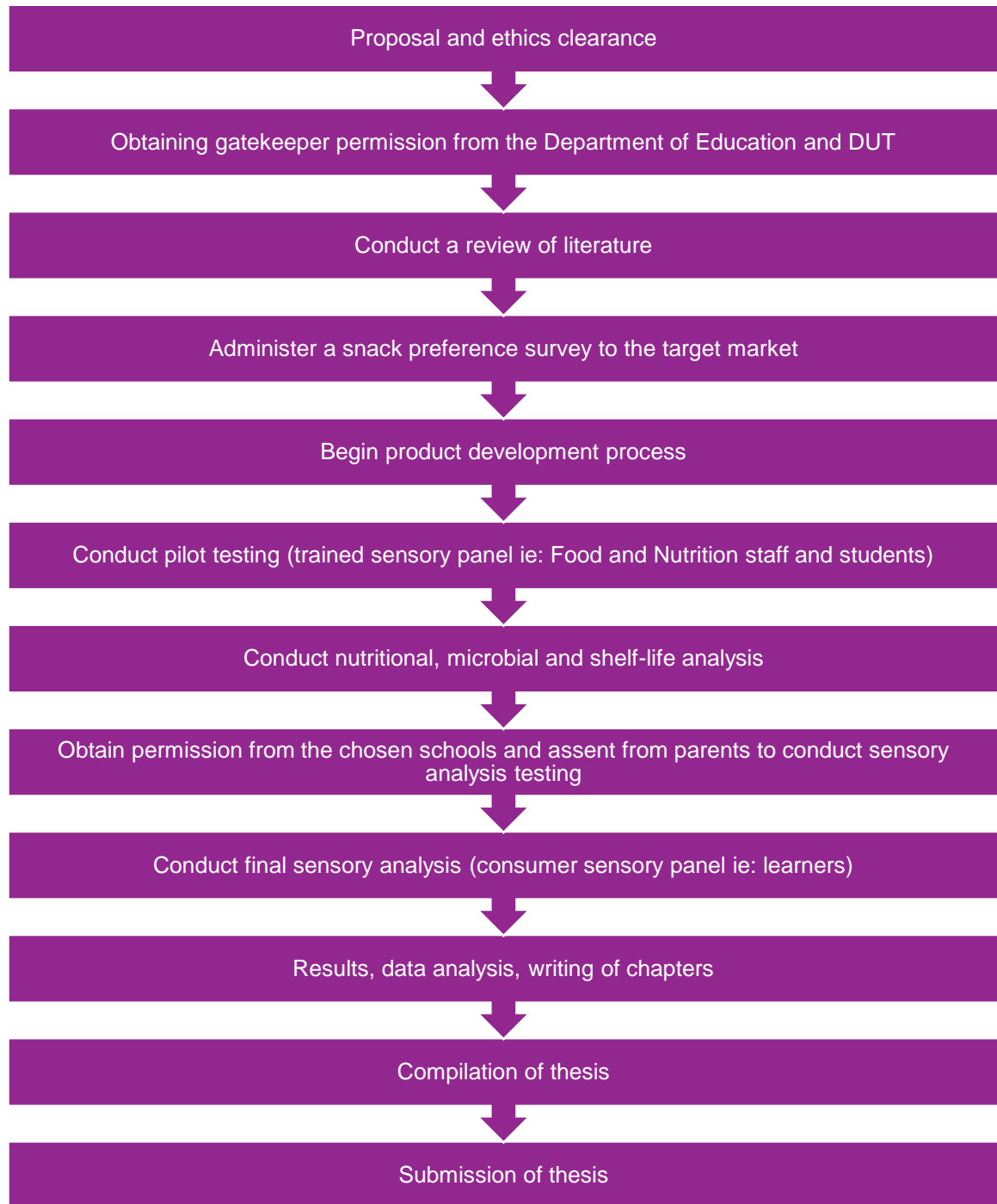


Figure 1.1: Framework of the study

1.9. Definition of terms:

COVID-19: A disease caused by the new strain of coronavirus (World Health Organisation 2020: 2).

Energy-dense: The amount of energy (kilojoules) per gram of food (British Nutrition Foundation 2018: 1).

Food security: A situation where people have access to a stable supply of good quality, sufficient, and safe food at all times, in order to lead an active, healthy life (South African Department of Social Development and Agriculture Forestry and Fisheries 2013: 8).

Malnutrition: When people do not have enough to eat, which leads to a lack of proper nutrition (Oxford Reference 2020: 1).

National School Nutrition Programme: Was established in SA, to ensure that hunger will not be a barrier to learning, among school learners attending quintile one to three -schools and aims to provide a free, nutritious meal for all 189 school days (South Africa, Department of Basic Education 2016: 1).

Nutrition security: The consumption of a wide range of healthy, nutritious foods that will provide adequate essential nutrients, and in addition, it also requires having adequate access to health, water and sanitation services (Siassi 2015: 114).

Product development: The stages involved in bringing a product from concept to market release (Product Plan 2020: 1).

Quintile: Schools in South Africa are ranked according to fees, where quintiles one to three are “no-fee paying schools”, and quintiles four and five are “fee-paying schools” (South African Department of Basic Education 2020b: 1).

Recommended Dietary Allowance (RDA): Average daily level of intake, to meet nutrient requirements of almost all healthy people (National Institute of Health 1995: 1).

Sensory analysis: The use of human senses to analyse foods on properties, such as taste, flavour, texture (Campden 2017: 1).

Snack: The act of consuming smaller amounts of food between main meals (Chaplin and Smith 2011: 53; Hess, Jonnalagadda and Slavin 2016: 467; Eng *et al.* 2017: E193).

Stunting: Determined by calculating height-for-age. Children whose height-for-age falls below two standard deviations (-2SD) of the median of the reference population, are considered short for their age (stunted) (Shung-King *et al.* 2019: 146).

Sustainability: The ability to be maintained over a period of time, at a certain rate or level (Oxford Reference 2020: 1).

Wasting: Determined by calculating weight-for-height. Children whose weight-for-height falls below two standard deviations (-2SD) of the median of the reference population, are considered to have acute malnutrition (wasting) (Shung-King *et al.* 2019: 146).

1.10. Structure of the thesis:

This thesis is reported according to the following format.

Chapter 1: Introduction

Provides the background to the study, research problem and justification of the research. The aim and objectives of the research are also presented.

Chapter 2: Literature review

A thorough review of the studies conducted by other researchers, based on snack consumption by primary school pupils.

Chapter 3: Methodology

Presents the research design and methodology of this research. The quality of the data, in terms of validity and reliability, is outlined and ethical issues relating to the research are discussed.

Chapter 4: Results

All results from the findings are displayed in the form of tables and graphs etc.

Chapter 5: Discussion

The results from the scoping review, snack preference survey, the product development, determination of acceptability and sensory evaluation are introduced, followed by an in-depth discussion, addressing its connection to the main aim and objectives of the study.

Chapter 6: Conclusion and recommendations

Conclusions and limitations of the study and suggests recommendations for further research.

1.11. Conceptual framework:

This study's conceptual framework begins with a formative survey to determine snack preferences among school learners and a scoping review on snack development in Africa for school feeding schemes. The findings of the formative work will be used to develop and test for acceptability of a cost-effective, energy-dense snack using the product development process.

1.12.Conclusion:

Chapter 1 has outlined the purpose and importance of the study. A framework (Figure 1.1) and structure is also included in this chapter, as a guide to the development of the research. The following chapter will discuss the nature of the study in further detail.

1.13.Referencing style:

The referencing style used in this thesis is according to the guidelines used at Durban University of Technology (DUT Harvard style 2015).

2. CHAPTER 2

2.1. Introduction

This chapter will enlighten upon the exposition of literature sources that were consulted to understand and investigate this research topic. It comprises a systematic, in-depth dive into the topics pertaining to primary school feeding schemes in SA.

2.2. South African food and nutrition security situation

2.2.1. The difference between food security and nutrition security

Food security is a situation where people have access to a stable supply of good quality, sufficient, and safe food at all times, in order to lead an active, healthy life (South African Department of Social Development and Agriculture Forestry and Fisheries 2013: 8). On the other hand, Siassi (2015: 114) defines nutrition security as the consumption of a wide range of healthy, nutritious foods that will provide adequate essential nutrients, and in addition, it also requires having adequate access to health, water and sanitation services. Both sources agree that a close link between food security and nutrition security exists and that these integral concepts work hand in hand to achieve the goal of a healthy society (South African Department of Social Development and Agriculture Forestry and Fisheries 2013: 8; Siassi 2015: 114).

2.2.2. The main drivers of nutrition and food insecurity

The state of food insecurity revolves around four main factors, namely availability, access, stability of food supplies and utilisation of food (Food and Agriculture Organisation (FAO), International Fund for Agricultural Development (IFAD), and World Food Programme (WFP) 2014: 13). Laborde, Tokgoz and Torero (2013: 1) briefly explain each point as follows. Availability refers to the quantity, quality and diversity of food produced, as part of agriculture for a country. Access refers to physical, economic, and social acquisition of foods, where an increase in productivity can lead to an increase in income for consumers, which improve access to food. Stability refers to the price of food fluctuations and political instability, e.g., when are when a country is poorly governed or in political conflict or experiences inflation of food prices all of these can compromise efforts to improve food security in such a country. The utilisation factor refers to the ability to utilise food and the ability to consume clean, safe water and have proper sanitation. If any of these factors are lacking, food insecurity will occur (FAO, IFAD and WFP 2014: 13). FAO, IFAD and WFP (2014: 17) also found that food availability plays a major function in food insecurity among poor locations in Sub-Saharan Africa (SSA). Utilisation still remains a problem, especially for developing countries, such as Eastern Asia and Latin America, while stability of food supplies is a challenge for those regions that import food for domestic supply, such as the North African region and the Caribbean. FAO *et al.* (2017: 3) identifies other factors that contribute to food and nutrition insecurity, such as lack of nutrition policies for young children and infants, insufficient clean, safe water, proper sanitation

facilities, health care, influences from food environment and culture. Some of these factors concur with the findings of the previous source FAO, IFAD and WFP (2014), which allude to the wide range of challenges faced in combating food and nutrition insecurity.

2.3. Levels of food insecurity worldwide and in SA

FAO, IFAD and WFP (2014: 15) have developed a scale, known as the Food Insecurity Experience Scale (FIES), which can monitor the severity of global food insecurity, based on the extent of people's difficulty in obtaining food. Recent statistics from FAO *et al.* (2019: 3) show that across the world, the number of people who were found to be food insecure, in 2019, were about 2 billion compared to 688.5 million in 2016. From the two billion food insecure people around the world, 9.0% (188 million) are from Latin America, 52.0% (1.04 billion) are from Asia and 34.9% (676 million) are from Africa (FAO *et al.* 2019: xvii). However, in the Southern and Eastern regions of Africa the total food insecurity levels are higher (53.6% and 62.7%, respectively), when compared to Western Africa, with 47.9% (FAO *et al.* 2019: 20). The Southern African Development Community (2020: 6) reported that approximately 44.8 million people, from both urban and rural areas in Southern Africa, are food insecure. Shisana *et al.* (2013: 10) broke down the statistics in SA, identifying the prevalence of hunger being the lowest in the Western Cape (16.4%) and Gauteng (19.2%), whereas the highest prevalence of hunger was found to be in the Eastern Cape and Limpopo, where prevalence was above 30.0%, for both provinces. According to race group, 30.3% of the African population was prone to food insecurity, whereas the white population was more food secure (89.3%) (Shisana *et al.* 2013: 10). In 2017 it was found that the provinces with the lowest proportion of households with adequate food access, were North West Province (64.0%) and Northern Cape (66.5%), and that black African and coloured headed households were less likely to have adequate access to food when compared to Indian and white headed households (Statistics South Africa 2019).

2.4. Solutions for food and nutrition security

It has become increasingly important, to many heads of state, governments and organisations around the world, to end world hunger and improve food security for all regions in the world (FAO, IFAD and WFP 2014: 25). The Sustainable Development Goals (SDG), developed by the United Nations, that aim to transform the world to make it a better place for all, had two goals that pertain to children and nutrition in particular, namely Goal 2: to alleviate hunger, improve, promote and sustain food security, nutrition and agriculture, and Goal 3: to make sure that people of all ages lead healthy lives (United Nations 2019: 1). In order to find a solution, to the impending nutrition insecurity and issues of hunger around the world, further research needs to be conducted. Three possible research outlooks are possible. Firstly, the health aspect which emphasises that having access to nutritious and safe food is important for individuals in order to lead a healthy, well-

balanced life. Therefore, food safety and agriculture associated diseases, including its influence on third world countries and the disadvantaged, as well as ways to prevent or minimise food safety risks, can be investigated (FAO *et al.* 2017: 19). Secondly, proper nutrition is essential to human well-being; however, due to the effects of food insecurity, many people are affected by malnutrition, which is a complex, multisectoral issue that ranges from the double burden of malnutrition (where both undernutrition and over nutrition exists in the same society) to non-communicable diseases. The nutrition aspect also deals with evaluating policies and programmes, which aim to improve the diets, nutritional status and health of people, through critical stages of the lifecycle (FAO *et al.* 2017: 19). Thirdly the agricultural aspect is of crucial importance. The key to reducing poverty and improving food security issues worldwide is to focus on development of innovative food products using highly nutritious raw ingredients that can provide adequate nutrition for majority of people who are disadvantaged, living in developing countries (FAO *et al.* 2017: 18). Topics of discussion could include fortification, biofortification, (process of improving the nutritional quality of food crops by means of modern biotechnology, the lack of nutrients and/or vitamins seen in people in countries where food insecurity is prevalent, ways to improve nutrition and/or vitamin and mineral intake and the effect of lack of nutrition during critical stages of the lifecycle. Several government policies have been initiated to address the issue of food insecurity in SA, such as the food fortification programme, food supplementation and school feeding programmes, including the NSNP and day care centre schemes (Labadarios *et al.* 2011: 895). Other strategies the South African government undertook, in 2020, are the expansion of the child support grant and USAID (United States Agency for International Development) investing in SA's public and private sectors, to increase agricultural trade of South African regions, in the effort to reduce hunger, poverty and malnutrition (Patel 2020: 1; United States Agency for International Development 2020: 1).

2.5. School feeding:

2.5.1. School feeding programme in South Africa

In 1994, a primary school feeding programme was established nationwide by the South African Department of Health, which was taken over in 2004 by the South African Department of Education (Buhl 2010: 8). According to Labadarios *et al.* (2011: 895), the South African government allocated more than R450 million since 1999, to the NSNP. Latest figures from the 2019/20 Basic Education Department Budget speech indicate that R1.6 billion has been allocated to the NSNP (Department of Basic Education 2019/20: 1). The NSNP reaches approximately 20 000 schools that are classified among the three poorest quintiles (quintiles one, two and three) and provides meals to more than nine million learners, nationwide (Devereux *et al.* 2018: 12). Schools in South Africa are ranked according to fees, where quintiles one, two and three are “no-fee paying schools” and quintiles four and five are “fee-paying schools” (South African Department of Basic Education 2020b: 1). The NSNP aims to enhance the learning capacity of learners, by providing a healthy

school meal, in order to increase learner's energy levels, making them alert and receptive during lessons (South African Department of Basic Education 2019: para. 1 line 1). Van Stuijvenberg (2005: S213) and Buhl (2010: 1) believes that school feeding is a perfect opportunity for targeted micronutrient fortification interventions, especially since school-age children are a group that is often neglected, because intervention strategies do not reach them. After evaluating the school feeding programme in 2000, the menus were changed to contribute an increased 20.0% of the RDA for energy, protein, calcium, iron, zinc, and vitamin A, of which this guideline was increased to 30.0% (Buhl 2010: 8). In February 2009, only quintile one to three public primary schools were part of the programme and it was extended to quintile one, two and three secondary schools in April 2009, 2010 and 2011, respectively (South Africa Department of Basic Education 2009: 2). According to The South African Department of Basic Education (2016: 3) and Buhl (2010: 9), challenges of school feeding programmes include: no variety in the menu (serving larger portions of starch in place of protein and vegetables); lack of water on-site at schools; lack of preparation and serving utensils and equipment; poor food quality, due to a lack of hygiene and poor food safety practices; disappearing food, caused by theft or corruption; and late deliveries from suppliers, as well as delays in funding. Research investigating food security in SA also states that infrastructural factors, such as lack of transportation, poor road conditions, poor storage and distribution facilities, may be barriers to the NSNP, which need to be addressed, to increase the effectiveness of the programmes (Labadarios *et al.* 2011: 895; South African Department of Social Development and Agriculture Forestry and Fisheries 2013: 13).

Based on the latest review of the NSNP, by the South African Department of Basic Education (2016: vii), certain recommendations were made to improve the programme's effectiveness, such as: ensuring that food is served promptly by 10:00 am and if this is not possible, then provisions must be made to provide a snack upon arrival at school; reducing the frequency of soya on the menu and including more meat alternates, such as legumes, peas, beans, split peas etc; conduct audits on infrastructure and equipment used in schools, to prepare meals for the learners; and monitoring the percentage of learners, who receive meals on time. Currently, the NSNP meets only 18.0% of the RDA for children, while the average cost of meals is R2.62 (\$0.19) (Aliyar, Gelli and Hamdani 2015: 148; Lesley, Alice and Donald 2016: 8; South African Department of Basic Education 2016: 40). In contrast, countries like India, which has the largest school feeding programme in the world, provides approximately 35.0% of RDA, while the Ivory Coast's feeding programme contributes more than 50.0% of RDA. However, the annual cost of feeding a child per year in these countries amounts to 32US\$ (R467.62) for India and 19US\$ (R277.65) for Ivory Coast (Lesley, Alice and Donald 2016: 8). South Africa has an opportunity to improve its school feeding programme and subject to the NSNP review, as conducted by the South African Department of Basic Education (2016: 1), to develop an energy-dense snack that would contribute at least 30.0%

of the RDA energy requirements to fill the gap in the current NSNP. The table below, by Lawson (2012: 9), depicts the pros and cons to pre-packaged snacks vs being served cooked meals:

Table 2.1: Different types of food for education programmes and the pros and cons
(Lawson 2012: 9)

	School feeding programme (Pre-packaged)	School feeding programme (Cooked meals)
Pros	Children who are supposed to benefit are reached with daily attendance Parents and students motivated to attend regularly Food may be shared with younger siblings, who may be in greater need of nutritional support Alleviates short term hunger so students may focus in classroom Foods are often fortified	Children who are supposed to benefit are reached with daily attendance Parents and students motivated to attend regularly Able to utilise local fresh produce from nearby farmers Alleviates short-term hunger so students may focus in classroom Meals often include milk products or other nutritionally dense foods
Cons	Targeting is broad May take away from teaching time	Costs may be higher (salaries for cooks, loss of economies of scale, etc.) Targeting is broad May take away from teaching time

2.5.2. School feeding programmes in other countries

In other countries around the world, school feeding schemes are usually benchmarked, using the Systems Assessment for Better Education Results (SABER) tool that is structured around the following five pillars: policy frameworks that can be integrated with other policy priorities, contributing to sustainability; Institutional capacity co-ordination, by involving the local, regional, as well as national sectors; budget and financing school feeding programmes, including purchasing of the ingredients for the meals and paying caterers can be defined; design and implementation of the programme needs to be planned out practically; and lastly, community participation, where community assistance is required for meal preparation and engagement in the programme (Bundy *et al.* 2009: 2).

Research by (Buhl 2010: 14) indicates that many other developing countries adopted a school feeding programme for learners, such as: The Ghana School Feeding Programme, launched in 2005 to reduce poverty and increase food security in Ghana. Kenya's School Feeding Program aims to improve the attention and learning abilities of children, as well as contribute significantly to the nutritional intakes of school children (Buhl 2010: 14). The Global Child Nutrition Foundation (GCNF) is collaborating with the Angolan Ministry of Education, to create and implement their own school feeding programme, in order to reduce short-term hunger, as well as increasing nutrition and health education (Buhl 2010: 14). The O'Meals programme in Nigeria aims to combat hunger and increase enrolment for primary school learners (World Food Programme 2013: 6). This programme provides more than 252 000 primary school children daily with a nutritionally balanced

meal, as well as providing job opportunities for locals (World Food Programme 2013: 6). In Brazil, a Zero Hunger Project (*Fome Zero*) is established, where one of its programmes, namely the *Bolsa Familia* programme, aims to increase children's attendance and encourage them to complete their primary level education, by providing the child's family with an amount of money (Aliyar, Gelli and Hamdani 2015: 6).

2.5.3. Cost-effectiveness

According to the South African Department of Basic Education (2016: 51), the cost of school meals is varied and specific to the economic status of the country. In 2006-2007, a report showed the average cost of school meals, in high income countries, to be \$2.58 (R35.56) at primary school and \$2.72 (R37.49) at secondary school level, whereas in middle to low income countries, it ranged from \$0.59 (R8.13) in Mali, \$0.48 (R6.62) in Rwanda, \$0.32 (R4.41) in Ghana and SA, \$0.19 (R2.62) in Kenya and \$0.15 (R2.07) in Brazil (Aliyar, Gelli and Hamdani 2015: 148). Galloway *et al.* (2009: 179) states that school feeding programmes are implemented in over 72 countries and costs for school feeding, in some African countries, are currently \$28 (R392.99) per child per year in Kenya, \$59 (R828.09) in Malawi to \$63 (R884.23) per child per year in Lesotho; however, these costs are determined by the standards of living of the community. In SA, the cost of school feeding per child per year amounts to \$58 (R830.95) (Lesley, Alice and Donald 2016: 44). As a general guideline, Galloway *et al.* (2009: 181) suggests that feeding interventions should not cost less than \$4 (R56.14) per child per year. The South African National Treasury (2017: 125) states that the average cost per daily meal (including cooking fuel and remuneration) should be R2.85/learner for primary schools and R3.60 for secondary schools (South African Department of Basic Education 2016: 5). It can be deduced that the developed snack should be cost-effective, while providing adequate contribution to the RDA.

2.5.4. How can interventions be improved

A recent study showed that school feeding initiatives, such as providing a breakfast meal for children in a well-equipped and well-organized school, proved to be more successful, better received and benefitted children's behaviour, as opposed to poorly organized and overcrowded schools, where school feeding programmes actually deteriorated (Powell *et al.* 1998: 873). According to Greenhalgh, Kristjansson and Robinson (2007: 859), theories why school feeding programmes do not work could stem from several factors, such as the food provided does not provide adequate amounts of the missing nutrients and the type of ingredients used may have a low bioavailability, making it difficult to absorb the necessary nutrients by the body in some cases, supplementation occurs too late, where older children are far too malnourished to be able to reverse the effects of malnutrition by the means of a single meal in the day, which supports the notion that targeting the younger school children would greatly improve the success of the school feeding

programme. Factors that may improve the efficacy of school feeding programmes are designing a school feeding programme, specifically for the needs of that particular community, by using local teams rather than distance experts, developing food that is palatable and acceptable and ensuring that food is actually being consumed, by using close supervision during feeding times (Powell *et al.* 1998: 873; Greenhalgh, Kristjansson and Robinson 2007: 853).

2.5.5. Sustainability

School feeding programmes are aiming to be more sustainable, to offer effective surety for poor families, in long-term development settings (Lawson 2012: 74). The World Food Programme (WFP) has developed a strategy for sustainability that utilises government's assistance, in making school feeding policies sustainable programmes that are owned and led nationally, but are locally sourced (Molinas and de la Mothe 2010: 222). The WFP's Home-Grown School Feeding initiative links school feeding programmes with local farmers and together provide school children with meals that are safe, nutritious and locally produced (World Food Programme 2018: 1). This strategy by the WFP links up with the sustainable development goals. The two sustainable development goals that pertain to sustainability are goal number 2 (Zero hunger), which is focused on agriculture, forestry and fisheries providing nutritious food for all, as well as promoting food security and sustainable food production systems and goal number 4 (Quality education), which is focused on improving quality of life and access to inclusive education (United Nations 2019: 1). The Home-Grown School Feeding model, below, shows the benefits to this sustainable strategy, where levels of opportunity and incentives are able to better the agricultural sector and the lives of local small holder farmers (Sumberg and Sabates-Wheeler 2011: 344):

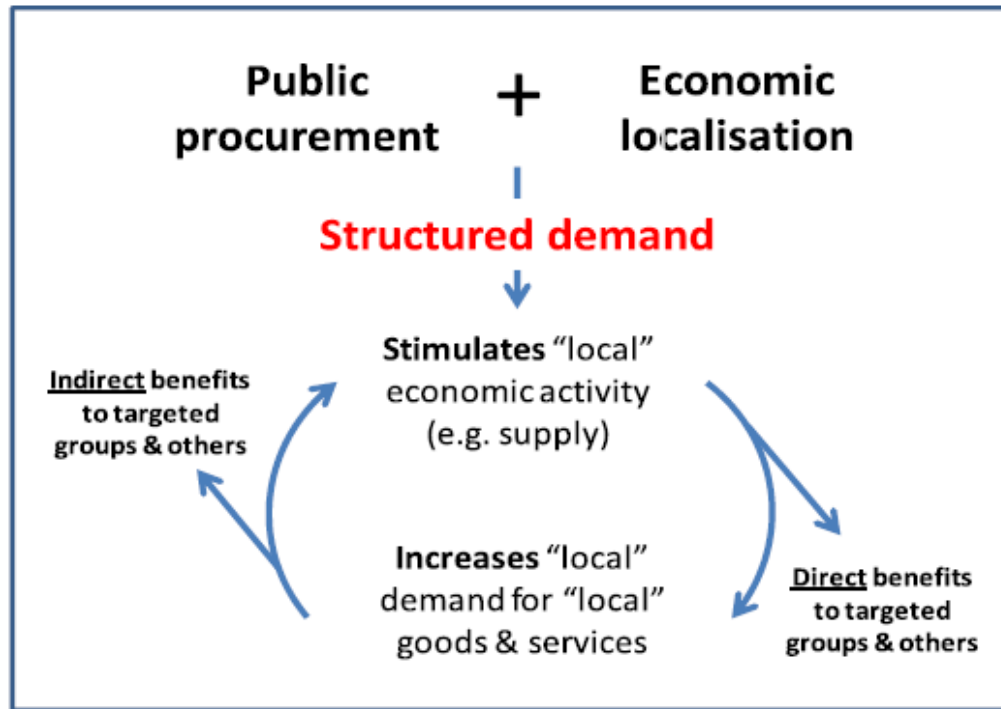


Figure 2.1: The Home-Grown School Feeding Model.

(Sumberg and Sabates-Wheeler 2011: 344)

By using locally sourced ingredients, such as locally produced soya beans, contribute to sustainability, as the ingredient is grown within the country. The increased demand, associated with school meals, supports local farmers' production, by utilising local purchases (World Food Programme 2018: 4). Through the integration of education policies, national development strategies and national financial budgets, a sustainable school feeding programme can be implemented and sustained over a long time (World Food Programme 2013: xii). As per Molinas and de la Mothe (2010: 223), school feeding initiatives should adhere to eight quality standards: (i) sustainability; (ii) adhering to national policy standards; (iii) established funding and budgeting; (iv) cost-effective programmes, (v) stable arrangements for implementation, monitoring and accountability; (vi) local sourcing; (vii) partnerships and coordination among sectors; and lastly (viii) strong community involvement.

2.5.6.Challenges of COVID-19

COVID-19 is a disease caused by the new strain of coronavirus (World Health Organisation 2020: 2). In March of this year, the World Health Organization (2020: 1) had declared COVID-19 as a pandemic. Its impact was felt by every sector of every country and brought the world to a standstill. The infection rate increased exponentially since its outbreak; however, many countries, including SA, initiated a national lock-down, in the hopes of flattening the curve and reducing the infection rate (Stiegler and Bouchard 2020: 695). During the lock down period, almost all sectors were

closed, except for those sectors providing essential goods and services. Due to schools being part of the shutdown, the NSNP was also put on hold. The lockdown affected the children that were part of the NSNP negatively, as many disadvantaged children were dependent on the single meal that was given to them daily and suddenly they were left stranded (Oxford Human Rights Hub 2020: 1). Evidence suggests that in emergency situations, such as the Haiti earthquake in 2010, compact foods, compressed food bars or fortified biscuits, created by relief agencies, help many people, who require food and assistance during that time (Young, Fellows and Mitchell 1985: 689; Grobler-Tanner 2002: 7). Another example, where high energy biscuits (HEB's) were part of a relief program, was after the hurricane Irma in the Caribbean in 2017 where thousands of people were left homeless and with no food to eat (Kosiewicz 2017: 1). It was also found that pre-packaged, ready-to-eat biscuits curb logistical problems, specifically preparation issues, distribution issues and concerns with hygiene during food preparation (Young, Fellows and Mitchell 1985: 695; Kosiewicz 2017: 1). A high energy biscuit could be part of the solution during the current lockdown, so that NSNP dependent children are still receiving some nutrition during difficult times (Grobler-Tanner 2002: 7). This could expand the reach of the NSNP by using situations such as this as an opportunity to assist not only children but communities in need as well (Young, Fellows and Mitchell 1985: 689).

2.6. Nutrition

2.6.1. Nutritional needs of primary school-going children

The development of the Food based Dietary Guidelines (FBDG) were prompted, by finding suitable nutritional guidelines that influenced the dietary patterns of the South African population, as former nutritional recommendations were criticised for being too complex and following a more western diet (Buhl 2010: 7). Labadarios *et al.* (2011: 896) found that South African children are not meeting their nutrient requirements. The South African Department of Health aims to promote the following guidelines; 'Food from animals can be eaten everyday', 'Eat dry beans, split peas and soya regularly' for improving micronutrient intake; and 'Eat plenty of vegetables and fruit everyday', in order to improve vitamin A, folate and vitamin C intake (Steyn *et al.* 2008: 312). According to Food and Nutrition Board: Institute of Medicine (2017: 1), Recommended Dietary Intake (RDI) is defined as the average daily dietary intake level that will be sufficient to meet nutrient requirements of nearly all healthy individuals, in a particular life stage and gender category. Adequate Intakes (AI's) are used when RDI cannot be determined and is defined as the average daily nutrient intake level, based on observed estimates of nutrient intake, by a group that is assumed to be adequate (Food and Nutrition Board: Institute of Medicine 2017: 1). Lotfi *et al.* (1996: 17) states that the RDI of iodine varies from 150 to 200µg/day, for iron from 12 to 14mg/day, and for vitamin A from 1330µg/day to 2000µg/day, for school-going children. The RDI's and AI's for children 9-13 for carbohydrates is 130g/day for both girls and boys, for fibre it is 31g/day for boys and 26g/day for

girls. For proteins it is 34g/day for both boys and girls, while important vitamins and minerals, such as calcium, it is 1300mg/day, for iodine 120µg/day, for iron 8mg/day, for vitamin A 600µg/day, and for vitamin C, it is 45mg/day (Del Valle *et al.* 2011: 1). The Acceptable Macronutrient Distribution Ranges (AMDR) for children, between the ages of 4-18, is 25 to 35% of fat, 45 to 65% of carbohydrate and 10 to 30% of protein, as depicted in the table below. These nutrient recommendations should be what the primary school feeding programmes aim to achieve, whether by fortifying meals or by additional snacks in-between meals, to ensure adequate levels of nutrients are reached for learners (South African Department of Basic Education 2016: vii).

Table 2.2: Dietary Reference Intakes: Acceptable Macronutrient Distribution Ranges
(Del Valle *et al.* 2011: 1)

Macronutrient	Range (% energy)		
	Children, 1–3y	Children, 4–18y	Adults
Fat	30–40	25–35	20–35
Carbohydrate	45–65	45–65	45–65
Protein	5–20	10–30	10–35

2.6.2. Nutritional status of primary school learners in developing countries

According to the first National Food Consumption Survey (NFCS), in 1 to 9-year-old children, micronutrients (calcium, iron, zinc, vitamin A, C and E, niacin, riboflavin, vitamin B₆ and folate) were deficient, specifically in rural children (Steyn *et al.* 2008: 308). Data shows that there is a poor micronutrient status among children under 5 years, particularly seen with vitamin A and Iron (Shung-King *et al.* 2019: 146). The South African National Health and Nutrition Examination Survey (SANHANES) reported in 2012 that 2.9% of children, aged 0-14 years, were wasted (Shisana *et al.* 2013: 206). It is estimated that over half the population of school-age children in low income countries suffer from iron deficiency anaemia, which in turn impedes cognitive development of the child, leading to poor performance in tests and poor attendance at school (Bundy *et al.* 2006: 20). In SA, the prevalence of vitamin A deficiency, among children between 0-14, years stood at 43.6% and Iron deficiency anaemia was at 10%, in 2012 (Shisana *et al.* 2013: 213). Vitamin A deficiency is often associated with protein or protein-energy malnutrition (Loffi *et al.* 1996: 16) and is a significant health issue worldwide, but especially in South-East Asia and Africa, mainly affecting children and pregnant women (World Health Organization 2019: 1). Globally, an estimated 250 million preschool children are vitamin A deficient (World Health Organization 2019: 1). National fortification programmes in Central American countries, utilising vitamin A fortified sugar, showed

significant reductions in the prevalence of vitamin A deficiency among preschool-age children (Darnton Hill and Nalubola 2002: 234).

The three major micronutrients that almost a third of the world's population lack, are iodine, iron and vitamin A, of which deficiencies in these micronutrients can cause serious consequences, including learning disabilities in children, impaired work capacity, serious illness and death (Lotfi *et al.* 1996: vii; Darnton Hill and Nalubola 2002: 232). Micronutrient deficiencies are common among school children, but are reversible with the use of school fortification feeding programmes or the addition of supplements into school feeding programmes (Buhl 2010: 3). Despite there being a national school feeding programme in SA, there are indications that micronutrient deficiencies still exist among primary school children (Van Stuijvenberg 2005b: S218).

2.6.3. Food fortification vs supplementation

As a means of eliminating and controlling micronutrient malnutrition, a combination of the three main strategies i.e. supplementation with high micronutrient doses, dietary improvement and food fortification are utilised (Lotfi *et al.* 1996: 3). Buhl (2010: 3) posits that, although supplementation may be a short-term solution for serious vitamin and mineral deficiencies, food fortification is a longer-term solution, as well as being more cost-effective than supplementation and, thus, more sustainable. Lotfi *et al.* (1996: 3) summarises the advantages and disadvantages of supplementation and fortification in Table 2.3 below:

Table 2.3: Advantages of food fortification over high dose supplementation

(Lotfi *et al.* 1996: 3)

Criteria	Supplementation	Food fortification
Effectiveness and timeframe	Effective strategy usually for short term	Effective medium-to-long term measure
Delivery requirements	An effective health delivery system	A suitable food vehicle and organized processing facilities
Coverage	Reaches only populations receiving the service	Reaches all segments of target population
Compliance	Requires sustainable motivation of participants	Does not require intensive cooperation and individual compliance of individual
Cost of maintenance	Relatively high financial resources needed	Low cost compared to supplementation- to maintain the system self-financing in the end
External resources	Foreign currency or external support required for obtaining supplements	Adequate technology that is locally available or can be easily transferred
Sustainability	Relates to compliance and existing resources	Fortification compounds may need to be imported

According to Darnton Hill and Nalubola (2002: 234), the addition of a single micronutrient to appropriate food vehicles are a less common approach to fortification programmes. A school snack fortification study concluded that the micronutrient-fortified biscuit was effective; however, the bioavailability of certain vitamins, such as ferrous fumarate, were inadequate and the use of a chelated form of iron, as a fortificant, needed further investigating (van Stuijvenberg *et al.* 2007: 1201).

In Indonesia, a school feeding programme, which developed and distributed fortified biscuits, along with a health, hygiene and nutrition education programme, was implemented for two years. Results from this intervention showed no significant improvement in anthropometric indicators, although there was a significant improvement in haemoglobin concentration, which resulted in a decreased anaemia prevalence (Bundy *et al.* 2009: 57). In Bangladesh, a high-energy fortified biscuit was provided daily to 400 000 students in primary schools and results showed that the body mass index

(BMI) of school children showed an increase by an average of 0.62 points, as well as increasing test scores by 15.7%, specifically in math tests. The cost of the development of these snacks was below the approximate value of US\$12 (R172.11) per child per year, which equates to approximately R1.00 per snack per day (Bundy *et al.* 2009: 58). A study conducted in Sri Lanka, by Talagala and Arambepola (2016: 3), showed that the most popular packaged snacks were biscuits (85.4%), bottled/package drinks (76.9%) and milk (70.7%). Kristjansson *et al.* (2007: 24) suggested a snack intervention, including serving milk as a school snack; however, the protein provided by milk was insufficient to meet the RDAs of school children. Food science and nutrition graduates, along with Professor John Taylor of the University of Pretoria (UP), spent many years developing a sorghum and cowpea biscuit that is highly nutritious and energy-dense, which was used for the purpose of combating protein-energy malnutrition (Zuydam 2014: 1). Boonyasirikool and Charunuch (2000: 1) developed a nutritious soy fortified snack which was a good source of vitamin B₂, vitamin B₆, calcium, sodium, vitamin B₁₂ and iodine. However, the NSNP requires the development of an energy-dense snack for the purpose of supplementing the NSNP, making sure primary school children are well nourished and meet a specific RDA of 30.0% for the day (South African Department of Basic Education 2016: 1).

2.6.4. How nutrition plays a role in learning and concentration

According to Buhl (2010: 1), undernutrition, hunger and malnutrition are causes for poor human health, and develop across the lifespan, but also especially among children from developing countries, by adversely affecting growth, development, quality of life, resistance to disease, leading to poor chances of survival. Bourre (2006: 377) states that children are more vulnerable to changes in mental and behavioural functions if they have a chronic status of poor nutrition. School feeding was identified as a means of addressing the Millennium Development Goals 1 and 2, which aimed to reduce the proportion of people, suffering from hunger worldwide, by 50.0% and to ensure universal enrolment in primary school education (Bundy *et al.* 2009: 11; Buhl 2010: 1). Devereux *et al.* (2018: 2) and Powell *et al.* (1998: 873) state that the effect of school feeding programmes is not only nutritional, but also educational, mainly having a greater impact on school attendance and improving learners' performance in tests and exams; however, the quality of education and the school feeding programme go hand in hand, because if the quality of education is poor, then even well-nourished learners may still struggle. Powell *et al.* (1998: 873) found that results from a study trial, on the effects of breakfast in rural primary school children showed that the height, weight and attendance of the children, from the experiment group, were greatly improved, as compared to the control group. Another study conducted in children showed a positive effect in memory and cognitive performance, when children consumed a lower glycaemic index (GI) breakfast cereal, as compared to a high glycaemic index breakfast cereal (Gilsenan, de Bruin and Dye 2009: 942). In addition to providing an incentive to attend school, implementation of a school feeding programme

may also reduce absenteeism, where a review of studies indicated that school feeding was associated with an estimated average of four to six days attendance at school per child, per year, which could be due to the attraction of a free meal (Kristjansson *et al.* 2007: 2; Galloway *et al.* 2009: 180).

It is noted that school nutrition programmes aim to foster a better quality of education, by enhancing the child's active learning capacity, alleviating short term hunger, providing a positive incentive for learners to attend school regularly and punctually, and lastly, to address micronutrient deficiencies (Labadarios *et al.* 2011: 895). Interventions by Ogunlade *et al.* (2011: 13) found that a high energy, easily digestible, micronutrient dense maize breakfast porridge can modify several cognitive functions for the learners. For example, the glucose from carbohydrates provides the main source of energy (Gilsenan, de Bruin and Dye 2009: 941). Many micronutrients, for instance iron (Metallinos-Katsaras *et al.* 2004: 1532), zinc (Corniola *et al.* 2008: 52), iodine (Gordon *et al.* 2009: 1264), and vitamin A (Bonnet *et al.* 2008: e3487), as well as many B vitamins (Bourre 2006: 377), are known to aid in brain development and functioning. A similar study by Haskell *et al.* (2008: 1086) found similar results, where micronutrient supplementation showed the potential to improve brain function among children, between the ages of 8 to 14, especially showing a consistent impact on math performance (Galloway *et al.* 2009: 176).

2.7. Snacking

2.7.1. Definition of a snack

There is no static definition for the term 'snack'; however, many publications have settled on snacking being defined as the act of consuming smaller amounts of food, between main meals (Chaplin and Smith 2011: 53; Hess, Jonnalagadda and Slavin 2016: 467; Eng *et al.* 2017: E193). Research by Eng *et al.* (2017: E193) states that snacks can be defined by using three criteria: the time of consumption (where a snack is recognised to be consumed outside the 'main meal' times); portion size (snacks are significantly smaller than main meals and if it falls below 570g, it is considered a snack); and energy contribution (where a snack will only contribute 15% or less of the total energy intake). However, Hess, Jonnalagadda and Slavin (2016: 467) note that the definition of a snack is adaptable, as it is also influenced by population, age, ethnic and cultural diversity. Therefore, the definition of a snack is variable, but the manner in which an individual defines a snack, may have an influence on their selection of food (Chaplin and Smith 2011: 53).

2.7.2. Snacking trends and behaviours

Larson and Story (2013: 104) and Pac *et al.* (2017: 107) suggest that recent trends in dietary intake show that there is an increase in the consumption of high-energy, nutrient deficient snacks, over the years and that could lead to the development of diet-related diseases in future. The effects of

urbanisation have shifted food consumption patterns worldwide, where the convenience of unhealthy food and drink are more easily available (Talagala and Arambepola 2016: 2). The current shift in eating patterns is moving away from the standard three meals per day towards more of a 'grazing' pattern with an increase in snacks rather than large meals, which promotes obesity (O'Connor *et al.* 2015: 1286). Cook *et al.* (2015: 640) acknowledge that the availability and accessibility of certain foods are important consumption predictors and that the higher availability of fruit and vegetables have been related to a greater intake by children and adolescents. However, Pearson *et al.* (2017: 35) observed that unhealthy eating behaviours, combined with a lower intake of fruit and vegetables, are commonly associated with adolescent's diets, which may have a significant impact on physiological health conditions, as well as increase the risk of obesity later in life. In Central Alberta (Canadian Province), Triador (2013: 1-155) studied the effects of a healthy snack programme, as well as a gardening initiative at schools, and the effect it had on children's consumption at home. The healthy snack programme was carried out for four months and the school gardening programme was carried out for seven months. Results from this study indicated that approximately 60.0% of children were overweight or obese. After reviewing, the school gardening programme and snack programme significantly improved their attitude towards fruit and vegetables. From the healthy snack programme, there was an increase in children's positive attitude towards vegetables, as most fruit had high likeability scores before and after the intervention and the fruit and vegetables the children were most knowledgeable about, were the ones they liked the most. According to Faber *et al.* (2014: 1219), approximately 57.0% of learners in grades 5-7 were given money to take to school. As shown in the figure below, a study that focused on school snacking preferences, from a low socio-economic community in SA found that sweets (39.0%) and chips (34.0%) were the most popular purchased snack items, followed by soft drinks (9.0%) and chocolate (7.0%) (Govender *et al.* 2018: 6).

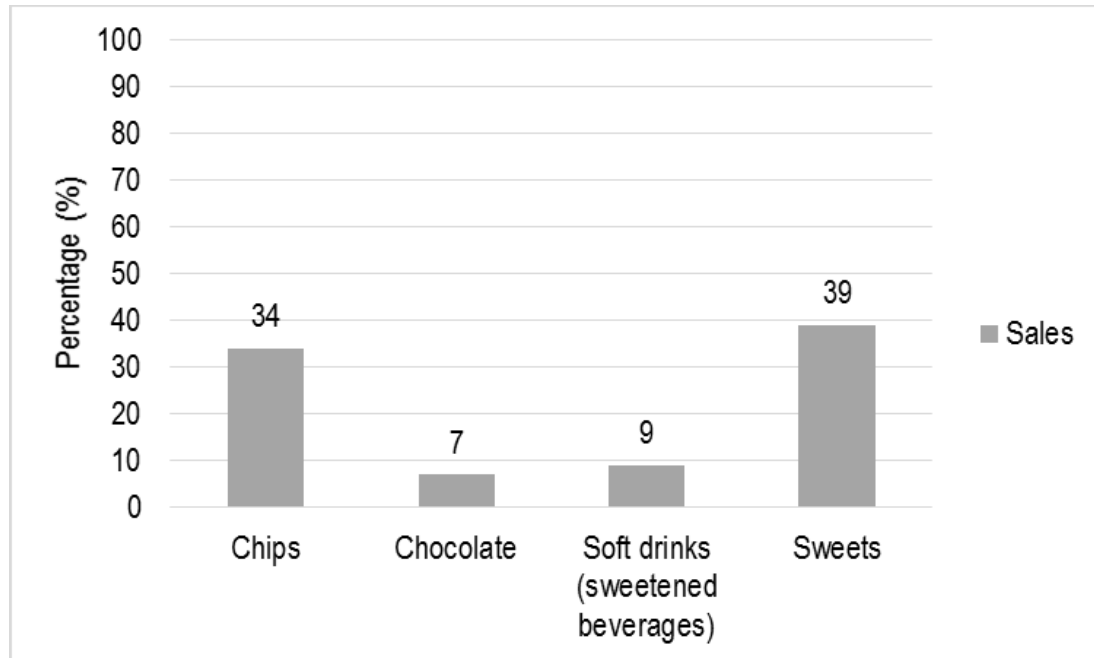


Figure 2.2: Tuck shop snack items reported as the percentage of children (grade 1-7) who purchased items during school breaks at one school located in KwaZulu-Natal, South Africa (n=536)

(Govender *et al.* 2018: 6)

2.7.3. Snacking and malnutrition

A high prevalence of both spectrums of malnutrition have been identified in SA, namely obesity (12.0%) and stunting (17.0%), among low socioeconomic groups of children (Symington *et al.* 2015: 68). The prevalence of childhood and adolescent related obesity and overweight has increased worldwide over the years (Smetanina *et al.* 2015: 1; World Health Organization 2015: 6). A study conducted in 2017 showed that among preschool children, the prevalence of obesity had increased from 7.0% in 1988 to 12.0% in 2013 and is still on the rise (Kranz *et al.* 2017: 445). Girls are at a greater risk of becoming overweight and maintaining unhealthy levels of fat that may go into their childbearing years, and may lead to poor pregnancy outcomes (Todd *et al.* 2015: 2306). It is indicated by Larson and Story (2013: 104) that food and beverages that are consumed during snacking can count for approximately 30.0% of the total daily energy intake and, therefore, are a significant source of essential nutrients, especially for young children aged 2-19 years. There is a concern that an increase in snacking may contribute to obesity; however, many studies found that snacking and eating frequency were not associated with obesity (Fayet-Moore *et al.* 2017: 2; Pac *et al.* 2017: 107). Nguyen (2016: 3) echoes the above observation, by stating that the causes of obesity amongst adolescents are due to many factors, such as incorrect portion sizes, poor choice of snack foods consumed, environmental and socio-economic factors and family and psychological factors, which make it difficult to determine the exact cause of obesity, as all the above factors play a role in contributing to obesity. The type of snack and hence the quality of snack choice have an

influence on the total energy intake and determines the fine line between snacking and obesity (Fayet-Moore *et al.* 2017: 2). Smetanina *et al.* (2015: 2) states that consumption of beverages rich in sugar, food high in fat and energy and low in fibre, coupled with little to no physical activity and poor sleeping patterns were shown to promote overweight and obesity in adolescents. According to a study by O'Connor *et al.* (2015: 1288), among women, a high snacking frequency was associated with increased BMI, waist circumference, abdominal fat thickness and was conversely associated with body fat percentage in men. Apart from obesity being a risk factor for the development of non-communicable diseases (NCD's), it is linked to inadequate micronutrient intake, especially iron and vitamin D, as excess adipose tissue hinders its absorption (Troesch *et al.* 2015: 6018).

The reverse spectrum of malnutrition leans towards undernutrition. Latest FAO estimates indicate that levels of global hunger reduction are increasing; however, in developing countries about one in nine people still have insufficient food (FAO, IFAD and WFP 2014: 8). FAO, IFAD and WFP (2014: 17) state that food availability and access to food is still a major concern for sub Saharan-Africa; however, targeted food security and nutrition interventions are in motion to combat certain issues of food insecurity and, in effect, undernutrition in developing countries. School feeding programmes that provide meals to alleviate short term hunger for school going children, is one way to improve access to food in developing countries (Bundy *et al.* 2009: 8). Another intervention that functions similarly to providing meals to learners, is providing fortified high-energy biscuits and snacks to children, which aim to alleviate short-term hunger and to also target micronutrient deficiencies (Bundy *et al.* 2009: 8).

2.7.4. Snacking recommendations

Azadbakht *et al.* (2016: 411) observed that the consumption of healthier snacks was correlated to a reduced risk of obesity among adolescents. Such healthy snacks include vegetables, fruit, nuts, dairy products and whole grain, low GI and high fibre biscuits and crackers. The South African Guidelines for healthy eating advocates including fruit and vegetables as snacks, as well as including low fat dairy and whole grain, high fibre carbohydrates as snacks (South African Department of Health 2015: 7). Countries with nutritional dietary guidelines that refer to snacking make similar recommendations, with regard to the type of snacks eaten, the frequency of consumption, and the amount eaten at a time (Hess, Jonnalagadda and Slavin 2016: 471). For example, in Canada, specific guidelines for girls, of a childbearing age, encourage fruit and yoghurt as suitable snack choices and in France their guide recommends yoghurt, milk, fruit and vegetables. Other countries recommend limiting processed snacks and increasing low-Kilojoule and nutrient-dense foods (Ancellin *et al.* 2011; Hess, Jonnalagadda and Slavin 2016: 471; Government of Canada 2020). Most often, snacks are high in saturated fats, salt and refined sugar.

Adolescents tend to consume too much unhealthy foods, which may result in negative consequences, such as obesity and lifestyle related diseases (Grunert *et al.* 2016: 82).

According to Grunert *et al.* (2016: 82), it is common for children to prefer unhealthy snack products as the existing healthy snack alternatives appear less attractive to them. This gives food manufacturers an opportunity for new product development, to develop a healthy snack product that children will find more appealing. Hamilton and Wills (2017: 202) suggest providing students with a greater choice of more nutritious food options on the school premises, while socialising with friends may encourage healthier snacking habits among children. Yan *et al.* (2016: 2173) states that the availability of healthy food products that contains nutritional information has led to more people improving their dietary habits. High fibre, protein and low GI snacks have been associated with an improvement in the nutritional quality of snacking habits, and reduce the impact of poor nutrition especially among children; this conditioning will eventually track into their adult years (Yan *et al.* 2016: 2172).

2.8. Energy-dense snacks

Early childhood is an important period of growth and development, both physically and cognitively, and, thus, requires an optimal dietary intake of energy and nutrients (Ogata and Hayes 2014: 1257). According to a study conducted in the United States by Shriver *et al.* (2018: 4), the most popular snacks identified, with the most fat and energy, are sweet bakery products (cakes, biscuits, and pastries) and milk. Findings suggest that snacks consumed in the morning have a higher nutrient density among young children (Shriver *et al.* 2018: 4). Nutrient-dense snacks are important to optimize children's nutritional status, cognitive development, as well as to promote physical growth (Shriver *et al.* 2018: 7). Studies have shown that consumption of a high protein snack reduces hunger and increases satiety, as compared with no snacking or consuming high fat and/or high carbohydrate snacks (Leidy *et al.* 2015: 1615). Grunert *et al.* (2016: 91) found that by combining healthy and unhealthy elements, with the inclusion of fresh fruit, specifically for girls, and savoury aspects for boys, increased the attractiveness of a healthy snack concept.

In Thailand, snack foods, by extrusion, have gained popularity; however, they have poor nutritional value, because in such products, cereal carbohydrate, frying oil and flavour coating are the main sources of energy. High consumption of such snacks could lead to malnutrition in children and obesity, causing several diseases in adulthood (Boonyasirikool and Charunuch 2000: 355). It is reported that the consumption of low-GI foods, high protein foods and dietary fibre are said to improve the nutritional quality, improve glycaemic control, as well as aid in satiety (Yan *et al.* 2016: 116). Troesch *et al.* (2015: 6026) suggest that cost-effective, nutrient dense foods, which address nutritional deficits in consumer diets, should be developed, to help resolve problems arising from

demographic and lifestyle changes, in our societies. A study that replaced typical between-meal American snacks with tree nuts, resulted in a more nutrient-rich diet, with less empty calories, decreased sodium and improved fatty acid profiles (Rehm and Drewnowski 2017: 1). Research has identified younger children as potential targets for snacking interventions, as children are still developing food preferences and may benefit from the development of healthier snacks that will promote healthy eating in South African low socio-economic communities (Govender *et al.* 2018: 3).

2.8.1. Energy-dense ingredients

Snack foods have become an integral part of the eating habits of many people, where functional food is a main topic of interest (Rathod *et al.* 2019: 511). Muoki, de Kock and Emmambux (2012: 1771) posits that Protein-Energy Malnutrition (PEM) is a big concern in Africa and to reduce its prominence, the nutritional improvement of staple foods should be investigated. Using school feeding programmes, as a vehicle for fortification, has the potential to alleviate short-term hunger and address micronutrient deficiencies among children (van Stuijvenberg 2005a: S213). Potential food items, such as biscuits, soups and bread spreads, can be successful carriers for food fortification initiatives (van Stuijvenberg 2005a: S213). Soybeans, scientifically known as *Glycine max L.*, are recognised as a high-protein food source, gaining popularity in cultivation and use in SSA (Khojely *et al.* 2018: 229). According to Khojely *et al.* (2018: 226), in 2016, SA was found to be the largest soybean producer, followed by Nigeria, Zambia and Uganda. Soya is seen as an inexpensive source of good quality protein and an excellent addition to school feeding programmes (Soya Life 2017: 1). Peanut butter is another ingredient that can be used as part of school feeding programmes. It is derived from ground nuts, which are rich in energy, protein, vitamin E and magnesium (Mg), making it an excellent energy-dense ingredient (van der Merwe 2017: 33). Peanut butter is well known for being a survival food during emergency or disaster situations; however, the only possible drawback is that people with nut allergies cannot consume it (SHTF 2016: 1).

2.9. Product development

New food product development plays a crucial part in the survival of many brands in the food industry. However, according to Costa and Jongen (2006: 457) and Grunert (2007: 181), these new products often have a high failure rate, due to poor investment in research and development, as well as the absence of consumer feedback in the product development process. The product development process is a rigorous task that involves many aspects, in order to develop a successful final product. It is identified by Asioli *et al.* (2017: 266) that food scientists rely on expert opinions and focus more on trained sensory evaluations, rather than holistically taking both

consumer and trained sensory evaluations into account. Below, the stages of product development will be discussed.

2.9.1. Stages of product development

For the development of food products, the British Food Journal recommends the use of the model of Fuller (Rudder, Ainsworth and Holgate 2001: 669). Fullers theory has six steps Idea generation is where the company will look at the consumer's needs and form an idea to be marketed and manufactured. Screening of ideas, where the company looks at the feasibility of the idea and whether it is marketable. Development, where a trial product is produced and it goes through a multitude of tests including objective testing, consumer preference testing, market testing and evaluation. Production, where requirements and specifications of the product are established. Consumer trials where the product goes through a series of trials that will determine the consumer acceptability of the product, using the skills of trained sensory analysis panellist. Test marketing, where the product is released onto the market and observed over a period of time (Fuller 2016: 324). Fullers theory is more acceptable for use to develop food products as it makes use of subjective methods. in order to measure the sensory properties of potentially new food products that are believed to be more accurate. in determining consumer acceptability and preference (Rudder, Ainsworth and Holgate 2001: 669).

2.10. Sensory evaluation

2.10.1. Importance of sensory evaluation

Sensory testing has been conducted ever since humans started evaluating the acceptability of food, water, weapons and anything else that can be used or consumed (Meilgaard, Civille and Carr 2006: 1). Two classes of consumer testing can be used for sensory testing. Acceptance testing is when consumers are asked to rate a product individually, without comparing with other products. This method measures the extent to which the product is liked or disliked (Lawless and Heymann 2010: 305; Stone, Bleibaum and Thomas 2012: 294). Preference testing: requires consumers to compare the most preferred product over a selection of products and this method produces data that identifies a sample preference, within the test set (Courcoux and Semenou 1997: 353; Lawless and Heymann 2010: 302). Hedonic testing is one of the most important sensory methods used in the food industry. Developed by Peryam and Girrardot in 1952, it was used as a sensory tool to aid menu planning for US soldiers in their canteens (Villanueva and Da Silva 2009: 1; Nicolas, Marquilly and O'Mahony 2010: 1008). According to Guinard (2000: 282); Popper and Kroll (2005: 75); Lawless and Heymann (2010: 328), more complex testing, such as the 9-point hedonic scale, can be successfully adapted for use with children over the age of four by the addition of faces, in conjunction with the appropriate wording.

2.10.2. Sensory evaluation techniques used for children

Sensory testing, with the aid of children, can provide invaluable information in the research and product development process. Guinard (2000: 273) states that food and beverage that are developed specifically for children should be sampled with children and the researcher should accommodate for the range of sensory and cognitive abilities of the target group of children. According to the ASTM's (American Society for Testing and Materials) Committee 18, children's cognitive abilities can be classified, according to their age, as shown in the table below (Wadsworth 1996: 275):

Table 2.4: Cognitive skills of children from infancy to teen age

(adapted from the ASTM's Committee 18 on Sensory Evaluation) (Wadsworth 1996: 275)

Skill/behaviour	8-12 years	12-15 years
Language-reading/written language vocabulary	Very verbal-able to express themselves adequately. Reading and written language skills increase rapidly and are sufficient for most self-administered tasks	Strong language and vocabulary skills. Reading and written language skills continue to increase. Adult level in most respects
Attention span	Potential attention span is increasing, but holding interest is critical	Similar to adult's involvement and interest subject to peer pressure
Reasoning	Full ability for understanding and reasoning, capable of decision making	Reasoning skills are fully developed and similar to adults
Decision making	Capable of complex decisions, peer influences a factor	Fully capable of adult decision processes, subject to peer influences
Understanding scales	Capable of understanding scaling concepts with adequate instruction	Similar to adults
Motor skills	Hand to eye and other fine motor skills developed	Similar to adults
Recommended evaluation techniques	Previous, plus more abstract reasoning tasks. Hedonic scales. Discrimination tasks	Capable of all adult evaluation techniques
Adult involvement	Attribute scaling and ratings	Adult participation not required, unless appropriate to evaluation technique

In school-age children, language skills, memory and ability to reason are more mature and allows for more complex reasoning tasks, such as discrimination tests and hedonic tests as the table suggests (Popper and Kroll 2005: 78). It was found that as children grow older, they are able to rank samples according to sensory attributes (saltiness, sourness, sweetness) (Issanchou 2015: 55).

2.11.Conclusion

There are many challenges faced by the NSNP; however, one of the recommendations for the improvement of the programme states that an energy-dense snack can be served in the morning to learners, to provide energy, until the lunch meal can be served (South African Department of Basic Education 2016: vii). According to Boonyasirikool and Charunuch (2000: 1); Zuydam (2014: 1); Grunert *et al.* (2016: 82); Hoskin (2016: 1); Kumar, Mohanty and Yashaswini (2018: 836) there are a variety of snacks currently on the market. According to the South African Department of Basic Education (2016: vii), an energy-dense snack that is specifically designed for the NSNP has not been addressed before. This snack will serve as a potential solution for the improvement of the NSNP's effectiveness, by being time efficient to distribute at schools for the NSNP, enabling minimum disruption to commencement of the morning classes. In conclusion, the development of a snack item that is cost-effective, efficient to serve and energy-dense would be ideal to supplement the NSNP, for the intellectual and nutritional development of primary school learners in SA.

3. CHAPTER 3

METHODOLOGY

3.1. Introduction

This chapter will lay the foundation for the research design and methodology of this product developmental research project. The study design, study population and sample selection, the product developmental process, validity of the sensory survey and, lastly, ethical considerations will be explained in detail.

3.2. Study design

This study was based on product development, where an energy-dense snack was developed for primary school learners, between the ages of 9 to 13 years. The aim of this study was to investigate, determine and develop a suitable cost-effective, energy-dense snack item for learners, who belonged to quintile one to three public primary schools, to supplement the NSNP by providing primary school learners with a suitable snack to sustain their energy and improve their concentration in class. Primary schools were the focus group of this study, as Yan *et al.* (2016: 2172) states that healthy snacking habits should start as early as possible. The snack product development was informed by a cross-sectional snack preference survey and a scoping review of literature on school feeding programmes, as well as past snack interventions that have shown success in SA and other developing countries in Africa. A cross-sectional study is defined as collection of data on the entire study population at one point in time, to assess the acceptability of the product being tested (Gaille 2018: 1). A survey, indicating snack preferences of primary school children, was conducted, to decide on a suitable cost-effective snack for development. The developed snack product then went through sensory evaluation, using trained personnel; thereafter, microbiological testing, deemed the product safe for consumption. The product then underwent nutritional analysis to determine the nutritional properties of the snack item and shelf-life testing. Finally, the product was presented to the learners for final sensory analysis, to determine sensory acceptability of the developed snack, using a simple 7-point facial hedonic scale.

The snack developed aimed to top up the energy, according to the targeted 30.0% of RDA, while being cost-effective. Cost-effectiveness is important for the NSNP, to afford to roll out this potential energy-dense snack on a larger scale for the primary school learners, receiving meals from the NSNP. The snack preference survey and sensory acceptability of the snack were conducted among two primary schools that receive meals from the NSNP. Specific schools that were identified as part of the NSNP were Quarry Heights Primary School and Duffs Road Primary school. Both these primary schools are based in the Kwa-Zulu Natal, Durban area (Figure: 3.1).

An average of eight consenting staff and students from the Department of Food and Nutrition at the Durban University of Technology, who were familiar with the sensory testing procedure, were used as trained sensory panellists throughout the product development trials. According to Gilbert (2008: 7), for a descriptive sensory test, a range of eight to twelve trained assessors are appropriate. The study population, consisting of approximately 100 primary school learners, aged between 9 and 13 years (50 each from two primary schools), was required for the snack preference survey, as well as consumer sensory evaluations, as a larger number of participants (at least 50 or more) yields more accurate results and a better understanding of consumer views (Zoecklein 2012: 2). Due to COVID-19 regulations, only one school was visited for the consumer sensory evaluation and had 81 participants in total. The sample size was reduced to 81, without negative impact, as reports of sample sizes of at least 40-50 participants are able to produce stable averages for sensory attributes (Moskowitz 1997: 247; Gacula Jr and Rutenbeck 2006: 130). The sample size was reduced, due to students' reluctance to return to school, post the COVID-19 pandemic lockdown. The results of a study, examining a variety of sample sizes, suggest that with a small sample size, the same pattern of confidence will reappear in a larger sample size. In addition, it also suggests that if a study expands too much, patterns discovered in small sample sizes may disappear or change qualitatively (Moskowitz 1997: 254). A flow chart (Figure 3.2) depicts the process of this research study.

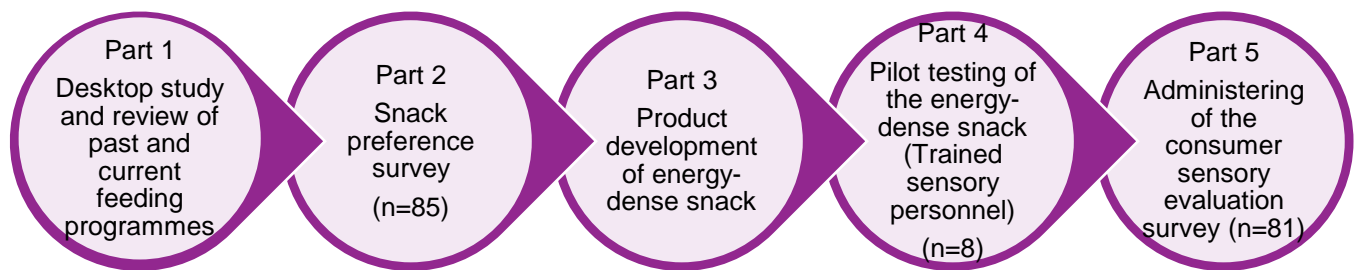


Figure 3.2: Flow chart depicting the process of the research study

3.3.1. Eligibility criteria

Inclusion criteria

- Quintile one to three primary schools in the KZN, Durban area.
- Primary schools that serve meals to the learners as per the NSNP.
- Both boys and girls.

- Boys and girls between the ages of nine to thirteen.
- All race groups.

Exclusion criteria:

- Secondary schools, part of the NSNP.
- Quintile four and five primary schools in the Durban area.
- Primary schools that do not provide a meal to learners and are not part of the NSNP.
- Teachers, catering staff, cleaning and maintenance staff.
- Children allergic to peanuts and gluten.

3.4. Research design

This section will cover the types of measuring instruments used to obtain data for analysis.

3.4.1. Scoping review

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were used to screen the articles for the scoping review (Moher *et al.* 2009: 6). Using a selection of keywords from five databases, articles were imported and reviewed from an endnote database. Using an inclusion criterion, relevant information was extracted and placed into a table for analysis.

3.4.2. Snack preference survey

A snack preference survey was designed, to indicate the type of snack primary school children would prefer. The survey was piloted among n=10 children, to determine understanding of the survey. The options on the survey were: biscuits, muffins, porridge, and an option for other snacks, not presented on the list. The survey form was also translated to isi-Zulu and the back translated into English. Prior to visiting the schools, permission was granted from the DoE (Appendix B). The principal of each school was contacted and after permission was granted, assent forms (Appendix E) were handed out to the learners, to hand to their parents. Once consent was granted on behalf of the learner by the parents to the schools, the snack preference survey could be conducted. Upon visiting the primary schools (Duffs Road Primary School and Quarry Heights Primary School), the researcher, assistants and supervisors were introduced and shown to the classroom, by the principal of each school. After the research project was explained to the learners in a simplified form, they were asked to indicate their gender and age at the top of the form, before indicating their favourite snack. The surveys were then collected and counted. Of the 100 students projected to participate in the survey, only 85 students participated, due to two learners being absent and the capacity of the class (one grade five class from Duffs Road Primary School contained 45 students and the other grade six class from Quarry Heights Primary School contained 40 students). The results were then analysed, in conjunction with the review of

literature, to determine the perfect snack for development. The next step was to begin the development process.

3.4.3. Product development trials

The product development process that was used was based on six phases (Figure 3.3), as described below by Fuller (1994: 22).

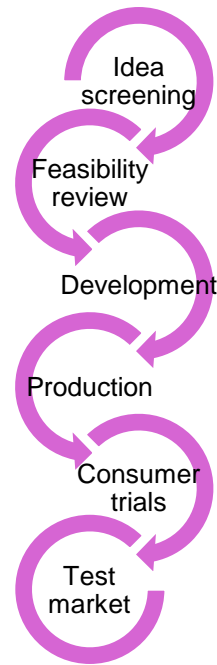


Figure 3.3: Product development process

Fuller (1994: 22)

The first phase was idea generation, where the objectives (cost-effective, easily reproduced, logistically durable) and consumer needs (sensorially acceptable, energy-dense, appealing, ease of consumption) were identified: and these criteria were used as basis for the biscuit. The second phase of this model was the feasibility review whether the product was cost-effective and whether it can easily be mass produced by the NSNP, in future. The development phase was where the product was produced, and sensory trials were conducted (trained sensory panel) to determine whether the product was appropriate and suitable for progression to the next phase. The next phase was the production of the new product which included the establishment of processing specifications, such as temperature, methods used, as well as microbial and shelf-life testing, to create the desired product. Consumer trials were then undertaken by 81 learners, to determine consumer acceptance of the product (consumer sensory panel). The final phase is that of the test market, where the final energy-dense product are mass produced and distributed to the primary school learners of the NSNP, and data is collected over a period, to gauge results of this energy-dense food solution for the NSNP.

After a rigorous desktop study on the past and current energy-dense snacks, created for school feeding programmes, as well as conducting a snack preference survey with the primary school children, the most viable snack food item was an energy-dense biscuit, as it lacks moisture and, therefore, holds a longer shelf-life. The base ingredients used in the development of the biscuit included soy flour, oat flour and peanut butter, due to their protein, fibre and energy content, respectively. Different ratios of the main ingredients were used to determine the most favourable proportions that would provide acceptable sensory properties, whilst being as affordable and practical as possible (Sam 2010: 1). The standard single serve portion was one biscuit, weighing 22g.

Eight recipe development trials were undertaken in the development of an appropriate, sensory acceptable, energy-dense biscuit. Trials were conducted by the researcher in a laboratory (test kitchen) at the Department of Consumer Science: Food and Nutrition at the DUT. The trial samples were subjected to trained panel sensory evaluations, which was conducted by the researcher and included a combination of eight (n=8) lecturers and students (based on availability). Initial development trials included the development of an energy-dense snack ball, which was discontinued, due to its value perception being perceived as too small of a snack for the learners, as well as having a potentially unfamiliar texture, compared to traditional snack items that primary school learners are accustomed to. Feedback gathered from the biscuit evaluation included insights into the acceptability of visual appeal, texture, flavour and aroma. After each recipe development trial, the recipe was reformulated, until the biscuits were deemed sensorially acceptable.

3.4.4. Nutritional analysis

The final version of the energy-dense snack was subjected to nutrient testing in an accredited laboratory, according to the South African National Accreditation System (SANAS), utilising Association of Analytical Chemists International (AOAC 2000) methods, including: protein- Kjeldahl, fat- Soxhlet extraction (Ether), moisture- drying oven 105°C, ash- furnace 600°C, sodium chloride- Laqua meter and carbohydrate- by difference and crude fibre- Wiender methods. AOAC methods are standardised globally and ensures accuracy of testing (AOAC International 2017: 1). The protein content of the biscuit was determined by the Kjeldahl method, which is calculated by digesting the product in a strong acid causing it to release nitrogen that is determined by a suitable titration technique. The amount of protein remaining is calculated from the nitrogen concentration of the food (BUCHI Labortechnik AG 2013: 1). The amount of fat in the biscuit was calculated by Soxhlet method, which uses a solvent to extract the fat from the sample the fat recovered is then weighed (Shin and Park 2015: 972). The carbohydrates were

calculated by difference meaning that the approximate carbohydrate value was determined by subtracting the measured protein, fat, ash and moisture from the total weight (Oxford Reference 2020: 1). The snack was tested and the nutrient content is provided in accordance with the regulations, relating to labelling and advertising for foodstuffs, as listed below (South Africa Department of Health 2010: 28):

- Energy (kJ/100g)
- Carbohydrates (g/100g)
- Protein (g/100g)
- Fat (g/100g)
- Total Dietary Fibre (g/100g)

3.4.5. Cost-effectiveness

Cost-effectiveness of the snack was calculated based on the macronutrients of the product, relative to the selling price of the snack, as compared to the selling price and macronutrients of similar snacks on the market (Faithful to nature 2007: 1; Off the Gluten Path 2020: 1). A table of comparison was drawn, depicting the selling price, as well as the macronutrients of the developed snack, against other commercial snacks currently on the market, to ascertain the products cost-effectiveness.

3.4.6. Microbiological testing

Microbiological testing was then conducted in a SANAS accredited laboratory, using Standard SABS methods for microbial testing of foods using Sabouraud Dextrose Agar plates. A yeast and mould plate count test was conducted, to determine if there are harmful microorganisms present in the product (Heredia, Wesley and Garcia 2009: 264). The product conformed to the regulations, governing microbial standards for foodstuffs and related matters Government Notice No. R490 of 8 June 2001 (South Africa Department of Health 2010: 46).

3.4.7. Shelf-life testing

Accelerated shelf-life testing was conducted, to establish the amount of time the snack can be stored in its final packaging, before quality, structure and microbial deterioration can occur (Graf and Saguy 1991: 67). The shelf-life study was conducted by storing the product, according to accelerated storage conditions and testing it daily against quality and microbiological criteria until it was no longer acceptable. The outcome of the shelf-life analysis projected that the product would be fresh for five weeks and be able to last five months, under proper storage conditions.

3.4.8. Sensory evaluation

Lawless and Heymann (2010: 473) state the primary importance of sensory evaluation is to analyse the variation in response (not limited to other factors such as ingredients, processes, packaging, shelf-life). The samples that were used for the consumer sensory evaluation were developed by the researcher. Each participant was given a single portion of the snack, which consisted of one sample. The sensory evaluation survey that was used for the trained sensory panel (Appendix D) consisted of specific questions, relating to the sensory properties of the snack, including visual appeal, texture, flavour and aroma. The sensory evaluation survey that was used for the consumer sensory panel, among the primary school learners, was designed in the image of a 7-point facial hedonic rating scale, where the faces depicted the degree of whether the participant liked or disliked the snack (Appendix H). Meilgaard, Civille and Carr (2006: 275) affirm that lower scales, using pictorials, are more acceptable to use for children of a grade-school age, as it is easily understood and comprehended.

3.5. Statistical analysis

Data was captured on a Microsoft Excel® spreadsheet, analysed and presented in tables and graphs in Chapter 4. The results of the snack preference survey and the sensory evaluation survey were statistically analysed using Statistical Package of the Social Science (SPSS) (software version 26.0® SPSS Inc. Chicago, IL, USA). The chi-square goodness-of-fit test was used to test for significance in preference for the snacks and the chi-square test of independence was used to test for differences across age and gender. For the sensory evaluation survey, non-parametric tests were used. The Mann-Whitney test for significant differences in scores across gender and the Kruskal Wallis test for significant differences across age were used. The chi-square goodness-of-fit test was used, to see if any score was selected significantly more than others.

3.6. Validity

Validity in research refers to the accuracy, in the extent to which the tools used to measure what it is intended to measure (Heale and Twycross 2015: 66). Reliability in research refers to the consistency in measure (Heale and Twycross 2015: 67). A validated hedonic scale was used for the sensory evaluation surveys. Official DRI tables were used for analysis, from the Institute of Medicine (2010: 1). The snack preference survey was also piloted, and ambiguous wording was removed, to simplify the survey. The standard, validated PRISMA guidelines were used to head the scoping review, ensuring reliability of results.

3.7. Quality assurance and reduction of bias

The trained panel sensory evaluation form was piloted by the supervisor. The snack preference survey and the consumer sensory evaluation form was piloted by children between the ages of 9

and 13 years which is the same age as the sample group of the study (however, these children did not take part in the study), to check for ambiguity, appropriateness and comprehend-ability. During the sensory analysis for the trained panellists, a sensory evaluation tray with the following standard items were presented to each panel member: product sample, sensory evaluation sheet, pencil, eraser, glass of water. The panel member would take a sip of water and proceed to taste the sample. Based on their analysis, they would rate the sample on a scale of 1-5 for the following sensory properties, visual appeal, texture, flavour and aroma. COVID-19 protocols were followed such as: maintaining a 1.5m distance between panellists, wearing a facemask and using an alcohol-based sanitiser before and after sampling the product.

All equipment (calibrated scale, bowls, spoons, measuring spoons and cups) used to prepare the trials and final product were consistent for every batch. To prevent variation, the same brand of all ingredients was used for all products produced. Each batch of dough was weighed and divided equally to yield 20 biscuits per batch, with each biscuit weighing 22g. The biscuits were baked at the same temperature (180°C) in the centre of the conventional electric oven for 8-10 minutes. Once the biscuits were baked, they were cooled completely, and heat sealed individually in plastic packets. Due to COVID-19 regulations, certain extra precautions were put in place for the development of the product in the lab, as stipulated in Standard Operating Procedures (SOPs) for Product Development (Appendix J). The biscuits were transported to the schools in a box.

During the consumer sensory evaluation, the children were spread out in the classroom (about one meter away from each other), ensuring that proper regulations for the prevention of COVID-19 were adhered to (South Africa 2020: 6). Learner's hands were sanitised before they were given a single wrapped biscuit, survey form, pencil and wet wipe. The children were also instructed to be silent while the session was in process. Standard Operating Procedures were drawn up to facilitate the sensory evaluation process (Appendix K). The researcher collected data with trained field workers and was accompanied by supervisors for quality checks.

3.8. Data quality management

Research assistants were responsible for inspecting that learners completed the snack preference and sensory evaluation forms. Data from the snack preference survey and sensory evaluation sheets were captured on a Microsoft Excel spreadsheet by the researcher. The data entry was cross-checked for accuracy by the supervisor and statistician. Throughout data capturing, coding and cleaning, data quality was maintained by making sure that all data was captured in a systematic manner, coded appropriately and cleaned so that no inconsistencies were present. Electronic data was password protected and only the researcher, supervisors and statistician had access to the data.

3.9. Ethics

Resnik (2015: 1) defines ethics as a method for determining the manner in which to act and for analysing complex problems and issues. It is important to follow ethical norms, as it promotes the aims of research, such as knowledge, truth and avoidance of error. To ensure ethical credibility, permission was obtained from the following gatekeepers, before proceeding with the methodology steps:

- The Durban University of Technology (DUT) together with the Institutional Research Ethics Committee (IREC) issued an ethics clearance letter (Appendix A), for permission to conduct sensory evaluations at primary schools, after careful review of the proposal for this research.
- Once permission was granted by the KZN DoE (Appendix B), gatekeeper permission from DUT for trained sensory analysis was obtained (Appendix C). Thereafter, the researcher contacted the primary schools, and through purposive sampling, two schools were chosen, and a letter of information was sent to the principles of the schools (Appendix D).
- After permission was granted from the principles of the schools, the parents of the learners (aged 9 to 13) chosen to participate in this study, was given a letter of information, as well as an assent form, granting permission on their child's behalf to participate in the study (Appendix E). These steps were taken as the age group of the participants of this study was regarded as a vulnerable group and, hence, special permission had to be taken for their inclusion into this study.
- During the sensory testing session, participants were told that if they wish to withdraw from the study, they were free to do so at any point in the session, without any penalties/negative consequences. Participants were also made aware of potential allergens.
- A code of confidentiality was also maintained during the trained and consumer sensory trials, where the participants were informed that no names would be used as part of the study.
- A strict code of hygiene, based on DUT and COVID 19 regulations, was always adhered to (Appendix J and K), where the researcher and assistants involved in the developmental process practised proper sanitation and dressed in specific chef's uniform, as well as certain Personal Protective Equipment (PPE), such as face masks and face shields, to avoid any possible contamination (South African Department of Basic Education 2020a: 6).

3.10. Conclusion

This chapter dived into the depth of the academic and scientific methodology that was used to conduct this study, ensuring that the methods and procedures were ethically, academically and scientifically sound. The next chapter will proceed to discuss the results of this study.

4. CHAPTER 4

RESULTS

4.1. Introduction

In this chapter, the results of the review of previous snack development studies, snack preference survey, product developmental tests, trained and consumer sensory evaluations, microbiological tests, nutritional tests and shelf-life tests will be presented and analysed as descriptive and inferential statistics in the form of graphs, figures, and tables.

4.2. Review of articles

The aim of the review was to analyse primary school feeding schemes that offered snacks and to identify and develop a viable snack option for the inclusion in the NSNP. The search strategy was formulated, based on knowledge of the literature, using the following keywords to broaden the retrieval of relevant articles: “energy-dense”; “snack foods”; “cost-effective”; “developing countries”; “healthy snacks”; “primary school children”; “Africa” and “nutrition feeding program”. Five databases were reviewed for articles, including National Research Foundation (NRF), NEXUS, Elton B. Stephens Company (EBSCO), International Food Information Service (IFIS), Nutrition and Food Sciences Center for Agriculture and Bioscience International (CABI.ORG) and Google Scholar. All papers (titles and abstracts) were imported into an endnote database and duplicates were removed. Using the pre-specified inclusion criteria, the article’s titles and abstracts were screened by one independent reviewer. Relevant information on the study design, duration, number of participants, age of study population, the type of product developed, outcomes, results and limitations were extracted. The critical appraisal of studies included the adherence to the steps of food product development. Other considerations included in the appraisal were packaging, storage, transport and food safety. After a careful screening process, based on the PRISMA guidelines (Figure 4.1), nine studies were identified as snack developmental studies, of which four were from Africa (including two from Tanzania and one each from Kenya and Ethiopia) and five within SA.

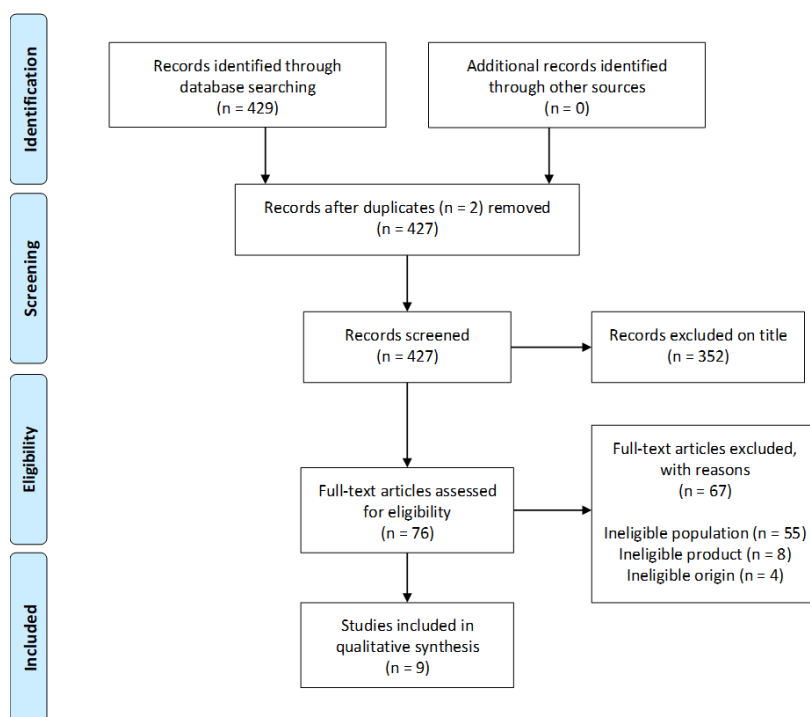


Figure 4.1: PRISMA flow diagram

(Moher *et al.* 2009: 6)

4.3. Review of previous snack developmental studies

The studies that were considered focused on snack development for school children, as part of a feeding program. Studies, reporting on snack development for school feeding programs in Africa, for both primary and secondary school children, were eligible for the review. Articles published in English, and unpublished dissertations and theses for the period 2000–2020 were included in the review. The included studies were not limited to reporting snack product development, but also included studies reporting health and educational outcomes from the snack product development. The age inclusion criteria covered the general school age of children in Africa, which was guided by the South African Schools Act of 1996, whereby children aged 7–15 are compelled to attend school as well as the RDA categories for children, namely 4–8 years, 9–13 years and 14–18 years (South Africa 1996; Institute of Medicine 2010). The study designs included: experimental, randomized and non-randomized control trials; cross-sectional designs; and pre- and post-test designs. An article in the International Journal of Environmental Research and Public Health has been published based on this review (Appendix I).

Table 4.1: Review of previous snack development studies

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
(Zivkovich 2011) Roche Village, Rorya District, Tanzania, East Africa	Non-randomised, experimental design	15 months	Uji (Corn based porridge made from the root of the cassava plant and millet grain).	The impact of a 130- kcal supplemental snack on growth of primary school children aged 4½ to 11 years old.	Significant decline in the mean height-for-age z- scores (-.37952) and mean weight-for-age z- scores (-.19452) from BL to F/U. (BL= 2.2% underweight, 5.3% stunted and 0.9% wasted; F/U= no student had a z-score of <-2 SD for underweight, stunting, or wasting.	No control group. Reduced reliability of anthropometric measures due to learners taking the measurements for themselves. No sensory acceptability tests. No delivery of ingredients on certain days. Variation in the preparation methods. No cost analysis.

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
(Murphy <i>et al.</i> 2007) Kenya	Randomised controlled design	2 years	Three equicaloric snacks were developed: a vegetarian snack designated the “energy snack,” a snack that included beef, and a snack that included whole milk. All snacks were designed to include the local staple food; githeri (a stew of maize, beans, and vegetables). The energy	Effect of snack design on micronutrient deficiencies in rural Kenyan schoolchildren.	Significant increase in energy intake and vitamin B12 for animal-source snack. Control group increased energy intakes by 18kJ/d. Meat group increased energy intakes by 536kJ/d.	Home intake and intake from the study was not evaluated side by side. Breaks in feeding due to weekend, school holidays or days missed due to illness. No cost analysis.

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
			<p>snack consisted of 230 g of vegetarian githeri, the meat snack contained 225g of githeri with 38% cooked minced beef. To include milk in a snack, the amount of vegetarian githeri was reduced to 100 g, and a glass of milk (250 g) was included in the snack.</p>			

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
(Ash <i>et al.</i> 2003) Mpwapwa district, Tanzania	Randomised, double-blind placebo-controlled trial	6 months	Multiple-micronutrient beverage powder fortified with ten micronutrients developed and produced by food technologists at Procter and Gamble.	Effect of a micronutrient-fortified beverage on iron status, anaemia, vitamin A status, and growth of the schoolchildren in Tanzania.	Nonsignificant differences at BL between children in the fortified and nonfortified groups for iron status and serum retinol. Improved anthropometric measurements in the fortified group (mean incremental changes in weight (1.79 compared to 1.24kg), height (3.2 compared to 2.6cm) and BMI (0.88 compared to 0.53) Significantly lowered prevalence of anaemia and vitamin A deficiency. Serum retinol levels (<200µg/l) dropped from 21.4% to 11.3% in the fortified group).	Eleven students were excluded from the entire study due to them having severe anaemia. The amounts of the nutrients selected for the fortified beverage were estimates because no previous efficacy data existed for a beverage fortified with multiple micro-nutrients. Sensory acceptability tests not indicated. No cost analysis.

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
(Belayneh <i>et al.</i> 2018) Ethiopia	Mixed methods (workshop, sensory testing, focus group discussions)	Not indicated	Kinchie (Porridge) made from QPM (quality protein maize) coarsely milled maize gain.	Stakeholders' consultation, sensory evaluation and potential impact of Quality protein maize (QPM) for school feeding in Ethiopia	QPM kinchie was liked very much by 58% of the participants, whereas only 1.7% rated conventional maize kinchie in this category. None of the participants scored QPM kinchie as poor in terms of taste, however 0.8% of participants scored conventional maize kinchie as poor in taste. Overall evaluation shows that approximately 61% of the participants perceived QPM kinchie as very good, whereas only 5% of the participants perceived conventional maize as very good.	Lack of the QPM seed was identified as a possible limitation in the way forward with implementing QPM into school feeding programs. Samples that were served later showed lower score ratings than samples that were served first. No cost analysis.

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
					66% of participants rated QPM kinchie to have good texture and 21% rated it as very good texture, whereas 58% reported conventional maize to have a fair overall sensory characteristic.	
(Kearney, Oldewage–Theron and Napier 2011) South Africa	Experimental product development study	6 months	A nutritious vetkoek (bread type cake fried in oil)	The development of a nutritious novel food product that is acceptable to children, rich in energy, protein and micronutrients. The product should be affordable, cost effective and easy to prepare, using locally available raw materials, with minimal waste and no need for specific	Sensory acceptability tests showed 90% of children found the product to be acceptable. 65% liked the vetkoek very much. The cost of the product was R1.50 (~0.080 USD) per day for a 120g portion and contributed to a nutrient intake of 21.6% for energy, 14.4% for calcium, 14.1% for	More research is needed to test compliance of consumption over a longer period (at least 12 months). No market needs analysis.

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
				fortification or enrichment.	iron, 62.42% for zinc and 17.8% for vitamin A. The vetkoek had a shelf life of two days stored at room temperature (25°C).	
(du Plessis 2010) South Africa	Cross sectional study	Not indicated	Biscuit enhanced with soy flour (nutty wheat flour, Supro Max 6010, flavoured sprinkle, baking powder, margarine, egg, fat free milk)	Development of a nutritious, acceptable and affordable snack food to prevent obesity in children.	An affordable, safe and acceptable food product, with a low-fat and high-density nutritional value, with at least 20% of RDI for protein and iron was successfully developed. Sensory evaluation: 58.3% liked the taste, 57.0% liked the texture, 54.3% liked the colour, 59.5% liked the smell and 48.9% liked the portion size. Cost per 30g portion of the biscuit was priced at 0.55 ZAR (~0.031 USD).	The final snack item was not sent for analysis again. This study was only carried out in 2 primary schools. Soy flour (Supro Max 60100) is not readily available to consumers.

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
(Hochfeld <i>et al.</i> 2016) Johannesburg, South Africa	Pre and post-test design (A study that measures a variable/ many variable of interest before and after an intervention)	10 months	Fortified cooked porridge (oats, maize, wheat and sorghum based)	Effect of an in-school breakfast program on the anthropometric and school performance of school children.	There was a positive and statistically significant nutritional change over the period of the program. A reduction in the numbers of overweight and stunted children was seen (BL 27.6% of learners were either overweight (16.9%) or severely overweight (10.7%). F/U Overweight (13.8%) and severely overweight (6.4%). Learners, educators and principals indicated that they perceived the breakfast program had a positive impact on the children's ability to learn by improving their participation and	The inability to conduct an experimental design where one can systematically control for other intervening factors. The design did not control for other factors to some extent and therefore the nutritional and performance changes cannot be scientifically attributed to the breakfast program. The nutrition program was launched before the baseline data could be collected. School performance data for the first two terms was missing therefore, the data analysis was compromised. No sensory acceptability tests. No cost analysis.

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
					concentration in the classroom.	
(van Jaarsveld <i>et al.</i> 2005) Durban, KZN, South Africa	Randomised controlled unmasked feeding trial.	53 school days	Cooked orange-flesh sweet potato and white fleshed sweet potato as the placebo.	The effect of daily consumption of boiled and mashed, orange-fleshed sweet potato on vitamin A status of primary school children.	The proportion of children with low serum retinol concentration ($<0.070\mu\text{mol/L}$) after intervention decreased from 71% to 50% ($P=0.001$) in the treatment group and decreased from 73% to 49% ($P=0.001$) in the control group.	The study did not assess the prevalence or degree of helminthic infections. No intervention took place during the school holidays. No sensory acceptability tests. No cost analysis The availability of orange flesh sweet potato is dependent on seasonality.
(van Stuijvenberg <i>et al.</i> 2007)	Cross-sectional study	2.5 years	Shortbread based biscuit, fortified with	Effect of a micronutrient-fortified biscuit on	The micro-nutrient fortified biscuit was enough to maintain	No intervention took place during the school holiday.

Author, year, Location	Study design	Duration	Product developed (ingredients)	Outcomes	Results of study	Limitations
South Africa			B-carotene, iron and iodine fortified biscuit, served with a cold drink, fortified with vitamin C.	micronutrient deficiencies in primary school children.	serum retinol concentrations on a day-to-day basis; however, was not enough to sustain levels during the long school holiday. Prevalence of low urinary iodine dropped from 97.1% before the intervention to 4.8% after the first 12 months of intervention	Logistical issues prevented the delivery of a vitamin C-fortified cold drink for nine months. The biscuit was baked at 210°C, which may have possibly degraded the iron amino acid chelate used in the biscuit. There was no control group as all children received the fortified biscuit. No sensory acceptability tests. No cost analysis.

4.3.1. Ingredient specification

Five out of the nine studies used staple foods in the product development of a snack for the school feeding program. In the study by Zivkovich (2011: 2) an Uji snack was developed, by boiling a mixture of water, ground corn flour and sugar, to create a corn-based porridge. In Kenya, Murphy *et al.* (2007: 1093) developed three snacks, using a local staple food as a main ingredient, namely githeri a stew of maize, beans and vegetables, to address micronutrient deficiencies in rural school children. Three equicaloric snacks were developed: a vegetarian snack designated the “energy snack”; a snack that included beef; and a snack that included whole milk. The energy snack consisted of 230 g of vegetarian githeri, the meat snack contained 225g of githeri, with 38% cooked minced beef. To include milk in a snack, the amount of vegetarian githeri was reduced to 100 g, and a glass of milk (250 g) was included in the snack. Belayneh *et al.* (2018: 377-382) developed a porridge, Kinchie, made from QPM (quality protein maize) coarsely milled maize grain, where QPM was compared with conventional maize for school feeding in Ethiopia. In the study by Hochfeld *et al.* (2016: 1-9), a fortified cooked porridge with oats, maize, wheat and sorghum was developed in Johannesburg, SA. Lastly, in the study by Kearney, Oldewage–Theron and Napier (2011: 4) a vetkoek was developed, which is a traditional South African snack that is a bread type cake fried in oil, which was 120g per portion and the ingredients formed part of the most commonly purchased household food items. Four out of the nine studies used fortified ingredients to develop snacks for the school feeding program. In the first study, a multiple-micronutrient fortified beverage powder, with ten micronutrients, was developed by food technologists at Procter and Gamble, for primary school children in Tanzania (Ash *et al.* 2003: 891). The second study, a long-term study done in SA by van Stuijvenberg *et al.* (2007: 1201-1209), a micronutrient-fortified biscuit was developed and served with a vitamin C fortified cold drink, to evaluate the impact of on micronutrient deficiencies in primary school children over a period of 2.5 years. In the third study, Hochfeld *et al.* (2016: 1-9) developed a fortified cooked porridge for an in-school breakfast program in SA. In Kenya, Murphy *et al.* (2007: 1093) developed three snacks, using githeri (stew of maize, beans and vegetables) to address micronutrient deficiencies in rural school children. Three equicaloric snacks were developed primarily from fortified cooking fat. In the remaining studies, orange-fleshed sweet potato was used to assess the effects of β -carotene on the vitamin A status of primary school children (van Jaarsveld *et al.* 2005: 1080-1087) and a biscuit enhanced with soy flour, was developed to prevent obesity in children in SA (du Plessis 2010: 1-174).

4.3.2. Nutritional outcomes

Seven out of nine studies evaluated nutritional outcomes of the developed product. The first study evaluated the impact of a 130kcal supplemental snack (corn-based porridge) on the growth of primary school children, living in rural Tanzania, over a period of 15 months. Findings showed that

there was a significant decline in the mean height-for-age z-scores and mean weight-for-age z-scores, from baseline to follow-up which contributed to a negative effect (Zivkovich 2011: 2). The second study involved the development of three snacks, using githeri to reduce micronutrient deficiencies in rural school children in Kenya. After a two-year duration, the effect of the snack design on micronutrient deficiencies in rural Kenyan school children was measured. There was a significant increase in energy intake, as well as vitamin B12 in the children who consumed the animal-source snack. Children in the control group had increased energy intakes by 18kJ/d, whereas those in the meat group had increased energy intakes of 536kJ/d (Murphy *et al.* 2007: 1093). In the third study, by Ash *et al.* (2003: 891) a fortified beverage was developed, to determine the effect of the micronutrient-fortified beverage on iron status, anaemia, vitamin A status and growth of schoolchildren in Tanzania, aged 6 to 11 years. Results noted non-significant differences at baseline, between children in the fortified and nonfortified groups in iron and serum retinol levels: however, at the six-month follow-up, mean incremental changes in weight, height and BMI were significantly higher in the fortified group than in the nonfortified group. Results also showed that the fortified beverage lowered the overall prevalence of anaemia and vitamin A deficiency. The fortified beverage improved anthropometric measurements in the fortified group and significantly lowered the overall prevalence of anaemia and vitamin A deficiency (Ash *et al.* 2003: 891). Kearney, Oldewage-Theron and Napier (2011: 4) developed a nutritious vetkoek (bread type cake fried in oil) snack, which contributed to a nutrient intake of the target group (children aged 6-13 years old) by 21.6% for energy, 14.4% for calcium, 14.1% for iron, 62.4% for zinc and 17.7% for vitamin A. In the study by Hochfeld *et al.* (2016: 1), the effect of an in-school breakfast program on the anthropometric and school performance of school children was evaluated. This study showed positive results, as there was a statistically significant nutritional change over the period of the program. A 4.7% decrease in severe stunting levels and an overall 4.3% positive change in the number of children in the category of normal height for the age limit were seen. Baseline measurements for overweight learners indicated 27.6% of learners were either overweight (16.9%) or severely overweight (10.7%) and follow-up results indicated that the overweight percentage reduced to (13.8%) and severely overweight dropped to (6.4%). Learners, educators and principles indicated that they perceived the breakfast program had a positive impact on the children's ability to learn, by improving their participation and concentration in the classroom (Hochfeld *et al.* 2016: 9). In another study, primary school learners were fed 125g of sweet potato for five days during the week, as a snack, to assess the effect on vitamin A status of the children. The treatment group were fed orange-fleshed sweet potato, which is rich in β -carotene, and the control group were fed white-fleshed sweet potato. The results of this study showed an improvement in vitamin A stores in the treatment group when compared to the control group. After intervention, the proportion of children with low serum retinol concentration ($<0.070\mu\text{mol/L}$) decreased from 71% to 50% ($P=0.001$) in the treatment group and decreased from 73% to 49%

($P=0.001$) in the control group (van Jaarsveld *et al.* 2005: S213). In the remaining study, the effect of a micronutrient-fortified biscuit, on micronutrient deficiencies in primary school children, was evaluated. Results indicated the micronutrient fortified biscuit was adequate to maintain serum retinol concentrations on a day-to-day basis; however, it was not sufficient to sustain levels during the long school holiday. Urinary iodine levels improved from baseline to follow-up, where the prevalence of low urinary iodine dropped from 97.1% before the intervention to 4.8% after the first 12 months of intervention (van Stuijvenberg *et al.* 2007: 1201).

4.3.3.Sensory analysis

Four out of the nine studies conducted sensory analysis. In the study by Murphy *et al.* (2007: 1093), sensory analysis was firstly conducted on research staff and then on children for acceptability; however, the type of sensory tests conducted were not indicated. In the study by Belayneh *et al.* (2018: 377) results of the sensory analysis showed a strong liking towards the QPM, with 58.0% of the participants liking QPM kinchie very much, whereas only 1.7% rated conventional maize kinchie in the same category. Overall evaluation showed that approximately 61.0% of the participants perceived QPM kinchie as very good, whereas only 5.0% of the participants perceived conventional maize as very good. 66.0% of participants rated QPM kinchie as having a good texture and 21.0% rated the texture as very good, whereas 58.0% of participants reported conventional maize kinchie as having fair overall sensory characteristic. None of the participants scored QPM kinchie as poor in terms of taste, however 0.8% of participants scored conventional maize kinchie as poor in taste. The sensory acceptability results for the product developed by Kearney *et al.* showed that sensory acceptability tests showed 90.0% of children found the product to be acceptable and 65.0% liked the vetkoek very much (Kearney, Oldewage–Theron and Napier 2011: 4). In the remaining study by du Plessis (2010: 119) sensory evaluation revealed that approval rates for the biscuit were as follows: 58.3% liked the taste; 57.0% liked the texture; 54.3% liked the colour; 59.5% liked the smell; and 48.9% liked the portion size.

4.3.4.Costing

Only two of the nine studies costed the developed product. In the study by du Plessis (2010: 138) the cost per 30g portion of biscuit priced at R0.55 and in the study by Kearney, Oldewage–Theron and Napier (2011: 1), the vetkoek was priced at R1.50 per 120g portion.

4.3.5.Conclusion

Analysis of the reviewed articles inferred that the most successful snack product to develop for this study is a biscuit. The results exhibit biscuits to have a longer shelf life than most other snacks. It can be emulated with ease and has the opportunity to carry many nutrients, while being cost effective.

4.4. Snack preference survey

A snack preference survey was conducted with a sample of the targeted primary school learners, to determine the snack item most preferred.

Table 4.2: Snack preference survey results based on gender (n=85)

Snack preference	Gender	
	Girls (n=43)	Boys (n=42)
Biscuit	14 (32.6)	14 (33.3)
Muffin	24 (55.8)	24 (57.1)
Porridge	3 (7.0)	3 (7.1)
Other	2 (4.7)	1 (2.4)

According to Table 4.2, girls made up most of the participants (50.6%), whereas boys made up 49.4%. The most preferred snack was equally liked by both girls and boys. Muffins were preferred by 57.1% boys and 55.8% girls, respectively. The snack with the second highest preference was also liked by both genders equally. Biscuits received the second highest preference at 32.6% for girls and (33.3%) for boys, respectively. The Fisher's Exact test show there was no significant relationship between gender and choice of snack ($p = 1.000$)

Table 4.3: Snack preference survey results based on age (n=85)

Snack preference	Age					Total
	9	10	11	12	13	
Biscuit	6 (7.05)	8 (9.41)	7 (8.23)	7 (8.23)	0	28
Muffin	2 (2.35)	19 (22.35)	16 (18.82)	8 (9.41)	3 (3.53)	48
Porridge	1 (1.18)	3 (3.53)	0	2 (2.35)	0	6
Other	0	3 (3.53)	0	0	0	3

Table 4.3 depicts the children, who preferred muffins the most, to be between 10 ($n=19$, 22.4%) and 11 ($n=16$, 18.8%). The children who preferred biscuits the most were aged 10 ($n=8$, 9.4%). Porridge was the least preferred. The children who preferred porridge were aged 10 ($n=3$, 3.5%). According to the Chi-square goodness-of-fit test ($\chi^2(3) = 62.435$, $p < .0005$), there was a significant difference in the frequency with which the snacks were preferred. Significantly more children preferred muffins (48-56.5%) and biscuits (28-32.9%); however, the Fisher's Exact test show that there was no significant relationship between age and choice of snack ($p = 0.141$).

From the review of previous studies and the snack preference survey, the research team decided to develop a biscuit, factoring in shelf-life, cost-effectiveness, and ingredient nutrient density. A recipe was sought and trained sensory trials followed.

4.5. Trained panellists sensory evaluation results of the biscuit trials

Table 4.4: Trained panellists sensory evaluation

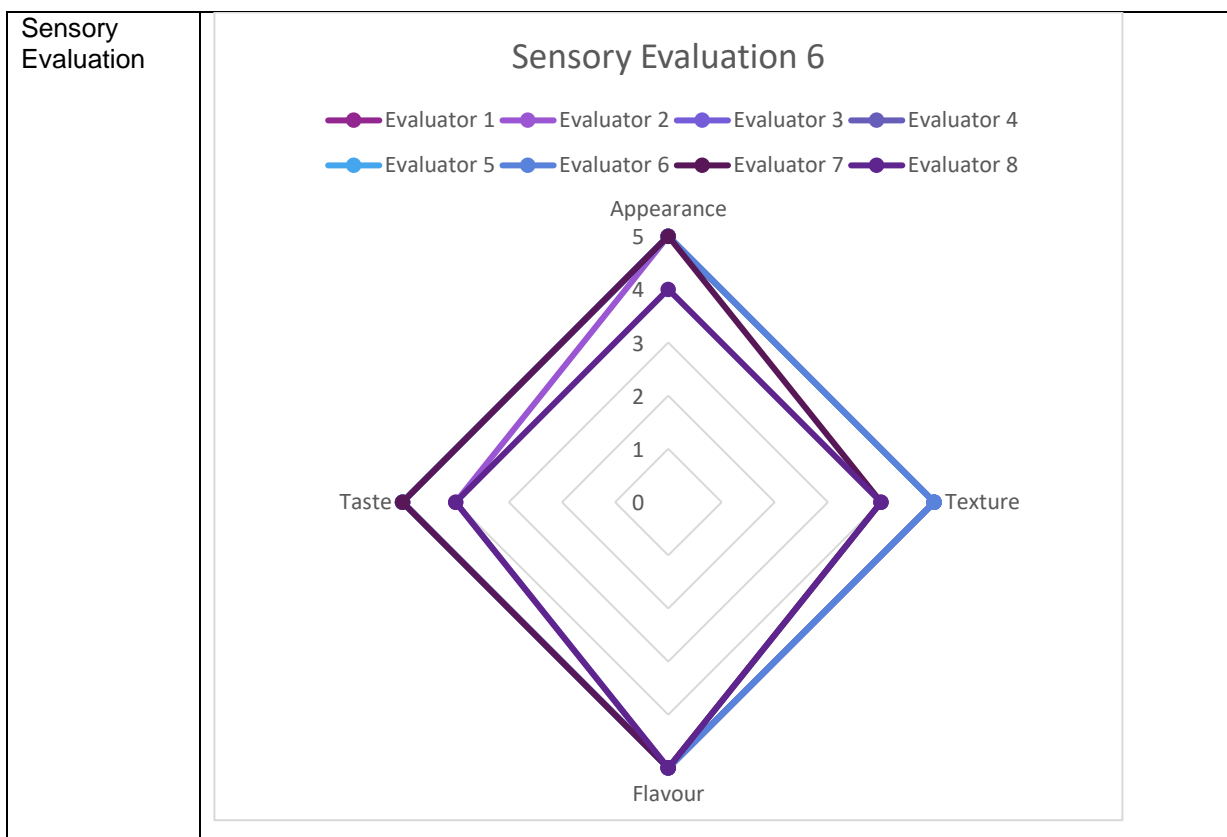
Product development Test 1	Recipe trial 1 (Appendix L)
Sensory Analysis	Appearance was appealing but light in colour. However, the biscuit spread out when baked which was not ideal for packaging and transport purposes. The texture was crisp and crunchy, slightly greasy- greasy texture not very pleasant. Flavour had a 'nutty', 'typical crunchie-like' taste, quite sweet, had a 'lingering peanut butter aftertaste'. Aroma was 'sweet', 'biscuit' aroma.
Changes	Appearance: could be improved, to be thicker rather than thin. Texture: texture could be improved by reducing the fat and sugar content, to reduce the spread when baking. Flavour and aroma: by reducing the sugar, the biscuit would be more appealing. Aromatics did not need to be altered.
Sensory Evaluation	<p>Sensory Evaluation 1</p> <p>Legend: Evaluator 1 (red), Evaluator 2 (purple), Evaluator 3 (blue), Evaluator 4 (dark blue), Evaluator 5 (light blue), Evaluator 6 (teal), Evaluator 7 (dark red), Evaluator 8 (purple)</p> <p>Attributes: Appearance, Texture, Flavour, Taste</p> <p>Scale: 0 to 5</p>
Product development Test 2	Recipe Trial 2 (Appendix M)
Sensory Analysis	The appearance was characteristic of a biscuit. Golden-brown with good shape. The texture had a 'good snap', typical of a crunchie. Flavour was characteristic of peanut butter, not unpleasantly sweet. Aroma was lacking.
Changes	Appearance: no alteration to the appearance. Texture: no alteration to the texture. Flavour and aroma: peanut butter flavour could be enhanced.

Sensory Evaluation	<p style="text-align: center;">Sensory Evaluation 2</p>
Product development Test 3	Recipe Trial 3 (Appendix N)
Sensory Analysis	<p>The appearance was characteristic of a drop biscuit. Golden-brown with good shape. The texture had a soft, tender mouthfeel. Oats added a chewy texture. Soft texture was not appealing to some.</p> <p>Flavour had a peanut butter taste. Balanced flavour profile.</p> <p>Aroma was lacking, had a slight peanut butter aroma.</p>
Changes	<p>Appearance: no alteration to the appearance.</p> <p>Texture: could be crispier.</p> <p>Flavour and aroma: peanut butter flavour could be enhanced.</p>

Sensory Evaluation	<p style="text-align: center;">Sensory Evaluation 3</p> <p style="text-align: center;"> Evaluator 1 Evaluator 2 Evaluator 3 Evaluator 4 Evaluator 5 Evaluator 6 Evaluator 7 Evaluator 8 </p> <p style="text-align: center;">Appearance</p> <p style="text-align: center;">5</p> <p style="text-align: center;">4</p> <p style="text-align: center;">3</p> <p style="text-align: center;">2</p> <p style="text-align: center;">1</p> <p style="text-align: center;">0</p> <p style="text-align: center;">Taste</p> <p style="text-align: center;">Texture</p> <p style="text-align: center;">Flavour</p>
Product development Test 4	Recipe Trial 4 (Appendix O)
Sensory Analysis	<p>The appearance was characteristic of a drop biscuit. Golden-brown with good shape. Looks appealing.</p> <p>The texture had a soft, tender mouthfeel. Oats added a chewy texture. Soft texture was not appealing to some. The oats were found to be 'too gritty' in the mouth.</p> <p>Flavour had a pronounced peanut butter taste. Too sweet for some participants.</p> <p>Aroma was pleasant, had a 'warm baked aroma', characteristic of peanuts.</p>
Changes	<p>Appearance: no alteration to the appearance.</p> <p>Texture: could be crispier and not so dense and gritty.</p> <p>Flavour and aroma: no changes to the flavour and aroma as less than half of participants found it too sweet.</p>

Sensory Evaluation	<p style="text-align: center;">Sensory Evaluation 4</p>
Product development Test 5	Recipe Trial 5 (Appendix P)
Sensory Analysis	<p>The appearance was characteristic of a ginger biscuit. Dark golden-brown colour, even shape, smooth exterior. Could be improved to be appealing for children.</p> <p>The texture had a slightly firmer mouthfeel. Oats added a chewy texture.</p> <p>Flavour could be a more pronounced peanut flavour.</p> <p>Aroma was pleasant, had a 'warm baked aroma'. Could increase the peanut aroma.</p>
Changes	<p>Appearance: could be more appealing to a child. Suggestion to indent a pattern on top.</p> <p>Texture: texture could be crisper. Suggestion to flatten the biscuit more before baking.</p> <p>Flavour and aroma: could be improved to increase the peanut flavour.</p>

Sensory Evaluation	<p style="text-align: center;">Sensory Evaluation 5</p>
Product development Test 6	Recipe Trial 6 (Appendix Q)
Sensory Analysis	<p>The appearance was characteristic of a ginger biscuit. Dark golden-brown colour, even shape, smooth exterior. The pattern on the biscuit added to the appeal.</p> <p>The texture was crispy. Crushed oats added a chewy texture.</p> <p>Flavour had a more pronounced peanut flavour.</p> <p>Aroma was pleasant, had a 'warm baked aroma'. Peanut butter aroma was prominent.</p>
Changes	<p>Appearance: none.</p> <p>Texture: none.</p> <p>Flavour and aroma: none.</p>



Trained sensory testing was undertaken by the Food and Nutrition staff and students (n=8), to determine sensory acceptability of the recipe. Table 4.4 depicts six sensory evaluation tests that were used to obtain a suitable recipe. The combination of energy-dense ingredients in various proportions were tested for sensory acceptance, before a suitable ratio could be determined that had a favourable impact on the texture, appearance, aroma and taste. Sensory evaluation one (a) revealed that the biscuit was too greasy, due to the high fat content and too sweet; hence, a reduction of fat and sugar was taken in test two. For the second sensory evaluation, participants felt that the flavour and aroma was lacking. Sensory evaluation three (b) indicated that these adjustments resulted in a softer biscuit texture, which was unappealing according to the sensory evaluation spider chart three. In the sensory test three, the whole oats were said to be unappealing, as it made the biscuit dense and chewy in texture. The oats were then crushed for sensory test four, but this did not solve the soft texture of the biscuit which, according to the sensory evaluation spider chart four, still showed that the texture was too soft. The texture of the biscuit for sensory test five (c) still needed development, as it was still chewy and soft in texture, although the appearance was improved with the crushed oats. The peanut flavour and aroma were also found to be lacking. Suggestions to make the biscuit more appealing to children, were considered and finally, in sensory test six (d), a suitable biscuit was achieved. By flattening the

dough before baking, the biscuit was crisper, rather than dense and chewy. The decorative pattern on the biscuit added to the appeal, and the peanut butter flavour and aroma was pleasant.

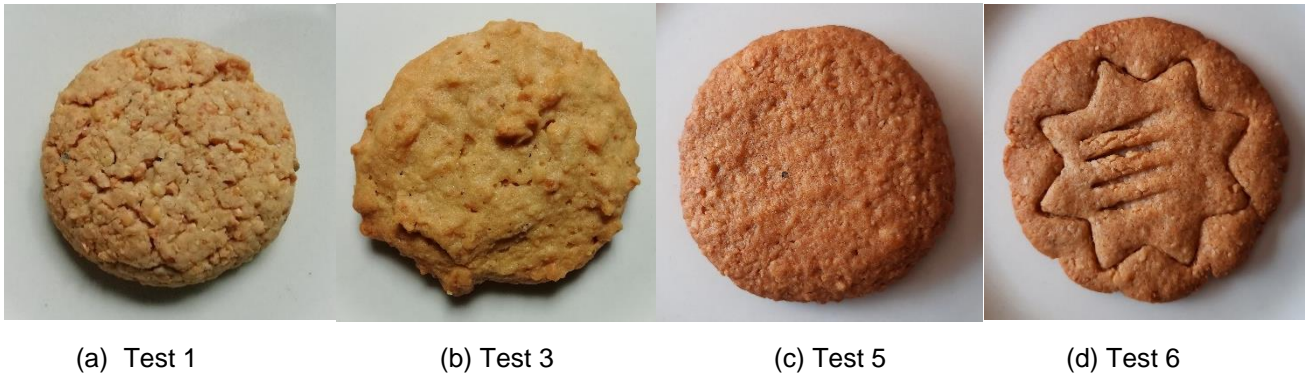


Figure 4.2: Recipe trials

4.6. Final recipe

Table 4.5: Final recipe

RECIPE/PRODUCT: Peanut butter biscuit SESSION NO: 6 TOTAL RECIPE YIELD: 432.15g PORTION YIELD: 20 portions (mass ~22g, after baking mass 20g) COST PER PORTION: R 0.79					
Qty	Unit	Percentage	Ingredient	Step	Method
				1	Preheat oven to 180°C and line baking sheets with baking paper.
62.5	g	14.46	Margarine	2	Cream the margarine and brown sugar until light and fluffy. Add the egg, vanilla essence, peanut butter and golden syrup, beat until smooth.
83.3	g	19.27	Brown sugar	3	
15	g	3.47	Egg		
2.5	g	0.58	Vanilla essence		
70	g	16.20	Peanut butter		
24	g	5.55	Golden syrup		
93.7	g	21.68	Wheat cake flour	4	Add the dry ingredients and mix well to combine.
35.5	g	8.21	Soy flour		
0.2	g	0.04	Salt		
0.4	g	0.09	Baking soda		
45	g	10.41	Instant oats (crushed)		
				5	Roll biscuit dough into 22g balls and flatten, before placing onto lined baking sheets. Decorate as desired and bake for 8-10 minutes. Allow to cool and package individually in airtight packets.

Table 4.5 shows the final recipe that was used to create the product. It contained peanut butter, soy flour and oats and when combined, creating an energy dense peanut butter biscuit. The main protein and energy-dense ingredients that were used were soybean flour, peanut butter and oat flour. The combination of these energy-dense ingredients in various proportions were tested for sensory acceptance, before a suitable ratio could be determined that had a favourable impact on the texture, appearance, aroma and taste. The recipe yielded 432.15g of dough and was divided into twenty portions of 22g per biscuit. After baking, the mass reduced to 20g per biscuit, due to moisture loss. The biscuits were packaged individually in airtight, clear, plastic packets when completely cooled, to maintain the quality of the product during storage and distribution, until consumption.

4.7. Microbial analysis

Table 4.6: Microbial analysis of the biscuit

Colony forming units per 1 gram

Sample	Coliforms	Yeast and mould	Total count
1	0	1	0
2	0	1	0

Standard South African Bureau of Standards (SABS) methods for microbial testing of foods using selective media (Sabouraud Dextrose Agar plates)

According to Table 4.6, microbial analysis was determined, using standard SABS methods for testing (South African National Standard 2007). Two samples were used to determine the microbial analysis of the product. The results show that no coliform bacteria were detected. One colony yeast and mould was detected. The WHO standard for yeast and moulds for total plate count (TPC) should be 2.0×10^5 cfu g⁻¹ yeasts and $<1.0 \times 10^4$ cfu g⁻¹ moulds (World Health Organisation 1994). Total plate counts were zero, showing no bacterial growth, deeming the product safe to consume.

4.8. Nutritional analysis

Table 4.7: Nutritional analysis of the biscuit

Nutrient	Quantity (grams)		Energy (Kilojoules)		Percent
	As per 100g	As per 20g (Serving size)	As per 100g	As per 20g (Serving size)	
Carbohydrates	42.01	8.40	688	137.60	30.2
Fat	36.72	7.34	1388	277.60	61.0
Protein	11.99	2.40	201	40.20	8.8
Moisture	0.62	0.12	0	0	0
Ash	8.66	1.73	0	0	0
Sodium chloride	0.01	0.00	0	0	0
Crude fibre	1.07	0.21	0	0	0
TOTAL ENERGY	-----	-----	2 277	455.40	100

Method-

AOAC 2000

- Protein-Kjeldahl
- Fat-Soxhlet extraction (Ether)
- Moisture-Drying oven 105 °C
- Ash –Furnace 600 °C
- Sodium chloride-Laqua meter.
- Carbohydrate-by difference
- Crude fibre-Wiender method

Table 4.7 depicts the nutritional analysis of 100g of the product, as well as for a single serving of 20g. Two biscuit samples were used to obtain the nutritional analysis of the product, as per requirement from the laboratory, used for nutritional analysis. Nutrients that contributed to energy were the focus however, the ash, sodium and fibre values were reflected in the nutrient analysis as well. The main energy dense nutrient was fat, which accounted for 1 388kJ of energy (61.0%) and 277.6kJ of energy per 20g serving. The second most energy dense nutrient was carbohydrates accounting for 688kJ of energy (30.2%) and 137.6kJ of energy per 20g serving. Protein contributed the least to the biscuit, contributing 201kJ of energy (8.8%) and 40.2kJ of energy per 20g serving. Lastly, crude fibre was 0.21g for each biscuit.

Table 4.8: Recommended Dietary Intake comparison

Macronutrient	Girls	Boys	Amount in single serve biscuit	Percentage of RDI: Girls	Percentage of RDI: Boys
Carbohydrate	130g	130g	8.40g	6.46	6.46
Fat	ND*	ND*	7.34g	-	-
Protein	34g	34g	2.40g	7.06	7.06
Dietary fibre	26g	31g	0.21g	0.81	0.68
TOTAL RDI Percentage of biscuit				14.33	14.20

*ND: Not determined

In Table 4.8, the RDIs of the biscuit, compared to the standard RDIs for children in the age category of 9-13 for the macronutrients, are calculated (Del Valle *et al.* 2011). The total RDI percentage of the biscuit amounts to 14.33% for girls and 14.20% for boys.

4.9. Shelf-life analysis

Table 4.9: Shelf-life analysis of the biscuit

**12 Biscuit Samples in 150mmx250mm plain plastic bags-Weight/mass monitoring in grams*

Sample	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	5 Month
1	18.8386	18.8660	18.5317	18.5983	18.3564	18.3765	18.3895
2	19.5358	19.6617	19.3233	19.3955	19.1521	19.1741	19.1838
3	20.0675	20.0870	19.7265	19.7959	19.5372	19.5638	19.5888
4	20.0677	20.0913	19.7358	18.8112	19.5571	19.6172	19.6216
5	20.1141	20.1383	19.8081	18.8951	19.6478	19.6805	19.7474
6	19.7079	19.7340	19.3924	19.4648	19.2196	19.2737	19.2632
7	20.2051	20.2318	19.8836	19.9605	19.7064	19.7255	19.7348
8	19.1929	19.2228	18.8822	18.9605	18.7242	18.7664	18.8024
9	19.1636	19.2045	18.3651	18.9678	18.6983	18.7267	18.7622
10	19.6300	19.6720	19.3381	19.4226	19.1806	19.2547	19.2547
11	20.0170	20.0469	19.7097	19.7925	19.5626	19.6025	19.6025
12	19.8387	19.8703	19.5336	19.6210	19.3551	19.4326	19.4326

- Day 0- 11.03.20
- Day 1- 12.03.20
- Day 2- 13.03.20
- Day 3- 16.03.20
- Day 4- 17.03.20
- Day 5- 17.03.20
- 5 month- 12.08.20

Table 4.9 represents the shelf-life testing for the product. The samples were individually packaged in 150mm x 250mm plastic bags upon submission to the laboratory. For each day, samples were weighed and the mass recorded. Samples were adequate and showed no visible sign of spoilage or product deterioration. The projected shelf-life is five weeks fresh and five months stored.

4.10.Consumer sensory evaluation results

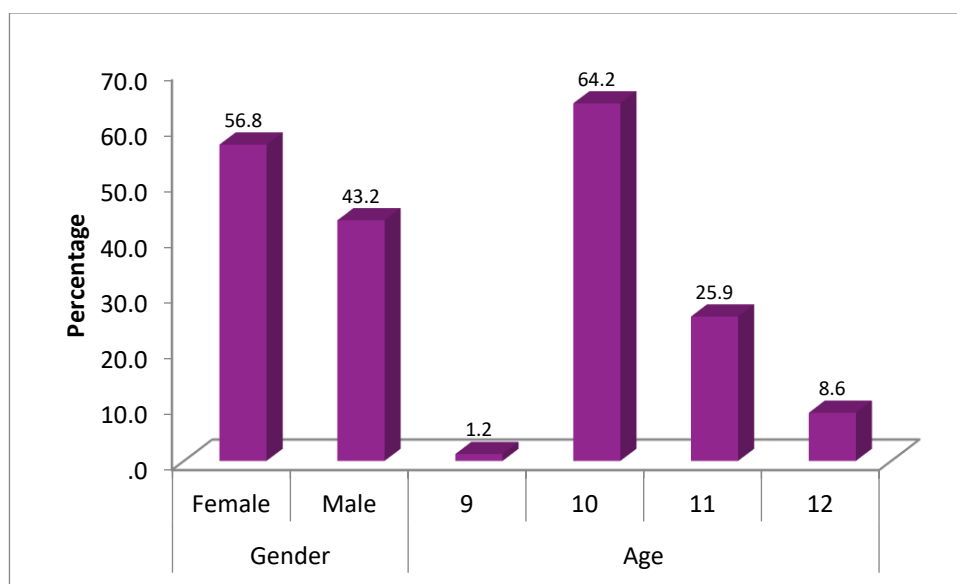


Figure 4.3: Sensory analysis according to gender and age (n=81)

Figure 4.3 above, shows that according to gender, there were more girls (n=46, 56.8%) who participated in the sensory evaluation and fewer boys (n=35, 43.2%). According to age, there were significantly more 10-year-olds that participated in the sensory evaluation (n=52, 64.2%), the 9-year-olds made up the least participants for the sensory evaluation (n=1, 1.2%). There was no significant difference in sensory scores across gender ($p=0.691$). There was no significant difference in sensory scores across age ($p=0.706$).

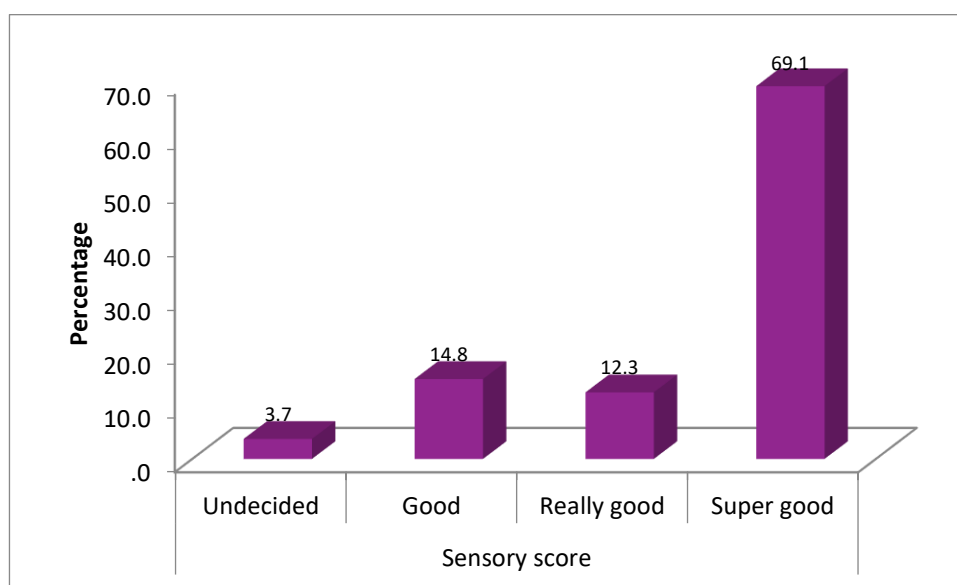


Figure 4.4: Sensory evaluation (n=81)

Figure 4.4 above depicts the sensory results of the final product. Majority of the learners found the product to be 'Super good' (69.1%, n=56), 14.8% (n=12) rated the product as 'Good', and 12.3% (n=10) rated the product as 'Really good'. Only 3.7% (n=3) were undecided. 'Super good' was chosen significantly more (69.1%) than the other ratings ($p < .0005$).

4.11. Cost of final recipe

Table 4.10: Cost of final recipe

RECIPE TITLE: Peanut butter biscuits

Ingredient	Quantity (mass, volume, number)	Price per (mass, volume)	Cost
Margarine	62.5g	÷ 1000g x R51.64	3.23
Brown sugar	83.3g	÷ 1000g x R23.00	1.92
Egg	15g	÷ 360g x R21.00	0.88
Vanilla essence	2.5g	÷ 1000g x R45.86	0.11
Peanut butter	70g	÷ 400g x R26.47	4.63
Golden syrup	24g	÷ 1000g x R45.75	1.30
Wheat cake flour	93.75g	÷ 1000g x R6.89	0.65
Soy flour	35.5g	÷ 1000g x R48.95	1.74
Salt	0.2g	÷ 1000g x R14.82	0.00
Baking soda	0.4g	÷ 1000g x R28.75	0.01
Instant oats (crushed)	45g	÷ 1000g x R28.95	1.30
TOTAL COST	432.15g		15.77
PORTION COST	~22g/biscuit (20 biscuits)		0.79

Table 4.10 depicts the cost of the recipe yielding 20 biscuits, each weighing 22g. The ingredient prices were derived from a general store (Pick n Pay 2020: 1). The total cost of the recipe is R15.77, and portion cost is R0.79 per 22g biscuit, excluding overheads.

4.12. Biscuit comparison analysis

Table 4.11: Biscuit comparison analysis

	Total kJ per 100g	Total kJ per portion	Total carbohydrates per portion (g)	Total fat per portion (g)	Total protein per portion (g)	Fibre per portion (g)	Cost per portion (R)
Energy-dense peanut butter biscuit	2277	20g portion= 455.4kJ	8.40	7.34	2.40	0.21	R0.79
Commercial biscuit #1 (Nature's Choice carob and peanut butter biscuits)	2036	20g portion= 407kJ	9.50	5.20	3.25	1.90	R4.99
Commercial biscuit #2 (Eat naked peanut butter biscuits)	2049	20g portion= 410kJ	9.60	5.20	2.40	1.20	R9.97

Table 4.11 shows a comparison of two other commercial biscuits on the market, against the developed product (energy-dense, peanut butter biscuit), in terms of macronutrients and cost per serving (Faithful to nature 2007: 1; Off the Gluten Path 2020: 1). For a 20g portion, commercial biscuit #1 was priced at R4.99, commercial biscuit #2 was priced at R9.97. When compared to the energy-dense peanut butter biscuit, which is priced at R0.79, it seems the energy-dense peanut butter biscuit is the most reasonably priced. Upon kilojoule inspection, commercial biscuit #1 had the lower score with 407kJ per portion, compared to the energy-dense peanut butter biscuit with 455.4kJ per portion and commercial biscuit #2 with 410kJ per portion. The macronutrients show that commercial biscuit #1 is higher in protein (3.25g) and fibre (1.90g) per portion, whereas commercial biscuit #2 has the higher value for carbohydrates (9.6g) per portion. Commercial biscuit #2 has the same amount of fat (5.20g) as commercial biscuit #1 and same amount of protein (2.40g) as the energy-dense peanut butter biscuit. The energy-dense peanut butter biscuit is the highest in fat (7.34g) per portion and has the same amount of protein (2.40g) as commercial biscuit #2.

4.13. Conclusion

Chapter 4 encompasses the results of the study that covers all the objectives of the study. The next chapter will unpack the results of Chapter 4 in greater detail, along with supporting literature.

5. CHAPTER 5

DISCUSSION

5.1. Introduction

In this chapter the results of the study, aligned to the objectives of the study, will be discussed. Comparisons with other published studies of a similar background will be made, to validate this study and determine whether the proposed objectives were met.

5.1. Review of previous snack developmental studies

The first objective of this study was to determine a suitable snack item for development, by means of conducting a review of previous snack development studies, along with a snack preference survey. The review assessed nine studies for their outcomes, results and limitations. The conclusions from the review steered the type of product developed.

The study by Zivkovich (2011: 2) evaluated the impact of a 130kcal supplemental snack on the growth in primary school children, living in rural Tanzania, over a period of 15 months. It was found that there was a significant decline in the mean height-for-age z-scores and mean weight-for-age z-scores from baseline to follow-up. The Uji snack was made by boiling a mixture of water, ground corn flour and sugar, to create a corn-based porridge. The baseline results showed the percentage of children underweight was 2.2%, 5.3% were stunted and 0.9% were wasted. At the follow-up, no learner had a z-score of <-2 SD for underweight, stunting or wasting. Limitations of this study was shown in the lack of a control group and the reduction of the reliability of the anthropometric measurements, due to the learners taking the measurements themselves. There were also no sensory acceptability tests performed with the children. The more obscure limitations were the lack of recorded data on the actual snack consumption, on certain days there was no delivery of ingredients and there was variation in the preparation methods, among other things. It was also found that children in a diseased state may compromise the true micronutrient and overall nutritional status of the intervention, due to lack of access to healthcare services in the village; it is possible that a sick child may be in a diseased state for a longer period of time.

In Kenya, Murphy *et al.* (2007: 1093) designed snacks (githeri: a stew of maize, beans and vegetables) to address micronutrient deficiencies in rural school children. Snacks that contained animal source foods (milk and meat) and an equicaloric vegetarian snack that provided extra vitamin A, was developed. There was a significant increase in energy intake, as well as vitamin B₁₂ by the children who consumed the animal-source snack. Children in the control group increased energy intakes by 18kJ/d, whereas those in the meat group increased energy intakes by 536kJ/d. The decrease in home intake, not being compared to the intake from the snacks provided, posed a limitation to the study. Another limitation was the breaks in the feeding, due to

weekends, school holidays and days missed due to illness. Including a sensory acceptability test as well as being more diligent with measuring the home, as well as school intake, would improve the methods of the study.

A multiple-micronutrient fortified beverage powder was developed by food technologists at Procter and Gamble, in a trial to measure efficacy among primary school children in Tanzania (Ash *et al.* 2003: 891). The beverage was fortified with ten micronutrients and evaluated to determine whether it influenced the iron and vitamin A status as well as growth of rural children, aged 6-11 years. Results depicted non-significant differences at baseline, between children in the fortified and nonfortified groups, in iron, serum retinol levels; however, at the six-month follow-up, mean incremental changes in weight, height and BMI were significantly higher in the fortified group than in the nonfortified group. Results also showed that the fortified beverage lowered the overall prevalence of anaemia and vitamin A deficiency. The fortified beverage improved anthropometric measurements more in the fortified group than in the nonfortified group and significantly lowered the overall prevalence of anaemia and vitamin A deficiency. Limitations of the study include the exclusion of 11 learners, due to them having severe anaemia and the amounts of nutrients selected for the fortified beverage were estimated, because no previous efficacy data existed for a beverage of this nature and purpose. Another limitation was the lack of a sensory acceptability test, to indicate the children's preference for the fortified beverage.

A study by Belayneh *et al.* (2018: 377-382) evaluated quality protein maize (QPM) for school feeding in Ethiopia, where QPM was compared with conventional maize and sensorially evaluated. Adolescent female students were asked to taste a popular maize porridge (kinchie) made from QPM, as well as conventional maize, and to rate the taste, texture, aroma, appearance and overall acceptability on a 5-point hedonic scale. Results from this evaluation showed a strong liking towards the QPM, with 5.0% of the participants liking QPM kinchie very much, whereas only 1.70% rated conventional maize kinchie in the same category. Overall evaluation shows that approximately 61.0% of the respondents perceived QPM kinchie as very good, whereas only 5.0% of the respondents perceived conventional maize as very good. 66.0% of respondents rated QPM kinchie as having a good texture and 21.0% rated the texture as very good, whereas 58.0% of respondents reported conventional maize kinchie as having a fair overall sensory characteristic. None of the participants scored QPM kinchie as poor in terms of taste, however 0.80% of participants scored conventional maize kinchie as poor for taste. In the study, samples that were served first had higher score ratings than those that were served last, which could have influenced the data results. Another possible limitation on the way forward, is the lack of the QPM seed, as this may hinder the incorporation of the QPM in school feeding programs.

In SA, Kearney, Oldewage–Theron and Napier (2011: 4) embarked on an experimental product development study, which was undertaken over a six month period. A nutritious novel food product, a vetkoek (bread type cake fried in oil) that appealed to children was developed. It was affordable and easy to develop. For the portion size of 120g per vetkoek, the sensory acceptability test showed that 90.0% of the children found it to be acceptable and 65.0% liked it very much. The total cost of the product was R1.50 (~0.080\$) per day and contributed to a nutrient intake of 21.6% for energy, 14.4% for calcium, 14.1% for iron, 62.4% for zinc and 17.8% for vitamin A. The shelf life of the product was two days at room temperature. Limitations showed that the product needed to be shelf life tested over a longer period of time (at least 12 months) and no market analysis of the product was conducted.

Another study, based in SA, focused on developing a snack biscuit that is nutritious, acceptable and affordable to prevent obesity in children (du Plessis 2010: 1-174). Sensory evaluation revealed that approval rates for the biscuit were as follows: 58.3% liked the taste; 57.0% liked the texture; 54.30% liked the colour; 59.50% liked the smell; and 48.9% liked the portion size, while the cost per 30g portion of biscuit was priced at R0.55. An affordable food product that is low-fat and has a high-density nutritional value, with at least 20% of RDI for protein and iron, was successfully developed. The product was modelled after a Pro-Vita biscuit. Limitations for this study was the final snack item did not go through nutrient analysis, due to time constraints and cost. This study was only done in two primary schools and, thus, were not representative of all primary schools in the area. Lastly, soy flour (Supro Max 60100) that was used to create the snack was not readily available to upscale production.

Hochfeld *et al.* (2016: 1-9) aimed to investigate whether breakfast made a difference and evaluated a school-based breakfast program in the city of Johannesburg, SA. As part of a Corporate Social Investment (CSI) strategy, a non-profit foundation initiated an in-school breakfast program, by providing a fortified cooked porridge to primary school learners, over a period of ten months. This study showed positive results, as there was a statistically significant nutritional change over the period of the program. A decrease in severe stunting levels by 4.7% and a positive change of 4.3% was seen in the number of children, in the category of normal height for age limit. Baseline measurements for overweight learners indicated 27.6% of learners were either overweight (16.9%) or severely overweight (10.7%) and follow-up results indicated that the overweight percentage reduced to 13.8% and severely overweight reduced to 6.4%. Learners, educators, and principles indicated that they perceived the breakfast program had a positive impact on the children's ability to learn, by improving their participation and concentration in the classroom. Limitations included the inability of the researchers to conduct an experimental design, where they could control for interfering factors. No sensory acceptability test took place. Therefore, the nutritional and performance changes could not be scientifically attributed to the breakfast

program. The nutrition program was launched before the baseline data could be collected, and lastly, school performance data for the first two terms was missing and therefore, the data analysis was compromised.

Orange-fleshed sweet potato was used in a study, to assess the effects of β -carotene on the vitamin A status of primary school children (van Jaarsveld *et al.* 2005: 1080-1087). Primary school learners were fed 125g of sweet potato for five days during the week, as a snack, to assess the effect on vitamin A status of the children. The treatment group were fed orange-fleshed sweet potato, rich in β -carotene, and the control group were fed white-fleshed sweet potato. The results of this study showed an improvement in vitamin A stores in the treatment group as compared to the control group. The proportion of children with low serum retinol concentration ($<0.070\mu\text{mol/L}$) decreased from 71% to 50% ($P=0.001$) after intervention in the treatment group and decreased from 73% to 49% ($P=0.001$) in the control group. The limitations of this study did not evaluate the prevalence or degree of helminthic infections, sensory acceptability was not assessed and during the school holidays the product could not be given to the children.

A long-term study done over 2.5 years in SA, by van Stuijvenberg *et al.* (2007: 1201-1209), evaluated the impact of a micronutrient-fortified biscuit and a vitamin C fortified cold drink on micronutrient deficiencies in primary school children. The biscuit was fortified with β -carotene (at 50.0% of the RDA), iron and iodine and a vitamin C-fortified cold drink was also given to the children, to improve iron absorption. Results indicated the micro-nutrient fortified biscuit was able to maintain serum retinol concentrations on a day-to-day basis; however, it was not able to sustain levels during the long school holiday. Urinary iodine levels improved in the follow-up, where the prevalence of low urinary iodine dropped from 97.1% pre-intervention to 4.8% post 12 months of intervention. During the school holiday the children could not receive the intervention, and this posed a limitation to this study, along with the following problems. Logistical issues prevented the delivery of a vitamin C-fortified cold drink during the last nine months of the intervention, which could have affected iron absorption. The biscuit was baked at 210°C , which may have possibly degraded the iron amino acid chelate used in the biscuit, in addition, there was no control group, as all children received the fortified biscuit and sensory acceptability tests were not conducted.

The results of the review suggested the development of a biscuit. The review of literature brought significant conclusions to the forefront, such as the developed snack being able to address targeted nutritional problems in children (Ash *et al.* 2003; van Jaarsveld *et al.* 2005; van Stuijvenberg *et al.* 2007; du Plessis 2010; Zivkovich 2011; Hochfeld *et al.* 2016), it has the potential to be a significant source of energy (Murphy *et al.* 2007; du Plessis 2010; Kearney, Oldewage-Theron and Napier 2011; Belayneh *et al.* 2018) and can be a cost effective snack (du Plessis

2010; Kearney, Oldewage-Theron and Napier 2011), as well as be sensorially acceptable (Guinard 2000: 273).

5.2. Snack preference survey

Following objective one of the study, which was to determine a suitable snack item for development, a snack preference survey was conducted. From the results, it can be noted that the most preferred snack was muffins, as it was equally liked by both girls and boys, with a combined percentage of 56.5%. The Chi-square goodness-of-fit test was used to compare the sample distribution, with the expected probability of distribution (Statistics Solutions 2020: 1). The Chi-square goodness-of-fit test was used to find out if there is significant difference in the frequency of snacks preferred. The results show, according to the formula $\chi^2(3) = 62.435$, $p < .0005$, significantly more participants prefer muffins (48-56.5%) and biscuits (28-32.9%). In a study by Nasar-Abbas and Jayasena (2012: 41), it was found that muffins are most popular as a snack however, they can be poor in nutritional value, with low protein and fibre content. In another study the consumer appeal for muffins was found in the soft texture, sweet taste and ready to eat nature; however, due to wheat flour being one of the main ingredients, it is low in essential amino acids, contributing to its poor nutritional value (Pauter *et al.* 2018: 227). It was also found that the shelf life of muffins is shorter, due to its moisture content, which is generally higher than biscuits (Smith *et al.* 2004: 19; Still Tasty 2020: 1). It is possible that muffins were chosen, because of their size, as most commercial biscuits are small. However, a study based on snack consumption and preference, found that “taste” was a common reason for choosing a snack (Liu *et al.* 2017: 1125).

The second most preferred snack was biscuits. Both girls and boys equally liked biscuits, with a combined preference percentage of 32.90%. The reason why biscuits are seen as a better option for this study is seen in a research study focused on wheat-soybean biscuits in Sri Lanka by Banureka and Mahendran (2011: 62). They found that biscuits have a wider consumption base and can have a long shelf-life, making it easy to produce and distribute on a larger scale. They also found that it can successfully be used for fortification and nutrient enrichment programs especially for children, the elderly and low-income populations. When statistical analysis was done, using the Fisher’s Exact test to determine if there are non-random connections between gender and snack choice, as well as age and snack choice (Weisstein Eric 2020: 1), it was found that there was no significant relationship between gender and choice of snack ($p=1.000$), as well as no significant difference between age and choice of snack ($p=0.141$). In the end, a recipe appropriate for the context of the study, and based on the review of previous studies and the snack preference survey, was obtained. It was decided that a crunchie recipe would be modified for this study, as crunchies are by nature energy dense as the base ingredients are oats, butter, coconut, and golden syrup (Sam 2010: 1). The main protein and energy-dense ingredients that were used in the development of the energy-dense biscuit were soybean flour, peanut butter and oat flour.

The following base changes were made to the recipe in the beginning, to increase the energy content and nutrient value and manage costs: margarine was used instead of butter; and the flour was replaced with soy flour. Soy flour is naturally higher in dietary fibre, protein, calcium, iron and omega 6 fatty acids, when compared to wheat flour (Souper Sage 2019: 1). Peanut butter was added, to increase the protein content cost-effectively (Drayer 2018: 1). Oats are popular in baked goods, and as such, became part of the recipe for its cost-effectiveness and dietary fibre content (Nordqvist 2018: 1).

5.3. Trained sensory evaluation trials

Objective two of this study was to develop a cost effective, energy dense snack, using the steps of product development. According to Fuller (2016: 65), the first step in the product development process is idea generation. This was accomplished in objective one, with the review of previous snack developmental studies and the snack preference survey. It was decided that a biscuit would be an optimal solution. The feasibility review is the next phase, and according to the South African Department of Basic Education (2016: 207), each meal costs R2.85 per learner per day. Based on this fact, a snack that is less than half of a whole meal (R0.89 per portion) can be feasible and mass production could be possible in the future. In the development stage, trained sensory trials were undertaken at each stage of product development, to determine if the recipe is texturally, sensorially and visually suitable for the target population. The purpose of sensory evaluation, as stated by Cornell College of Agriculture and Life Science (2020: 1) is to provide information on how products are perceived through the senses and is used in the developmental process to measure the success variation to the recipe. Six sensory trials were administered to eight random participants from the Department of Food and Nutrition. At each trial, the appearance, texture, flavour and aroma were examined and after each evaluation, changes to the recipe were affected, until a final recipe that had suitable appearance, textural, flavour and aroma qualities was mastered. A crispy peanut butter flavoured crunchie was created after six trials. The final recipe contained 15.8% peanut butter, 10.2% oats, 8.0% soy flour, as well as 5.7% egg. The total yield of the recipe amounted to 442g and singular portions worked out to 22g before baking and, due to moisture loss, the mass reduced to 20g. Once cooled, the biscuits were packaged and sealed for distribution. In-house sensory evaluations are important during product development, as an experienced panel is able to judge the product on a number of analytical and linguistic descriptors (Zeng, Ruan and Koehl 2008: 443).

5.4. Microbial and shelf-life analysis

For the fourth objective, the standard SABS method was used for the microbial analysis, using selective media. The importance of microbial testing is to rule out any contaminants, microorganisms or pathogens that can potentially cause spoilage or food poisoning and make

sure the product is microbiologically safe for consumption (Zwietering *et al.* 2016: 31). For yeasts and moulds, a sample of the product is placed in a culture using a selective culture medium and aerobically incubated at a temperature of 25°C for 3-5 days. The number of yeasts and moulds were calculated per gram. The results show that no coliform bacteria were present, and one colony of yeasts and moulds was detected. The overall counts were zero, showing no bacterial growth. According to the World Health Organisation (1994: 1), the maximum limits for total microbial plate count is 2.0×10^5 cfu g⁻¹, coliform bacteria <200MPN g⁻¹, yeasts and moulds are < 1.0×10^4 cfu g⁻¹, with *E.coli* absent. The factors that influence microbial quality of baked goods are moisture content, pH and water activity, where high moisture products, such as muffins and cakes, have more water activity and thus, more food safety concerns. The developed product was deemed safe to consume, as it had a relatively low moisture content.

The fifth objective was to determine the shelf life of the product. The moisture content of the product was calculated by loss-on-drying, using a drying oven, where the sample was placed in the drying oven at a consistent temperature of 106°C, for a defined period. The sample is weighed before and after drying, and, thus the difference is the resultant moisture content (Ahn *et al.* 2014: 1615). The moisture content is important, as it directly affects the shelf-life and quality of the product (Mettler Toledo 2020: 1). Moisture is seen as the limiting factor during storage and is what controls the shelf-life of the product (Ergun, Lietha and Hartel 2010: 162). Twelve samples were taken and weighed each day for a period of five days and again after five months, to determine the shelf life of the product. Results show that the samples were adequate, and no signs of spoilage or product deterioration had occurred. The final shelf-life analysis deemed the product fresh for five weeks and five months stored shelf-life.

5.5. Nutritional analysis

The third objective was the nutritional analysis of the developed snack biscuit. The protein content for the biscuit amounted to 2.40g/40.2kJ, which contributed approximately 8.8% energy to the biscuit. The fat content for 20g of the biscuit was 7.34g/277.6kJ, which contributed to approximately 61.0% energy to the biscuit and is the most energy dense nutrient of the biscuit. The amount of carbohydrates in 20g of the biscuit was 8.40g/137.6kJ, contributing to 30.2% of energy to the biscuit. RDIs are defined as a set of recommended daily intakes, based on the RDA for essential macronutrients and vitamins and minerals (Pitkin *et al.* 2000: 1). Del Valle *et al.* (2011: 1) states that the Institute of Medicine defined the RDIs for children aged 9-13 as:

Table 5.1: Recommended Dietary Intake table for children 9-13

Macronutrient	Girls	Boys
Protein (g)	34	34
Carbohydrate (g)	130	130
Dietary Fibre (g)	26	31
Fat	ND*	ND*

*ND: Not determined

The RDIs this product provide for protein, carbohydrates, fat and dietary fibre are 14.3% for females and 14.2% for males. Even though carbohydrates were the highest in a single serve portion of the biscuit, the protein content of the product contributed to the most percentage of RDI, for both girls and boys. The International Dairy Federation (IDF) Standing Committee on Nutrition and Health and IDF Standing Committee on Marketing (2020: 6) studies have shown that quality education, health and nutrition programs, e.g. school feeding programs, can benefit child development. Proper nutrition can enhance school performance and assist in the ability to learn and promote attendance (Devereux *et al.* 2018: v).

5.6. Consumer sensory evaluation

Post lockdown, special social precautions had to be implemented to prevent the spread of the virus, including the frequent washing of hands, disinfecting with alcohol based sanitizers, social distancing of 1.5m and the wearing of PPE, (Personal protective equipment) such as masks, in public spaces (South African Department of Basic Education 2020a: 4). With this new information, the researchers followed a set of Standard Operating Procedures (SOPS's) relating to COVID-19 regulations during product development and during the sensory evaluation.

The last objective was to determine the sensory acceptability and palatability of the product. The results of the sensory evaluation were conducted with 81 students from grade five, from one of the schools in the study, instead of two schools, due to the other school not accepting any visitors on their premises, in line with their COVID-19 protocol. The sample size taken for the consumer sensory analysis is between 40-100, which is viable based on reports that sample sizes of 40-50 panellists are able to generate stable averages for sensory attributes (Gacula Jr and Rutenbeck 2006: 130; Lawless and Heymann 2010: 266). Results from the sensory evaluation show that more girls (56.8%) participated than boys (43.2%) and more ten-year olds (64.2%) participated in the sensory analysis. The sensory evaluation sheet was based on the 9-point hedonic scale and depicted a hedonic scale of seven levels of positives and negatives, which ranged from 1= Super bad to 7= Super good (Lim 2011: 742). It is stated that consumer sensory testing is best suited to

analytical and hedonic descriptors, according to preference (Zeng, Ruan and Koehl 2008: 444). Lim (2011: 739) also believes that the 9-point hedonic scale is an effective and simple measuring device. Research from Mademgne and Dorys (2016: 16) suggests that translating the hedonic scale in native languages for sensory evaluation and reducing the scale from nine to five, for example, assist participants who come from rural areas and may have problems understanding. For children, extra adaptations need to be put in place, e.g. smiley faces along with the hedonic scale can be used to represent how much the sample was liked or disliked (Popper and Kroll 2005: 78). The theory behind the smiley face hedonic scale is that children find the pictures entertaining and are thought to attract more attention to the task at hand (Guinard 2000: 273; Lawless and Heymann 2010: 332). This information advised the sensory evaluation sheet that was drawn up and was translated into isi-Zulu. The scale was dropped to seven points and smiley faces were added according to like or dislike. The results show that a significant percent of the participants found the biscuit to be 'Super Good' (69.1%) ($p < 0.0005$) however, there was no significant difference in sensory scores across gender ($p = 0.691$) or age ($p = 0.706$). In a study, testing for differences in age and gender among food preferences for children aged from 4-16 years, it was found that there was an increase in the number of foods tried ($P < 0.001$), liked ($p < 0.005$) and disliked ($p < 0.05$) (Cooke and Wardle 2005: 741). However, Cooke and Wardle (2005: 741) also indicate that if the number of foods tried were controlled in a study, the increase in dislikes and likes, based on age, would be non-significant.

5.7. Biscuit comparison analysis

Building on objective two of the study, a cost-effective product was developed. The cost of the final product was R0.79 for a 20g biscuit. The cost was compared against two commercial biscuits of a similar nature, with the common ingredient being peanut butter. It was challenging to acquire biscuits with a similar specification to the developed biscuit. The results show that in terms of pricing, the peanut butter biscuit was the most reasonably priced (R0.79). The South African Department of Basic Education (2016: 146) states that the average cost of a meal per learner is R2.85. Therefore, for a snack to be compared to the price of a whole meal, R0.79 is reasonable. The energy the peanut butter biscuit provides comes mostly from fat (7.34g/ portion). A snack with a high fat content has the ability to enhance satiety and curb hunger for longer periods of time (Abou Samra 2010: 1). The product was average in protein content (2.40g) and lower in carbohydrates (8.40g) and fibre (0.21g), when compared to the commercial biscuits. The cost of the production of the biscuit is an important factor, as it can determine the sustainability of its development for the future. The product is reasonably priced and along with sourcing the ingredients locally, can enrich the community, as well as promote the nutritional programme set by the government (World Food Programme 2018: 1). Schools are seen as a predictable market for small local businesses, as school feeding schemes create a local income, by linking to local

suppliers, households, businesses and traders, making it a sustainable venture for an energy dense snack development initiative such as this (FAO *et al.* 2019: 106).

5.8. Conclusion

This chapter focused on the discussion of the results presented in the previous chapter. An energy dense biscuit can influence a great number of disadvantaged children in a positive way, especially during a pandemic situation. Its energy-dense nature keeps stomachs full for longer and can assist the NSNP, by providing energy to children at the beginning of the day, until the specified meal can be served, with minimal disruption to the school day. This, in turn, can promote attendance to school and help keep children alert and active during lesson time. In the next chapter, the conclusion to this study will be elucidated.

6. CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1. Introduction

This chapter will entail the conclusions drawn from the study, based on the analysis of the results from the previous chapter. Recommendations for further areas of research will also be highlighted. The aim of this study was to develop a suitable cost-effective, energy-dense snack item, which would increase the recommended daily nutrient for learners of the NSNP. The objectives for this study was: 1. To determine a suitable snack item for development, by conducting a literature review and by conducting a snack preference survey, with a sample of the target population. 2. To develop a cost-effective, energy-dense snack item, using the steps of product development. 3. To determine the macronutrients and micronutrients of the snack through nutritional analysis. 4. To determine food safety of the snack item developed, using microbiological tests. 5. To determine shelf-life stability of the snack, by conducting shelf-life analysis. 6. To determine sensory acceptability and palatability of the snack item, using a sensory evaluation survey with a sample of the target population.

6.2. Main findings

It is no secret that school feeding programmes create a positive impact on the world, more especially for school children, as it enriches their lives and provides much needed nutrients in most cases. That is why many countries have adopted school feeding schemes. In SA, the NSNP is well established. Although there are snack development studies that exist, this study is unique, in the sense that it is designed to assist the NSNP to fill the gap in the RDA for the children of SA. The review of literature made it clear that, while school feeding programmes are put in place to assist school children in acquiring important nutrients daily, the vehicle for the nutrients can take many forms, but are not limited to porridges, biscuits, fortified beverages, cereals, and fortified bakery goods. With the increase in snacking behaviour, the introduction of snacks to school feeding programmes has taken off over the last decade and can range from porridges to biscuits to fortified drinks. The main reasons for school feeding programmes in schools are to address food and nutrition security issues, which ultimately achieve the goal of a healthy society

Upon review of the NSNP, the development of a morning snack, together with the meal provided at lunch time, has the potential to curb hunger and contribute energy to the RDA of the children (South African Department of Basic Education 2016: 7). A thorough review of previous snack development studies suggested that the most viable product that has a substantial shelf-life and is a great carrier for nutrients are biscuits. Although from the snack preference survey, muffins were preferred as the most popular snack product, and biscuits followed as the second choice by

a small margin, biscuits were chosen to be developed, due to the shorter shelf-life properties of muffins (Banureka and Mahendran 2011: 62).

Following the systematic steps of food product development, at the end of the trained sensory trials, a crispy, flavourful biscuit was developed. The final recipe yielded 20 portions of 20g each. The microbial analysis deemed the product to be safe to consume. The nutritional analysis showed that fat contributed the most energy from the biscuit portion. The RDI percentage values were in-keeping with the first objective of creating an energy dense product. The product developed was the most cost-effective, when compared to two similar commercial biscuits on the market. The shelf stability of the product proved that the product is highly shelf stable. It was found that a significant number of children found the snack to be 'Super good', following the consumer sensory evaluation.

6.3. Limitations of the study

- The greatest limitation was due to COVID-19 pandemic, where the study was delayed due to schools and other sectors of the economy shutting down for the lockdown period.
- The study was limited to quintile one, two and three schools; however, quintile one and two were not included, due to virtue of the location of the study.
- The population group was limited to two primary schools that were part of the NSNP; however, one school could not participate in the consumer sensory evaluation, due to COVID-19 drawbacks.
- The population group was limited to the Durban area and the results cannot be generalized to the greater KwaZulu-Natal region.
- Having the research team present at the consumer sensory evaluation could have influenced the participants responses, as they were under pressure to conform.
- Both grades five and six were used for the snack preference survey; however, only grade fives were used for the consumer sensory evaluation, due to COVID-19 drawbacks.
- There was difficulty in finding quintile one to three schools in the Durban area, as not many schools were part of the NSNP; hence, the primary schools closest to the researcher were chosen.
- The fact that the product contained peanut butter, which is a common allergen, limited the study.
- The GI value of the biscuit was not calculated.
- The recipe development challenges and reformulations could be presented differently to highlight at a glance, tracking changes made to the recipe during development.

6.4. Recommendations of the study

- Further development of this study is recommended. This study can be scaled-up to include more schools, including high schools, that are part of the NSNP, to provide a more accurate reflection of the study population and a more accurate reflection of quintile one, two and three schools.
- Local people in each community can volunteer to prepare this energy dense biscuits every month, thereby engaging and involving the community in contributing to the nutrition of the school children. This, in turn, can benefit the community economically and provide employment opportunities.
- A recommendation for the government to organize a specific budget for snack development as part of the NSNP, as no budget is currently in place.
- If a budget is allocated, production of this snack biscuit can contribute to the upliftment of the economy through job creation.
- This study can be a solution, not only for the NSNP of SA, but schools around the world, as it also fits the SDG goals two and three.
- The developed snack can be a solution for emergency situations when the NSNP is not operational, such as during the COVID-19 lockdown. The standard cooked meal could not be served and those children, dependent on the meal, were left stranded. The biscuit, on the other hand, has the potential of being distributed to children, as it is prepacked and ready-to-eat.
- Future studies to determine the effect of the biscuit consumption by learners, in terms of learner concentration, hunger reduction and nutritional benefit, through a randomized control trial should be conducted.
- It is recommended that the microbiological testing be conducted before and after the shelf-life testing.
- Regional acceptability of the introduced snack can also be assessed, and up-take compared, in relation to current breakfast up-take, where offered.

6.5. Conclusion

This study focused on the NSNP addressing the need for a solution to ensure that school children's energy levels are sustained, until the NSNP lunch meal can be served through the development and acceptability of a cost-effective, energy-dense snack. The combination of a systematic developmental process, which includes market needs analysis, previous studies research, sensory acceptability microbiological, nutrition and shelf-life testing and, lastly, cost analysis has strengthened the integrity of this study. All objectives of this study were reached, and a suitable energy-dense snack biscuit was developed, in response to a solution for the NSNP. This study will be brought to the attention of NSNP stakeholders, in the hopes of the programme adopting this solution, to fill the gaps identified in the well-established NSNP.

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Appendix A



Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
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Durban University of Technology
P O Box 1334, Durban, South Africa, 4001
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http://www.dut.ac.za/research/institutional_research_ethics
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11 October 2019

Ms S Hassanally
260 Yusuf Dadoo Street
Durban
4000

Ms Hassanally

Development and acceptability of a cost effective, energy-dense snack suitable for the National School Nutrition Program
Ethical Clearance number IREC 103/19

The Institutional Research Ethics Committee acknowledges receipt of your gatekeeper permission letters.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

(Signature)

Professor J K Adam
Chairperson: IREC



Appendix B



education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Phindile Duma

Tel: 033 392 1063

Ref.:24/8/2020

Mrs S Hassanally
95 Clayton Road
Overport
4091

Dear Mrs Hassanally

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"DEVELOPMENT AND ACCEPTABILITY OF A COST EFFECTIVE, ENERGY-DENSE SNACK SUITABLE FOR THE NATIONAL SCHOOL NUTRITION PROGRAM"**, in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 30 September 2019 to 01 October 2022.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Phindile Duma at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

UMlazi District

Dr. E. V. Nzama
Head of Department: Education
Date: 01 October 2019

KWAZULU-NATAL DEPARTMENT OF EDUCATION
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...Championing Quality Education - Creating and Securing a Brighter Future

Appendix C



Appendix D



260 Yusuf Dadoo Street
Overport
Durban
4001

Dear Parent

LETTER OF INFORMATION

Title of the Research Study: Development and acceptability of a cost effective, energy-dense snack item suitable for the National School Nutrition Program (NSNP).

Principal Investigator/s/researcher:

Saffia Hassanally, B-Tech in Consumer Science: Food and Nutrition.

Co-Investigator/s/supervisor/s:

Dr. Ashika Naicker, PhD Nutrition and Mrs. Evonne Singh, Masters in Consumer Science: Food and Nutrition

Brief Introduction and Purpose of the Study:

The purpose of this developmental research is to strengthen nutritional education in primary schools to promote healthier lifestyles of the poorest learners and to promote sustainable food production initiatives in schools. The research will be conducted within the eThekweni municipality in KwaZulu- Natal. Your child will comprise of 100 primary school learners from 2 public primary schools that receive meals from the NSNP. The nature of the study will be based on product development and the sensory acceptability is a cross sectional in nature. The researcher will conduct a literature search on school feeding programs in South Africa and other developing countries in order to decide on a suitable cost-effective snack to be developed. The developed snack product will then go through a sensory analysis using trained personnel, thereafter the product will go through a nutritional analysis to determine the nutritional properties of the snack item, as well as microbiological testing to deem the product safe for consumption. The product will then undergo shelf life testing and lastly be presented to your child for final sensory analysis and to determine sensory acceptability of the developed snack item using a simple 7-point facial Hedonic surveys. The results of each stage of the methodology will determine if the snack item developed is suitable for incorporation into the NSNP as a way of improving the program's effectiveness and to ensure that hunger is not a barrier to learning by providing an energy-dense snack which will result in significant health and nutritional benefits to school learners.

Outline of the Procedures:

The aim of this study is to investigate, determine and develop a suitable cost effective, energy-dense snack item for learners in public primary schools to supplement the National School Nutrition Program (NSNP) in providing primary school learners with a more balanced meal to reach the recommended daily amount of food groups for the learners. Prior to the development of the snack, a favourite snack survey will be presented to your child which will require them to indicate their favourite snack. After data has been collected, a suitable snack would be developed for your child. During the school day, consenting learners that are part of the NSNP will be presented with a snack which they will be required to taste and complete a sensory evaluation form. This will take 10 minutes of school time.

Risks or Discomforts to the Participant:

There are no potential risks to your child unless the participant suffers from any allergic reaction from potential allergens which will be declared before the sensory analysis to parents and to the child.

Benefits:

Your child will benefit from the consumption of the energy-dense snack item by the potential improvement of their energy levels. Upon the successful results of this study, the recipes for the energy-dense snack item will be made available to the caregivers in charge of providing meals to the primary school learners and can also be used as a community upliftment project providing job opportunities for the women in the community to prepare the snack items for the schoolchildren. The researcher will benefit by obtaining the necessary data required to complete a M-Tech Degree.

Reason/s why your child May Be Withdrawn from the Study:

Participation will be voluntarily, and your child will be allowed to withdraw at any time of the study.

Remuneration:

Parent's of the learners will be informed that there will be no financial gain.

Costs of the Study:

No costs will be expected to be covered by your child if they choose to volunteer their participation in this research study.

Confidentiality:

The information gathered will be of a confidential nature and will not seek to jeopardize the school's status nor the identity or status of your child who chooses to be involved in the study. Data will be saved in confidence. No form of identity will be required from your child which will further ensure confidentiality of the data. The data collected will be stored in the Department of Food and Nutrition in a lockable cupboard for 5 years after which it will be disposed for shredding and electronic data will be securely deleted after 5 years.

Research-related Injury:

Should there be any research-related injury or adverse reaction, the parents or caregivers of your child will be informed, and a mutual compensation will be agreed upon.

Persons to Contact in the Event of Any Problems or Queries:

Please contact my supervisor: Dr. Ashika Naicker (0313732335 or 0822009726 or ashikan@dut.ac.za) or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the DVC: Research, Innovation and Engagement Prof S Moyo on 031 373 2577 or moyos@dut.ac.za.

Appendix E



ASSENT FORM

Statement of Agreement for your child to Participate In the Research Study:

- ☐ I hereby confirm that I have been informed by the researcher, Saffia Hassanally about the nature, conduct, benefits and risks of this study and my child's involvement in the study- Research Ethics Clearance Number: IREC 103/19.
- ☐ I have also received, read and understood the above written information (Letter of Information) regarding the study.
- ☐ I am aware that the results of the study, including personal details regarding the sex, age, date of birth, initials and diagnosis of my child will be anonymously processed into a study report.
- ☐ In view of the requirements of research, I agree that the data collected from my child during this study can be processed in a computerized system by the researcher.
- ☐ I understand that my child may, at any stage, without prejudice, withdraw assent and participation in the study.
- ☐ I have had sufficient opportunity to ask questions and (of my own free will) declare my child prepared to participate in the study.
- ☐ I understand that significant new findings developed during this research which may relate to my child's participation will be made available to me.

Full Name of Parent

Date

Time

Signature

I, Saffia Hassanally here confirm that the above parent has been fully informed about the nature, conduct and risks of the above study, and is willing to allow their child to participate in this research study.

Full Name of Researcher

Date

Signature

Full Name of Witness (if applicable)

Date

Signature

Full Name of Legal Guardian (if applicable)

Date

Signature

Appendix F

SNACK PREFERENCE SURVEY

✓Tick **ONE BOX** to show your favourite snack.

If you don't see your favourite snack below, write what your favourite snack is in the OTHER box:

<u>SNACKS</u>	<u>✓TICK</u>
<u>BISCUITS</u>	
<u>MUFFIN</u>	
<u>PORRIDGE</u>	
<u>OTHER</u>	

THANK YOU!

I-SNACK UCWANINGO

✓ Thikha i-ONE BOX ukukhombisa umthamo owuthandayo.

Uma ungawuboni umthamo wakho owuthandayo ongezansi, bhala lokho okudla okuthandayo okukubhokisi elingu-OTHER:

<u>I-SNACK</u>	<u>✓ KHETHA</u>
<u>IBHESIKIDI</u>	
<u>IMAFINI</u>	
<u>IPHARISHI</u>	
<u>NOKUNYE</u>	

NGIYABONGA!

Appendix G

SENSORY ANALYSIS EVALUATION FORM (Trained sensory panel)

Please take a sip of water before starting.

Please taste the snack item.

Based on your taste preference, please rate and comment accordingly.

<u>CHARACTERISTICS</u>	<u>OVERALL RATING</u>	<u>COMMENTS</u>
	5-Like extremely 4-Like moderately 3-Neither like nor dislike 2-Dislike moderately 1-Dislike extremely	
VISUAL APPEAL		
TEXTURE		
FLAVOUR		
AROMA		

Thank you for participating!

Appendix H
SENSORY ANALYSIS EVALUATION FORM
(Consumer sensory panel)

NAME: _____

AGE: _____

GENDER:








Girl	Boy
------	-----

GRADE:

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7
---------	---------	---------	---------	---------	---------	---------

Please take a sip of water before starting.

Please taste the snack and tick the face that best describes how much you like or dislike the snack.

						
Super bad	Really bad	Bad	Maybe good or maybe bad	Good	Really good	Super good

Thank You!

IFOMU LOKUHLAZIWA KWE-SENSORY ANALYSIS
(Iphaneli yezinzwa zabathengi)

IGAMA: _____

IMINYAKA: _____

UBULILI:







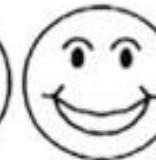
ISIFAZANE	ISILISA
-----------	---------

IBANGA:

Ibanga 1	Ibanga 2	Ibanga 3	Ibanga 4	Ibanga 5	Ibanga 6	Ibanga 7
----------	----------	----------	----------	----------	----------	----------

Ngicela uphuze amanzi ngaphambi kokuthi siqale.

Ngicela uzwe lokudla okusheshayo mase ukhetha ubuso ukuveza ukuthi ukuthandile noma cha.

						
Kubi kakhulu	Kubi ngempela	kubi	Ngathi kumnandi futhi ngathi kubi	kumnandi	Kumnandi ngempela	Kumnandi kakhulu

Ngiyabonga!



Review

Snack Development for School Feeding Programs in Africa: A Scoping Review

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Abstract: The benefits of school feeding have been well documented. As such, school feeding programs have continuously gained popularity in developing countries. However, challenges and potential opportunities persist, calling for a review of school feeding for long-term sustainability. South Africa has an opportunity to improve their National School Nutrition Program (NSNP) by including an energy-dense snack that would increase the recommended dietary allowance (RDA) of school children to meet at least 25% of their energy requirements. The objective of this scoping review was to conduct a review and an appraisal of studies on snack food development for school feeding programs in Africa. Eligible studies had to report snack development for school feeding programs in Africa. We conducted an electronic search in National Research Foundation (NRF) NEXUS, Elton B. Stephens Company (EBSCO), International Food Information Service (IFIS), Nutrition and Food Sciences Center for Agriculture and Bioscience International (CABI.ORG), and Google Scholar. Of the 429 articles identified, nine studies were included in the final review—five from within South Africa and four from elsewhere in Africa. Data extracted included the study design, intervention, outcomes, relevant findings, and limitations. Results were presented in a narrative summary. The review findings showed that energy-rich staple foods and food fortification were commonly used in snack development. The popular snack products developed included porridges and biscuits. While most studies reported nutritional outcomes, few studies reported on sensory acceptability tests and only two studies conducted a cost analysis. This review of previous snack development initiatives for school feeding programs in Africa underscores the importance of establishing the sustainability of any food product developed. The findings of this review have the potential to inform future snack product development for school feeding programs.

Keywords: school feeding program; snacks; healthy; learners; primary school; energy-dense

1. Introduction

It has become increasingly important to many heads of state, governments, and organizations around the world to end world hunger and improve food security for all regions in the world [1]. School feeding has been identified as a means of addressing the Millennium Development Goals 1 and 2, which aim to halve the proportion of people suffering from hunger worldwide and to ensure universal enrolment in primary school education [2,3]. Several government policies have been initiated to address the issue of food insecurity in South Africa, such as the Food Fortification Program, food supplementation, and school feeding programs, including the National School Nutrition Program (NSNP), as well as daycare center schemes [4]. In 1994, a national scale primary school feeding program was established by the South African Department of Health and was taken over by the Department of Education in 2004 [3]. The latest figures from the 2019/20 Basic Education

Department Budget Vote speech indicate that 1.6 billion ZAR (89736464 USD) was allocated to the NSNP in South Africa [5]. The NSNP reaches approximately 20,000 schools that are classified among the three poorest quintiles and provides meals to more than nine million learners nationwide [6]. The NSNP aims to enhance the learning capacity of learners by providing a healthy school lunch meal to increase learners' energy levels, as well as improving micronutrient intake, making them alert and receptive during lessons [7]. Currently, the South African School Feeding Program provides only 18% of the recommended dietary allowance (RDA) for children [8,9]. South Africa has an opportunity to improve current gaps in its school feeding program. The recent report on the National School Nutrition Program in South Africa recommended the development of an energy-dense snack to increase the recommended dietary allowance (RDA) of school children to meet at least 25–30% of their energy requirements, which will also address other critical issues, such as micronutrient deficiencies and hunger [9]. The three major micronutrients that almost one-third of the world's population lack are iodine, iron, and vitamin A, deficiencies of which can result in severe consequences, including learning disabilities in children, impaired work capacity, serious illness, and death [10,11]. Micronutrient deficiencies are common among school children, but unlike stunting and various other effects of long-term malnutrition, micronutrient deficiencies are reversible with the use of food intervention strategies, such as school fortification feeding programs or the addition of supplements into school feeding programs [3]. School feeding programs not only reduce short term hunger but alleviate the effects of malnutrition on learning capacity, having a greater impact on the improvement of learner performance in tests and exams [6]. In addition to providing an incentive to attend school, implementation of a school feeding program may also reduce absenteeism. A review of studies showed that school feeding was associated with an estimated average of four to six additional days of attendance at school per child per year, which could be due to the attraction of a free meal [12–14]. The benefits of snacks in the school feeding programs are well established. Snacks alleviate short-term hunger and micronutrient deficiencies, improve learning, and are cheaper and easier to distribute than meals [2]. In accordance to business plans and minimum feeding requirements as outlined by the South African National Treasury department, the suitable average cost per meal per learner per day (inclusive of cooking fuel and honorarium) should be 2.85 ZAR (0.16 USD) for primary schools and 3.60 ZAR (0.20 USD) for secondary schools in South Africa; hence, the inclusion of a snack has to be cost-effective [9].

The food product development process from concept to commercialization plays a crucial role in the success of new food products; however, some products have a high failure rate due to low investment rates in research and development activities and lack of incorporation of consumer preferences in the product development process [15,16]. Research in snack development for school feeding programs in Africa has mainly been driven by food security, health, or educational outcomes; however, it is not clear how the product development process is integrated and what impact it has for country-wide scalability.

Scoping reviews provide an overview and analysis of the available research evidence without providing a summary answer to a discrete research question [17]. This paper aims to identify and review the literature of the snack product development for school feeding programs that have been developed in Africa to inform future snack development for school feeding programs.

2. Materials and Methods

A scoping review was conducted to synthesize research evidence on snack product interventions developed for school feeding programs in Africa. In reporting this review, we have been guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for Scoping Reviews (PRISMA-ScR) guidelines [18]. Our search strategy was formulated based on knowledge of the literature, using the following keywords to broaden the retrieval of relevant articles: "energy-dense", "snack foods", "cost-effective", "developing countries", "healthy snacks", "primary school children", "Africa", "nutrition feeding program". Five databases were reviewed for articles, including National Research Foundation (NRF) NEXUS, Elton B. Stephens Company (EBSCO), International Food Information Service (IFIS), Nutrition and Food Sciences Center for Agriculture

and Bioscience International (CABI.ORG), and Google Scholar. We imported all papers (titles and abstracts) into an endnote database and removed duplicates. Using the pre-specified inclusion criteria, the article's titles and abstracts were screened by one independent reviewer. Relevant information on the study design, duration, number of participants, age of study population, the type of product developed, outcomes, results, and limitations were extracted. The critical appraisal of studies included the adherence to the steps of food product development. Other considerations included in the appraisal were packaging, storage, transport and food safety. Conformance to the product development was assessed using the model by Fuller, as follows: (1) idea generation, where the company looks at the consumers' needs and forms an idea, involving technical marketing and manufacturing personnel; (2) screening of ideas, where the company looks at the feasibility of the idea and whether it is marketable; (3) development, where a trial product is produced and goes through a multitude of tests, including objective testing, consumer preference testing, market testing, and evaluation; (4) production, involving the establishment of certain requirements and specifications of the product; (5) consumer trials, where the product goes through a series of trials that determine the consumer acceptability of the product using the skills of trained sensory analysis panelists; (6) test marketing, where the product is released onto the market and is observed over a period of time. Fuller's theory is more acceptable for developing food products as it makes use of subjective methods to measure the sensory properties of new food products, which are believed to be more accurate in determining consumer acceptability and preference [19,20]. Studies reporting on snack development for school feeding programs in Africa for both primary and secondary school children were eligible for the review. Articles published in English and unpublished dissertations and theses for the period 2000–2020 were included in the review. The included studies were not limited to reporting snack product development, but also included studies reporting health and educational outcomes from the snack product development. The age inclusion criteria covered the general school age of children in Africa, which was guided by the South African Schools Act of 1996, whereby children aged 7–15 are compelled to attend school; and the RDA categories for children: 4–8 years, 9–13 years, and 14–18 years [21,22]. The study designs included experimental, randomized, and non-randomized control trials; cross-sectional designs; and pre- and post-test designs. Data were extracted by two reviewers (S.H., A.N.) into a master table. All extractions were checked for accuracy by a third reviewer (E.S.). Any disagreements were discussed until agreement was reached.

3. Results

3.1. Study Characteristics

Of the 429 unique articles identified, 427 were screened after excluding 2 duplicates. Out of the remaining articles, 352 were excluded because their abstracts and titles did not meet the eligibility requirements (Figure 1). From a full-text review of the remaining 76 articles, a total of 9 articles were identified for the final review. The reasons for excluding 67 studies were that they had ineligible population, products, or origin. The nine studies included in the final review included four from Africa (including two from Tanzania and one each from Kenya and Ethiopia) and five from South Africa.

3.2. Review of Previous Snack Developmental Studies

Table 1 includes summaries of articles by study design, product development intervention, outcomes, results, appraisals, and limitations.

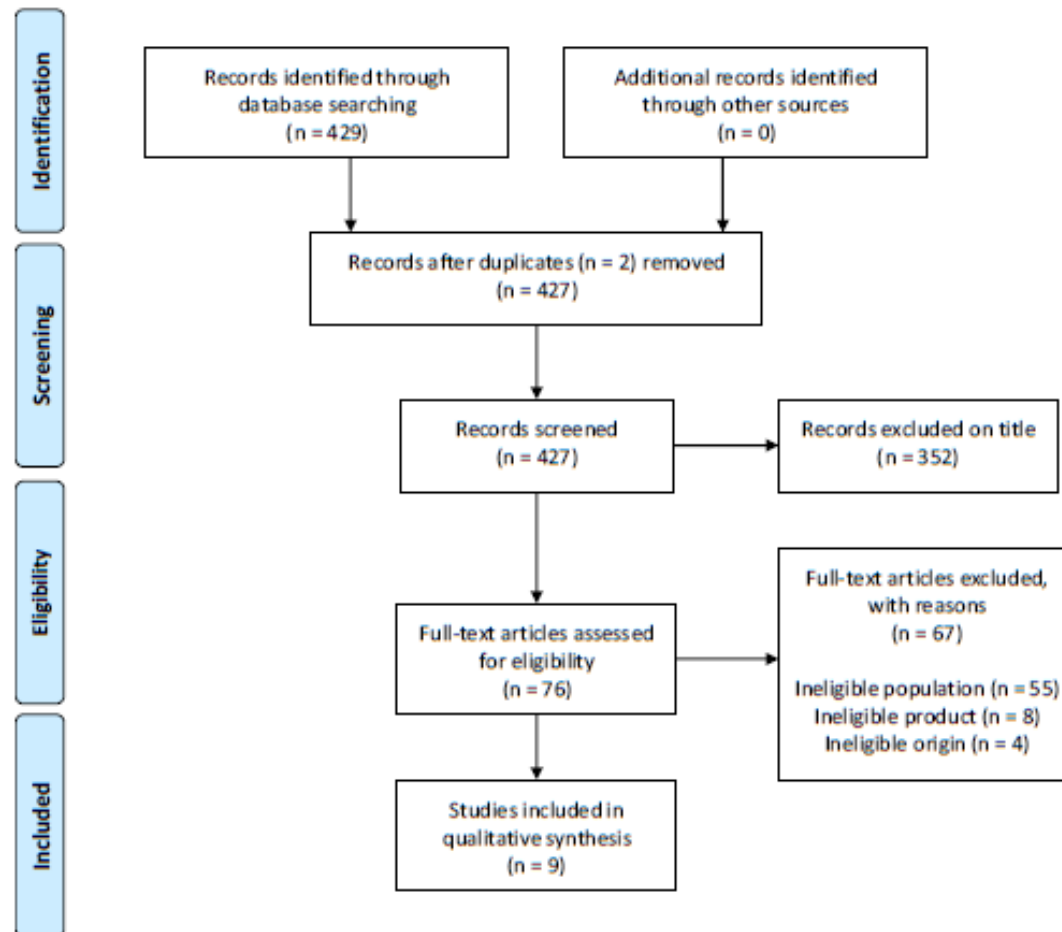


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram [23].

3.3. Summary of Table 1

From the nine studies reviewed, three were randomized control trials, two were non-randomized controls trials, two were cross-sectional studies, one was an experimental product development study, one was a mixed methods design, and one was a pre- and post-test design. The duration of the studies ranged between 1 month and 2.5 years. Children from rural schools were used for seven of the studies, while the remaining two studies recruited children from urban schools. The types of snacks developed ranged from porridges to biscuits, while one study developed a beverage snack. Five studies reported only nutritional outcomes [24–28]; two studies reported nutritional, sensory, and cost-effectiveness outcomes [29,30]; one study reported nutritional and educational outcomes [31]; and one study reported on only the sensory outcome [32]. For studies conducting anthropometric measurements, standardized methods were used for two out of three studies, using World Health Organization (WHO) growth reference charts appropriate to each study population [28,31]. The remaining study, which conducted anthropometric measurements, did not indicate which methods and growth reference charts were used [24]. Standardized serum retinol measurement methods were used for studies that measured serum retinol levels [24,25,27].

Table 1. Review of previous snack development studies.

Author, Year, Location	Study Design	Duration, Number of Participants, Age of Study Population	Intervention: Product Developed (Ingredients)	Outcomes and Classification of Outcome	Results of Study	Appraisal	Limitations
Ash, Tatala [24] (2003) Mpwapwa district, Tanzania	Randomized, double-blind, placebo-controlled trial	Duration: 6 months; 841 rural primary school children aged 6–11 years	Multiple-micronutrient beverage powder fortified with ten micronutrients developed and produced by food technologists at Procter and Gamble.	Effect of a micronutrient-fortified beverage on iron status, anemia, vitamin A status, and growth of the schoolchildren in Tanzania. Classification: Nutritional	Non-significant differences at BL between children in the fortified and non-fortified groups for iron status and serum retinol. Improved anthropometric measurements in the fortified group (mean incremental changes in weight (1.79 compared to 1.24 kg), height (3.2 compared to 2.6 cm), and BMI (0.88 compared to 0.53). The prevalence of low serum retinol levels (<200 µg/l) dropped from 21.4% to 11.3% in the fortified group.	Steps of product development: Ideation and screening of ideas not indicated. No consumer trials or test marketing. Food Safety: NI Packaging: Sachet Storage: NI Transport: NI	Eleven students were excluded from the entire study due to them having severe anemia. The amounts of the nutrients selected for the fortified beverage were estimates because no previous efficacy data existed for a beverage fortified with multiple micronutrients. Sensory acceptability tests not indicated. No cost analysis.
van Jaarsveld, Faber [25] (2005) Durban, Kwa Zulu Natal, South Africa	Randomized, controlled, unmasked, feeding trial	Duration: 53 school days; 180 semi-rural primary school children aged 5–10 years	Cooked orange flesh sweet potato and white-flesh sweet potato as the placebo.	The effect of daily consumption of boiled and mashed orange-fleshed sweet potato on vitamin A status of primary school children. Classification: Nutritional	The proportion of children with low serum retinol concentration (<0.070 µmol/L) after intervention decreased from 71% to 50% ($p = 0.001$) in the treatment group and decreased from 73% to 49% ($p = 0.001$) in the control group.	Steps of product development: Ideation and screening of ideas not indicated. No consumer trials or test marketing. Food Safety: Class monitors observed cooking and serving. Packaging: n/a Storage: served immediately Transport: n/a	The study did not assess the prevalence or degree of helminthic infections. No intervention took place during the school holidays. No sensory acceptability tests. No cost analysis. The availability of orange flesh sweet potato was dependent on seasonality.
Murphy, Gowa [26] (2007) Kenya	Randomized, controlled design	Duration: 2 years; 900 school children aged 7–9 years	Three equicaloric snacks were developed: a vegetarian snack designated the “energy snack,” a snack that included beef, and a snack that included whole milk. All snacks were designed to include the local staple food, githeri (a stew of maize, beans, and vegetables). The energy snack	Effect of snack design on micronutrient deficiencies in rural Kenyan schoolchildren. Classification: Nutritional	Significant increase in energy intake and Vitamin B12 for animal-based snack. Control group increased energy intakes by 18 kJ/d. Meat group increased energy intakes by 536 kJ/d.	Steps of product development: Ideation and screening of ideas not indicated. Food Safety: NI Packaging: n/a Storage: n/a Transport: n/a	Home intake and intake from the study were not evaluated side-by-side. Breaks in feeding due to weekends, school holidays, or days missed due to illness. No cost analysis.

<p>consisted of 230 g of vegetarian githeri, the meat snack contained 225 g of githeri with 38% cooked minced beef. To include milk in a snack, the amount of vegetarian githeri was reduced to 100 g, and a glass of milk (250 g) was included in the snack.</p>					
van Stuijvenberg, Dhansay [27] (2007) South Africa	Cross-sectional study	Duration: 2.5 years; 115 primary school children aged 6–11 years	Shortbread-based biscuit fortified with B-carotene, iron, and iodine-fortified biscuit, served with a cold drink fortified with vitamin C.	Effect of a micronutrient- fortified biscuit on micronutrient deficiencies in primary school children. Classification: Nutritional	<p>The micronutrient-fortified biscuit was enough to maintain serum retinol concentrations on a day-to-day basis, however, was not enough to sustain levels during the long school holiday. Prevalence of low urinary iodine dropped from 97.1% before the intervention to 4.8% after the first 12 months of intervention.</p> <p>Steps of product development: Ideation and screening of ideas not indicated. No consumer trials or test marketing. Food Safety: NI Packaging: NI Storage: NI Transport: NI</p> <p>No intervention took place during the school holiday. Logistical issues prevented the delivery of a vitamin C-fortified cold drink for nine months. The biscuit was baked at 210 °C, which may have possibly degraded the iron amino acid chelate used in the biscuit. No sensory acceptability tests.</p> <p>No cost analysis.</p>
Zivkovich [28] (2011) Roche Village, Rorya District, Tanzania, East Africa	Non- randomized, experimental design	Duration: 15 months; 363 primary school children aged 4.5– 11 years	Uji (Corn based porridge made from the root of the cassava plant and millet grain).	The impact of a 130-kcal supplemental snack on growth of primary school children aged 4½ to 11 years old. Classification: Nutritional	<p>Significant decline in the mean height-for-age z-scores (−0.37952) and mean weight-for-age z-scores (−0.19452) from BL to F/U. (BL = 2.2% underweight, 5.3% stunted, and 0.9% wasted; F/U = no student had a z-score of <−2 SD for underweight, stunting, or wasting.</p> <p>Steps of product development: Ideation and screening of ideas not indicated. No consumer trials or test marketing. Food Safety: NI Packaging: n/a Storage: n/a Transport: n/a</p> <p>No control group (study was a pre-post study design). Reduced reliability of anthropometric measures due to learners taking the measurements for themselves. No sensory acceptability tests. No delivery of ingredients on certain days. Variation in the preparation methods.</p> <p>No cost analysis.</p>
du Plessis [29] (2010) South Africa	Cross-sectional study	Duration: Not indicated; 209 children aged 9–13 years	Biscuit enhanced with soy flour (nutty wheat flour, Supro Max 60/0, flavored sprinkle, baking powder, margarine, egg, fat-free milk).	Development of a nutritious, acceptable, and affordable snack food to prevent obesity in children. Classification: Nutritional, Sensory, Cost effectiveness	<p>An affordable, safe, and acceptable food product with a low-fat and high-density nutritional profile, with at least 20% of RDI for protein and iron was successfully developed. Sensory evaluation: 38.3% liked the taste, 57% liked the texture, 54.3% liked the color, 99.5% liked the smell, and 48.9% liked the portion size.</p> <p>Steps of product development: Ideation and screening of ideas not indicated. No test marketing. Food Safety: Microbiological analysis conducted Packaging: NI</p> <p>The final snack item was not sent for analysis again. This study was only carried out in 2 primary schools. Soy flour (Supro Max 60/100) is not readily available to consumers.</p>

				Cost per 30 g portion of the biscuit was priced at 0.55 ZAR (−0.031 USD).	Storage: NI Transport: NI
Kearney, Oldewage-Theron [30] (2011) South Africa	Experimental product development study	Duration: 6 months; 580 rural children aged 6–13 years	A nutritious vetkoek (bread type cake fried in oil).	<p>The development of a nutritious novel food product that is acceptable to children, and rich in energy, protein, and micronutrients. The product should be affordable, cost-effective, and easy to prepare using locally available raw materials with minimal waste and no need for specific fortification or enrichment.</p> <p>Classification: Nutritional, sensory, cost-effectiveness</p>	<p>Sensory acceptability tests showed 90% of children found the product to be acceptable, while 65% liked the vetkoek very much. The cost of the product was R1.50 (−0.080 USD) per day for a 120 g portion and contributed to nutrient intakes of 21.6% for energy, 14.4% for calcium, 141% for iron, 62.42% for zinc, and 17.75% for vitamin A. The vetkoek had a shelf life of two days when stored at room temperature (25 °C).</p> <p>Steps of product development: Ideation and screening of ideas not indicated. Food Safety: Training provided in preparation of the vetkoek. Packaging: n/a Storage: n/a Transport: n/a</p>
Hochfeld, Graham [31] (2016) Johannesburg, South Africa	Pre- and post-test design	Duration: 10 months; 666 learners aged 6–17 years received the intervention. 857 learners were used for anthropometric sampling	<p>Effect of an in-school breakfast program on the anthropometric and school performance of school children.</p> <p>Classification: Nutritional, school performance</p>	<p>There was a positive and statistically significant nutritional change over the period of the program.</p> <p>Reductions in the numbers of overweight and stunted children were seen (BL = 27.6% of learners were either overweight (1.9%) or severely overweight (10.7%), F/U = Overweight (13.8%) and severely overweight (6.4%).</p> <p>Learners, educators, and principals indicated that they believed the breakfast program had a positive impact on the children's ability to learn by improving their participation and concentration in the classroom.</p>	<p>Steps of product development: Ideation and screening of ideas not indicated. No consumer trials or test marketing.</p> <p>Food Safety: NI Packaging: n/a Storage: n/a Transport: n/a</p>
Belayneh, Yeneberk [32] (2018) Ethiopia	Mixed methods: workshop, sensory testing, focus group discussion	Duration: Not indicated; 95 adolescent girls with an average age of 14.3 years	<p>Kinchie (Porridge) made from QPM (quality protein maize) coarsely milled maize gain.</p>	<p>QPM kinchie was liked very much by 58% of the participants, whereas only 1.7% rated conventional maize kinchie in this category. None of the participants scored QPM kinchie as poor in terms of taste, however 0.8% of participants scored</p>	<p>Steps of product development: Ideation and screening of ideas not indicated. Food Safety: NI Packaging: n/a</p>

The inability to conduct an experimental design where one can systematically control for other intervening factors. The design did not control for other factors to some extent, and therefore the nutritional and performance changes cannot be scientifically attributed to the breakfast program.

The nutrition program was launched before the baseline data could be collected. School performance data for the first two terms were missing, therefore the data analysis was compromised. No sensory acceptability tests.

No cost analysis.

Lack of the QPM seed was identified as a possible limitation in the way forward when implementing QPM into school feeding programs. Samples that were served later showed lower score

	Sensory	conventional maize kinchle as poor for taste; 61% of the participants perceived QPM kinchle as very good, whereas only 5% of the respondents perceived conventional maize as very good;	Storage: n/a Transport: n/a	ratings than samples that were served first. No cost analysis.
		66% of participants rated QPM kinchle to have good texture and 21% (very good texture) and 58% reported conventional maize to have a fair overall sensory characteristic.		

BL = Baseline; F/U = Follow-up; NI = Not indicated; n/a = Not applicable; QPM = Quality protein maize; RDI = Recommended daily intake; BMI = body mass index.

3.4. Review of Studies

Studies reviewed assessed modalities used in the product development of snack foods for school feeding programs.

3.4.1. Ingredient Specification

Five out of the nine studies used staple foods in the product development of a snack for the school feeding program. In the study by Zivkovich, an uji snack was developed by boiling a mixture of water, ground corn flour, and sugar to create a corn-based porridge [28]. In Kenya, Murphy, Gewa [26] developed three snacks using a local staple food, githeri, as the main ingredient. Three equicaloric snacks were developed: a vegetarian snack, designated the “energy snack”; a snack that included beef; and a snack that included whole milk. The energy snack consisted of 230 g of vegetarian githeri, while the meat snack contained 225 g of githeri with 38% cooked minced beef. To include milk in a snack, the amount of vegetarian githeri was reduced to 100 g and a glass of milk (250 g) was included in the snack. Belayneh, Yetneberk [32] developed a porridge, named kinchie, made from quality protein maize (QPM) coarsely milled maize grain, where QPM was compared with conventional maize for school feeding in Ethiopia. In the study by Hochfeld, Graham [31], a fortified cooked porridge with oats, maize, wheat, and sorghum was developed in Johannesburg, South Africa. Lastly, in the study by Keamey [30], a vetkoek was developed, a traditional South African snack similar to a bread-type cake that is fried in oil, measuring 120 g per portion. The ingredients formed part of the most commonly purchased household food items.

Four out of the nine studies used fortified ingredients to develop snacks for the school feeding program. In the first study, a multiple-micronutrient fortified beverage powder with ten micronutrients was developed by food technologists at Procter and Gamble for primary school children in Tanzania [24]. In the second study, a long-term study done in South Africa by van Stuijvenberg, Dhansay [27], a micronutrient-fortified biscuit was developed and served with a vitamin C-fortified cold drink to evaluate the impact of on micronutrient deficiencies in primary school children over 2.5 years. In the third study, Hochfeld, Graham [31] developed a cooked porridge that was fortified for an in-school breakfast program in South Africa. In Kenya, Murphy, Gewa [26] developed three snacks using a local staple food—githeri, a stew of maize, beans, and vegetables—as the main ingredient to address micronutrient deficiencies in rural school children. Three equicaloric snacks were developed primarily from fortified cooking fat. In the remaining studies, orange-fleshed sweet potato was used to assess the effects of β -carotene on the vitamin A status of primary school children [25] and a biscuit enhanced with soy flour was developed to prevent obesity in children in South Africa [29].

3.4.2. Nutritional Outcomes

Seven out of nine studies evaluated the nutritional outcomes of the developed product. The first study evaluated the impact of a 130 kcal supplemental snack (corn-based porridge) on the growth of primary school children living in rural Tanzania over 15 months. Findings showed that there was a significant decline in the mean height-for-age z-scores and mean weight-for-age z-scores from baseline to follow-up [28]. The second study involved the development of githeri, a stew made of local ingredients (maize, beans, and vegetables), to reduce micronutrient deficiencies in rural school children in Kenya. After a two year duration, the effects of snack design on micronutrient deficiencies in rural Kenyan school children were measured. There was a significant increase in energy intake and vitamin B12 by the children who consumed the animal-based snack. Children in the control group increased energy intakes by 18 kJ/d, whereas those in the meat group increased energy intakes by 536 kJ/d [26]. In the third study by Ash et al. [24], a fortified beverage was developed to determine the effect of the micronutrient-fortified beverage on iron status, anemia, vitamin A status, and growth of schoolchildren in Tanzania aged 6–11 years. Results noted non-significant differences at baseline between children in the fortified and non-fortified groups in terms of iron and serum retinol levels;

however, at the 6 month follow-up mean incremental changes in weight, height, and body mass index (BMI) were significantly higher in the fortified group than in the non-fortified group. The results also showed that the fortified beverage lowered the overall prevalence of anemia and vitamin A deficiency [24]. Specific nutrient information on fiber was not mentioned in any of the studies.

In the study by Kearney et al. [30], the developed snack contributed 21.6% of energy, 14.4% of calcium, 141% of iron, 62.4% of zinc, and 17.7% of vitamin A for the group of children. In the study by Hochfeld et al., the effects of an in-school breakfast program on the anthropometric and school performance of school children were evaluated. This study showed positive results, as there was a statistically significant nutritional change over the period of the program. A 4.7% decrease in severe stunting levels and an overall 4.3% positive change in the number of children in the category of normal height-for-age limits were seen. Baseline measurements for overweight learners indicated 27.6% of learners were either overweight (1.9%) or severely overweight (10.7%), while follow-up results indicated that the overweight percentage reduced to 13.8% and severely overweight reduced to 6.4%. Learners, educators, and principles indicated that they perceived that the breakfast program had a positive impact on the children's ability to learn by improving their participation and concentration in the classroom [31].

In another study, primary school learners were fed 125 g of sweet potato for five days during the week as a snack to assess the effect on the vitamin A status of the children. The treatment group were fed orange-fleshed sweet potato, which is rich in β -carotene, while the control group were fed white-fleshed sweet potato. The results of this study showed an improvement in vitamin A stores in the treatment group as compared to the control group, as the proportion of children with low serum retinol concentration ($<0.070 \mu\text{mol/L}$) after the intervention decreased from 71% to 50% ($p = 0.001$) in the treatment group and decreased from 73% to 49% ($p = 0.001$) in the control group [25]. In the remaining study, the effects of a micronutrient-fortified biscuit on micronutrient deficiencies in primary school children were evaluated. The results indicated that the micronutrient-fortified biscuit was enough to maintain serum retinol concentrations on a day-to-day basis; however, it was not enough to sustain levels during the long school holiday. Urinary iodine levels improved from baseline to follow-up, where the prevalence of low urinary iodine dropped from 97.1% before the intervention to 4.8% after the first 12 months of intervention [27].

3.4.3. Sensory Analysis

Four out of the nine studies conducted sensory analysis. In the study by Murphy et al. [26], sensory analysis was conducted first on study staff and then on children for acceptability; however, the types of sensory tests conducted were not indicated. In the study by Belayneh et al. [32], the results of the sensory analysis showed a strong preference towards the QPM, with 58% of the participants liking QPM kinchie very much, whereas only 1.7% rated conventional maize kinchie in the same category. The overall evaluation showed that approximately 61% of the respondents perceived QPM kinchie as very good, whereas only 5% of the respondents perceived conventional maize as very good. Furthermore, 66% of respondents rated QPM kinchie as having a good texture and 21% rated the texture as very good, whereas 58% of respondents reported conventional maize kinchie as having fair overall sensory characteristics. None of the participants scored QPM kinchie as poor in terms of taste, however 0.8% of participants scored conventional maize kinchie as poor for taste. The sensory acceptability test results for the product developed by Kearney et al. showed that 90% of children found the product to be acceptable and 65% liked the vetkoek very much [30]. In the remaining study by du Plessis [29], sensory evaluation revealed that approval rates for the biscuit were as follows: 58.3% liked the taste, 57% liked the texture, 54.3% liked the color, 59.5% liked the smell, and 48.9% liked the portion size.

3.4.4. Cost of the Developed Product

Two out of the nine studies included the cost factor of the developed product. In the study by du Plessis [29], the cost per 30 g portion of biscuit was priced at R0.55, while in the study by Kearney [30] the vetkoek was priced at R1.50 per portion of 120 g.

3.5. Study Appraisal

The reviewed studies were appraised by assessing the conformance to the food product development steps. Other considerations included in the appraisal were packaging, storage, transport, and food safety. The limitations of the studies included a lack of a systematic processes in terms of ideation and screening of ideas and prototype creation, while only four studies conducted consumer acceptance tests (sensory analysis). Only one study indicated the packaging type, while in six studies the snacks were cooked and served immediately on the premises. Three out of the nine studies reported a food safety aspect; one study used microbiological tests, one study indicated that the snack preparation and serving were observed by food monitors, and the remaining study indicated that food handlers received training on food safety and preparation of the snacks.

4. Discussion

To find a solution to the impending nutrition insecurity and issues of hunger around the world, further research needs to be conducted. Three possible research outlooks are: (1) Health aspect: Having access to nutritious and safe food is important for individuals to lead a healthy, well-balanced life, therefore research on food safety and agriculture associated diseases and how they affect developing countries and disadvantaged populations, as well as ways to prevent or minimize food safety risks, should be investigated [33]. (2) Nutrition aspect: Proper nutrition is essential to human well-being; however, due to the effects of food insecurity, many people are affected by malnutrition, which is a complex, multisectoral issue that ranges from the double burden of malnutrition (where both undernutrition and overnutrition exists in the same society) to non-communicable diseases. The nutrition aspect also deals with evaluating policies and programs that aim to improve the diets, nutritional status, and health of people through critical stages of the lifecycle [33]. (3) Agricultural aspect: The key to reducing poverty and improving food security issues worldwide is to focus on the development of innovative food products using highly nutritious raw ingredients that can provide adequate nutrition for majority of people who are disadvantaged and living in developing countries [33]. Topics of discussion could include fortification, biofortification (process of improving the nutritional quality of food crops using modern biotechnology), the lack of nutrients or vitamins seen in people in countries where food insecurity is prevalent, ways to improve nutrition and vitamin and mineral intake, and the effects of lack of nutrition during critical stages of the lifecycle. Several government policies have been initiated to address the issue of food insecurity in South Africa, such as the food fortification program, food supplementation, and school feeding programs, including the National School Nutrition Program, as well as daycare center schemes [4].

It is noted that National School Nutrition Programs aim to foster a better quality of education by enhancing children's active learning capacity, alleviating short-term hunger, providing a positive incentive for learners to attend school regularly and punctually, and lastly to address micronutrient deficiencies [4]. Early childhood is an important period of growth and development, both physically and cognitively, and thus requires an optimal dietary intake of energy and nutrients [34]. Nutrient-dense snacks are important to optimize children's nutritional status and cognitive development, as well as to promote physical growth [35]. According to Greenhalgh, Kristjansson [36], the reasons why school feeding programs do not work could stem from a number of factors, such as the food provided does not provide adequate amounts of the missing nutrients; the type of ingredients used may have a low bioavailability, making it difficult for the body to absorb the necessary nutrients; supplementation occurs too late, whereby older children are far too malnourished to be able to reverse the effects of malnutrition by means of a single meal in the day, which supports the notion that targeting the younger school children would greatly improve the success of the school feeding program. Factors that may improve the efficacy of school feeding programs include designing a school feeding program specifically for the needs of that particular community using local teams rather than distance experts, making sure food is developed to confirm palatability and acceptability, and having measures in place to ensure that food is actually being consumed, such as close supervision during feeding times [14,36].

In this review, several modalities have been used in the product development of snack foods for school feeding programs in Africa: staple foods, food fortification, evaluation of nutritional outcomes, sensory acceptability, and cost-efficacy. Given the central role of staple crops in human nutrition, agricultural production, and food security at large, staple foods are often used in snack product development in resource-constrained settings [37]. Being locally produced foods, their inexpensive nature and energy-dense nutritional offering make them suitable ingredient choices in snack food development for school feeding programs [38]. Food fortification is another modality that has been used to improve the nutritional status of populations. With its cost-effectiveness, food fortification has the potential to significantly benefit the nutritional wellbeing of large segments of populations [39]. Most snack product development initiatives were aligned to nutritional outcomes, with significant benefits; however, adoption and rollover of these snack foods into the mainstream school feeding programs were not evident. In general, the appraisal of the review highlights certain missing components of the product development process of snack foods for school feeding programs in terms of product success at scale, particularly ideation, consumer acceptability, and cost-efficacy.

Certain limitations of this scoping review were identified. Specific databases, such as Scopus, were not used as main sources of information but as secondary sources through Google Scholar. Hence, the review may have missed some relevant studies, and searching other databases may have identified additional pertinent studies. Screening of articles was done by a single reviewer, increasing the margin for error; however, extraction of articles was done by two reviewers. The appraisal process of the review did not assess the quality of studies. Instead, this was guided by the conformance to steps of new food product development for long-life products, a measure that is used mainly in the food industry and often excludes the measurement of health outcomes. This review only included studies in Africa. Snack development for school feeding programs in other developing countries outside Africa would have added more value to the study.

5. Conclusions

There is a global consensus that school feeding programs generate a lasting impact that can shape the future of a nation. Upon review of previous snack development initiatives for school feeding programs in Africa, key points have been identified, which have the potential to inform future snack development for school feeding programs. The impact and positive effects of nutrient- and energy-dense snacks on the growth and development of school learners confirm the importance of various authors' publications. It is recommended that snack development for school feeding programs be grounded in a hybrid model of food product development processes with health outcomes, taking into account children's nutritional needs in specific countries to ensure maximum impact on learning outcomes and sustainability for mass production.

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Appendix J



Standard Operating Procedures (SOPs) for Product Development

Viral illness spread among people when an infected person coughs or exhales and releases moisture droplets. These droplets can survive for a long time on some surfaces. By touching a contaminated surface, then touching your face the virus can also be transferred. 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. (Institute of Child Nutrition 2020)

Please adhere to the following preventative measures when working in the test kitchen:

1. Always wear your mask and visor.
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 sanitise hands regularly when working in the lab.
6. Handle food wastes 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 supervisors and approved staffs are allowed in the lab.
9. If you are feeling unwell, please report to your supervisor.
10. Biscuits are to be packaged in clean, unused plastic packets and sealed immediately once the biscuit is inside.
11. The biscuits should be placed in a box thereafter and kept at room temperature (23°C) including during transportation to the school.



(Institute of Child Nutrition 2020)



WASH YOUR HANDS

THE MOST IMPORTANT **20 SECONDS** OF YOUR LIFE



1 Wet hands with water



2 Apply enough liquid or bar soap to cover all hand surfaces



3 Rub hands palm to palm



4 Right palm over left dorsum with interlaced fingers and vice versa



5 Palm to palm with fingers interlaced



6 Rotational rubbing of left thumb clasped in right palm and vice versa



7 Back of fingers to opposing palm with fingers interlocked and vice versa



8 Rotational rubbing, back and forth with clasped fingers of right hand in left palm and vice versa



9 Rinse hands with water



10 Dry thoroughly with a single use towel



11 Use towel to turn off tap



12 Your hands are now clean and safe!



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Appendix K



Standard Operating Procedures (SOPs) for Sensory Evaluations

1. Always keep masks and face-shields on at all times.
2. Distribute the sensory evaluation sheets, a pencil as well as a biscuit and wet wipe to each learner, keeping a 1.5m distance between each learner.
3. Take your position at the front of the classroom. Brief the students on the sensory sheet.
4. Allow the learners to sample the product and state their opinion on the evaluation sheet (+-5min).
5. Once they have finished, ask them to dispose the wrappers of the biscuit and any left-overs they don't finish into the bin bag provided.
6. Collect the evaluation sheets from each learner, thank them collectively and exit the room.
7. Keep the completed sensory evaluation sheets safely in a box.
8. Make sure you sanitise your hands after each group.
9. Repeat for the remainder classes. (if the sampling is to be continued in the same classroom, sanitise between group swaps.)

Appendix L

RECIPE

NAME: Saffia Hassanally

STUDENT NO: 21506973

RECIPE/PRODUCT: Peanut butter biscuit

SESSION NO: 1

DATE: 5 November 2019

RECIPE TITLE: Peanut butter biscuit

TOTAL RECIPE YIELD: 285g

PORTION YIELD: 12 portions (20g balls)

PORTION MASS: 23.75g

COST PER PORTION: R1.02

SPECIAL EQUIPMENT: baking tray

QTY	UNIT	INGREDIENT	STEP	METHOD
			1	Preheat oven to 150°C.
62.5 55 30 7.5	g g g g	Margarine Sugar Golden syrup Smooth peanut butter	2	Melt the margarine, sugar, golden syrup and peanut butter together in a small pot.
60 10 15 2 43	g g g g g	Jungle oats Rice crispies Desiccated coconut Baking powder Cake flour	3 4 5 6 7	Place all the dry ingredients into a clean bowl. Combine the wet ingredients to the dry ingredients and mix well. Divide into 20g balls and flatten onto a baking tray leaving at least 3cm space between each biscuit. Bake at 150°C for 15 minutes till golden-brown. Cool completely and store in an airtight container.

Appendix M

RECIPE

NAME: Saffia Hassanally

STUDENT NO: 21506973

RECIPE/PRODUCT: Peanut butter biscuit

SESSION NO: 2

DATE: 5 November 2019

RECIPE TITLE: Peanut butter biscuit

TOTAL RECIPE YIELD: 265g

PORTION YIELD: 12 portions (20g balls)

PORTION MASS: 20g

COST PER PORTION: R1.30

SPECIAL EQUIPMENT: baking tray

QTY	UNIT	INGREDIENT	STEP	METHOD
			1	Preheat oven to 150°C.
62.5 55 30 7.5	g g g g	Margarine Sugar Golden syrup Smooth peanut butter	2	Melt the margarine, sugar, golden syrup and peanut butter together in a small pot.
60 10 15 2 23	g g g g g	Jungle oats Rice crispies Desiccated coconut Baking powder Soy flour	3 4 5 6 7	Place all the dry ingredients into a clean bowl. Combine the wet ingredients to the dry ingredients and mix well. Divide into 20g balls and flatten onto a baking tray leaving at least 3cm space between each biscuit. Bake at 150°C for 15 minutes till golden-brown. Cool completely and store in an airtight container.

Appendix N

RECIPE

NAME: Saffia Hassanally

STUDENT NO: 21506973

RECIPE/PRODUCT: Peanut butter biscuit

SESSION NO: 3

DATE: 7 February 2020

RECIPE TITLE: Peanut butter biscuit

TOTAL RECIPE YIELD: 593g

PORTION YIELD: 30 portions (18g biscuits)

PORTION MASS: 18g

COST PER PORTION: R R0.50

SPECIAL EQUIPMENT: baking sheet

QTY	UNIT	INGREDIENT	STEP	METHOD
			1	Preheat oven to 180°C and line baking sheets with baking paper.
62.5	g	Margarine	2	Cream the margarine and brown sugar till light and fluffy. Add the egg, milk, vanilla essence and peanut butter and beat until smooth.
125	g	Brown sugar		
1		Egg	3	
2.5	g	Milk		
1.5	g	Vanilla essence		
50	g	Peanut butter		
93.75	g	Cake flour	4	Combine the dry ingredients and add to the mixture. Mix well to combine.
35.5	g	Soy flour		
0.2	g	Salt		
0.4	g	Baking soda		
20	g	Instant oats		
			5	Drop biscuit dough onto lined baking sheets with a teaspoon. Bake for 8-10 min, allow to cool and package individually in airtight packets.

Appendix O

RECIPE

NAME: Saffia Hassanally

STUDENT NO: 21506973

RECIPE/PRODUCT: Peanut butter biscuit

SESSION NO: 4

DATE: 11 February 2020

RECIPE TITLE: Peanut butter biscuit

TOTAL RECIPE YIELD: 460g

PORTION YIELD: 20 portions (23g biscuits)

PORTION MASS: 23g

COST PER PORTION: R R0.80

SPECIAL EQUIPMENT: baking sheet

QTY	UNIT	INGREDIENT	STEP	METHOD
			1	Preheat oven to 180°C and line baking sheets with baking paper.
62.5	g	Margarine	2	Cream the margarine and brown sugar till light and fluffy. Add the egg, vanilla essence and peanut butter and beat until smooth.
125	g	Brown sugar		
1	ea	Egg	3	
2.5	g	Vanilla essence		
70	g	Peanut butter		
93.75	g	Cake flour	4	Combine the dry ingredients and add to the mixture. Mix well to combine.
35.5	g	Soy flour		
0.2	g	Salt		
0.4	g	Baking soda		
45	g	Instant oats		
			5	Drop biscuit dough onto lined baking sheets with a teaspoon. Bake for 8-10 min, allow to cool and package individually in airtight packets.

Appendix P

RECIPE

NAME: Saffia Hassanally

STUDENT NO: 21506973

RECIPE/PRODUCT: Peanut butter biscuit

SESSION NO: 5

DATE: 18 February 2020

RECIPE TITLE: Peanut butter biscuit

TOTAL RECIPE YIELD: 436g

PORTION YIELD: 20 portions (21g biscuits)

PORTION MASS: 21g

COST PER PORTION: R 0.76

SPECIAL EQUIPMENT: baking sheet

QTY	UNIT	INGREDIENT	STEP	METHOD
			1	Preheat oven to 180°C and line baking sheets with baking paper.
62.5	g	Margarine	2	Cream the margarine and brown sugar till light and fluffy. Add the egg, vanilla essence, peanut butter and golden syrup and beat until smooth.
83.3	g	Brown sugar		
½	ea	Egg	3	
2.5	g	Vanilla essence		
60	g	Peanut butter		
30	g	Golden syrup		
93.75	g	Cake flour	4	Combine the dry ingredients and add to the mixture. Mix well to combine.
35.5	g	Soy flour		
0.2	g	Salt		
0.4	g	Baking soda		
45	g	Instant oats (crushed)		
			5	Roll biscuit dough into 21g balls and flatten before placing onto lined baking sheets. Bake for 8-10 min, allow to cool and package individually in airtight packets.

Appendix Q

RECIPE

NAME: Saffia Hassanally

STUDENT NO: 21506973

RECIPE/PRODUCT: Peanut butter biscuit

SESSION NO: 6

DATE: 18 February 2020

RECIPE TITLE: Peanut butter biscuit

TOTAL RECIPE YIELD: 432.15g

PORTION YIELD: 20 portions (22g biscuits)

PORTION MASS: 22g

COST PER PORTION: R 0.79

SPECIAL EQUIPMENT: baking sheet

QTY	UNIT	INGREDIENT	STEP	METHOD
			1	Preheat oven to 180°C and line baking sheets with baking paper.
62.5	g	Margarine	2	Cream the margarine and brown sugar till light and fluffy. Add the egg, vanilla essence, peanut butter and golden syrup and beat until smooth.
83.3	g	Brown sugar	3	
15	g	Egg		
2.5	g	Vanilla essence		
70	g	Peanut butter		
24	g	Golden syrup		
93.7	g	Cake flour	4	Add the dry ingredients and mix well to combine.
35.5	g	Soy Flour		
0.2	g	Salt		
0.4	g	Baking soda		
45	g	Instant oats (crushed)		
			5	Roll biscuit dough into 22g balls and flatten before placing onto lined baking sheets. Bake for 8-10 minutes. Allow to cool and package individually in airtight packets.