A FOOD MULTI-MIX TO ADDRESS MALNUTRITION AMONGST PRIMARY SCHOOL CHILDREN LIVING IN EATONSIDE

Delia Oosthuizen, BTech: Food Service Management

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Supervisor: Mrs C Napier
Co-supervisor: Prof WH Oldewage-Theron

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CONFIDENTIALITY CLAUSE

January 2006

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This work is of strategic importance.

The contents of this dissertation are to remain confidential and are not to be circulated for a period of five years.

Sincerely

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DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed:......5/04/06......

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ABSTRACT

A FOOD MULTI-MIX TO ADDRESS MALNUTRITION AMONGST PRIMARY SCHOOL CHILDREN LIVING IN EATONSIDE

The primary objective of this study was to formulate a multi-mix, which could supply at least one-third of the daily requirements of primary school children, aged six to 13 years. The secondary objective was to ensure the adherence to the criteria of multi-mix formulation, which included affordability, convenient, palatability, culturally acceptable and cost effective, whilst providing high nutritional value for the specified target group. The nutritional criteria included the Index Nutrient Quality (INQ) and Energy Density (ED) requirements, for a specific target group. This study was conducted in Eatonside, an informal settlement situated in Gauteng. A situational analysis previously conducted in Eatonside (Napier 2003) showed that the children between the ages of six and 13 years, were 17% underweight (weight-for-age -2SD from the reference NCHS median), 12,7% were wasted (BMI-for-age -2SD) and 18% stunted (height-for-age -2SD).

With the nutritional requirements of children and the most consumed food list, the multi-mix formulation began. Foods from the Top 20 list (Napier 2003), were combined with the ingredients most common within the households, and vegetable gardens already established. Estimated nutritional values were calculated using the food composition tables of South Africa. The ingredients were prepared and chemically analysed to determine the experimental nutritional value and to assess if the nutritional objectives were being achieved. The multi-mix was then combined with other commonly consumed ingredients to form recipes and sensory evaluated by professionals and the primary school children to assess the acceptability of the multi-mix and recipes. The multi-mix

and recipe products were then sent for shelf life testing to assess its storage time at room temperature.

The results from the nutritional analyses showed nutrient values to be above 30 percent of the Estimated Average Requirements (EAR). The INQ of the targeted nutrients was above 1,0 and the ED at 3,7kcal/g, which was within the 3,6-4,5 kcal/g requirements. The sensory evaluation for the multi-mix recipes had proved favourable response to snack items with preference for sweet products. The final evaluation session resulted in scores of 83.9 percent preference to the biscuit with the sweet muffin scoring 94.5 percent liking, whilst the savoury muffin at 73.1 percent. The average scores for all three recipes were above 80 percent. The multi-mix had a shelf life of minimum one-month, the biscuit, seven days and muffins, only 24 hours, at room temperature. The objectives of cultural acceptability had been achieved through the positive response from the use of ingredients within the community. The multi-mix had been cost effective as the final cost of R1.55, was within the R2.90 spent per person per day, for all three meals (Oldewage-Theron *et al.* 2005).

Further studies need to be conducted in order to implement the multi-mix into an intervention within the community to assess the effect on nutritional status. This study, aimed to reduce the underlying cause of malnutrition, food insecurity, by improving the nutritional status of children aged six to 13 years with the strengthening of food intake, through the combination of various scant ingredients, a multi-mix, providing maximum nutritional value with small quantities. An advantage of the multi-mix is a lower cost when compared with tablet supplementation on the market and versatility in relation to various recipes.

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GLOSSARY

%: Percentage

AAS: Absorption Spectroscopy

AIDS: Acquired immunodeficiency syndrome

ARC: Agricultural Research Council

B.cereus: *Bacillus cereus*

BMI: Body Mass Index

CASP: Comprehensive Agricultural Support Programme

CBNP: Community Based Nutrition Programme

Cfu: Colony forming units

CHO: Carbohydrates

Cm: Centimetres

DC: District Columbia

DNA: Department of Native Affairs

DoH: Department of Health

DoW: Department of Welfare

Dr.: Medical practitioner

Dr: Academic

DRI: Dietary reference intake

DSW: Department of Social Welfare

E.coli: *Escherichia coli*

EAP: Emergency Aid Programme

EAR: Estimated Average Requirement

EC: Eastern Cape

ED: Energy Density

et al.: more than one author

FACS: Food Advisory Consumer Services

FAO: Food Aid Organisation

FAO (UN): Food and Agricultural Organisation of the United Nations

FAP: Food Aid Programme

FDA: Food and Drug Association

FLAG: Food Legislation Advisory Group

FMM: Food multi-mix

FNS: Food and Nutrition Science

g: Grams

HACCP: Hazard Analysis Critical Control Point

HFBNP: Health Facility-Based Nutrition Programme

HIV: Human immunodeficiency virus

HPLC: High Performance Liquid Chromatography

ICP-MS: Inductively coupled Plasma Mass

IDA: Iodine Deficiency Anaemia

IDD: Iodine Deficiency Disease

i.e.: for example

ILSI: International Life Science Institute

IM: Institute of Medicine

INP: Integrated Nutrition Programme

INQ: Index Nutrient Quality

IOTF: International Obesity Task Force

IQ: Intelligence quotient

IU: International units

JAM: Joint Aid Management

kJ: kilo-Joules

KZN: Kwazulu-Natal

kg/m^2: Kilogram per square metre

Kms: kilometres

LRAD: Land Redistribution for Agricultural Development Programme

Ltd: Limited

mg: milligram

MI: Micronutrient Initiative

ml: Millilitres

MQC: Microbiological Quality Control

MRC: Medical Research Council

MUG: 4methylumbelifery-βD-glucuronide

N: Number

NALEDI: National Labour and Economic Development Institute

NFSMI: National Food Service Management Institute (USA)

NDP: National Development Programme

NFCS: National Food Consumption Survey

NICUS: Nutrition Information Centre

NIRU: Nutrition Intervention Research Unit

NNSDP: National Nutrition and Social Development Programme

NRDF: National Rural Development Programme

PEM: Protein-Energy Malnutrition

PLPs: Presidential Lead Projects

PSNP: Primary School Nutrition Programme

Pty: Proprietary

PVM: Protein-Vitamin Malnutrition

RDA: Recommended Dietary Allowance

RDP: Reconstruction of Development Programme

RE: Retinol equivalents

RNI: Recommended Nutrient Intake

RSA: Republic of South Africa

s.a.: year unknown

S.aureus: *Staphylococus aureus*

SAFBGD: South African food-based dietary guidelines

SAJCN: South African Journal of Clinical Nutrition

SAMJ: South African Medical Journal

SARPN: South African Regional Poverty Network

SAVACG: South African Vitamin A Consultative Group

SD: Standard Deviation

StatsSA: Statistics South Africa

TB: Tuberculosis

Tbs: Tablespoon

Tsp: Teaspoon

TQM: Total Quality Management

µg: micrograms

UK: United Kingdom

UNICEF: United Nations Children's Fund

UOM: Unit of Measurement

USA: United States of America

USDA: United States Department of Agriculture

UN: United Nations

VAD: Vitamin A Deficiency

VAT: Value Added Tax

Vit.: Vitamin

VUT: Vaal University of Technology

WHO: World Health Organisation

CHAPTER 1: THE PROBLEM AND ITS SETTING

1. Introduction

This research project focuses on malnutrition amongst dwellers within an informal settlement in the Vaal Triangle, South Africa. The Vaal Triangle is an industrial area situated approximately 70 kilometres (kms) south of Johannesburg. The specific community, Eatonside, is an informal settlement consisting of 1 261 households. Various questionnaires were used to determine the situational analysis, in order to obtain data pertaining to demographics, physical infrastructure, socio-economic situations and dietary intake and food consumption patterns (Oldewage-Theron *et al.* 2005). The situational analysis (Oldewage-Theron *et al.* 2005) revealed that from 357 respondents, mothers were present in 76 per cent of the households. Education levels were low and only 20 per cent of the respondents were present as both parents. From all respondents, 90 per cent live in corrugated iron shacks with widespread overcrowding occurring. During 2001 the government supplied all households with sufficient access to water, sewerage facilities and pre-paid electricity meters. Unfortunately, due to the high levels of unemployment, meals primarily consist of the staple food item with very little or no variation. All nutrients are lacking within the diets except for carbohydrates due to the high consumption of the staple food item, which is maize meal. The community is faced with a problem of poverty, malnutrition and household food insecurity.

Malnutrition is classified as both over- and under-nutrition. The latter occurs when food required for growth and development is omitted or lacking, resulting in conditions such as micronutrient deficiencies, wasting, stunting and being underweight. Depending on the nutrient and the severity of deficiency, the consequences of malnutrition may also include anorexia, susceptibility to infections, behavioural changes and learning disabilities (Mahan & Escott-Stump 2000; Klugman 2002; Thummala & Ayyagari 1997; WHO 2001).

Over-nutrition is the condition when food is consumed in excess, resulting in conditions such as obesity, cardiovascular disease, hypertension, diabetes, gallbladder disease, osteo-arthritis and some forms of cancer in adulthood (The Georgia Mateljan Foundation 2002-2005).

The most vulnerable group for over- or under-nutrition is children. They are at a higher risk, as this is the crucial stage of development. In young children, malnutrition reduces motivation and curiosity whilst also reducing play and exploratory activities and interaction with peers and care providers (Klugman 2002; Bellamy 1998). Malnutrition in children is the consequence of much food insecurity, which stems from poor food quality and quantity, severe and repeated infections or a combination of all three. These conditions are linked to the standard of living and whether basic needs can be met (Thummala & Ayyagari 1997; WHO 2001).

The United Nations Children's Fund (UNICEF) developed a framework in 1990 (Figure 1.1) which clearly assists in determining the state of malnutrition and the causes thereof. Food insecurity is an immediate and underlying cause of malnutrition, as a result of poor quality and quantity of food intake. UNICEF classified two immediate causes of malnutrition to be insufficient dietary intake and diseases. Inadequate access to food, defective care of children and women due to poor education, insufficient health services and unhealthy environments are the underlying causes of malnutrition. The basic causes are however political and ideological factors, poor economic structure and a lack of resources (UNICEF 1998; UNICEF 2001).

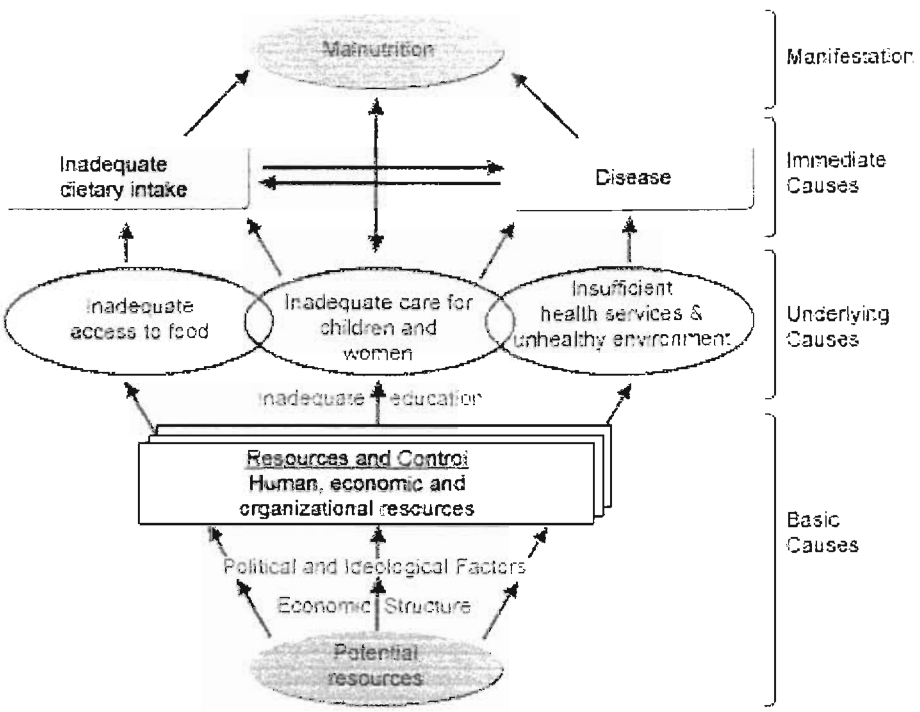

Figure 1.1: Framework of malnutrition (UNICEF 1990).

According to UNICEF (2001) most nutrition problems in developing countries are further complicated by causes of diarrhoeal and acute respiratory diseases. During times of illness, the body requires a higher nutritional intake and in poor communities this demand cannot be met due to lack of good quality and quantity of food. The framework recognizes that there are various factors contributing to malnutrition, namely human, environmental, economical and ideological. The framework is used internationally to determine the causes of malnutrition and at which level emphasis needs to be placed (Santos-Pais 1990; UNICEF 1998; UNICEF 2001).

1.1 Malnutrition

Malnutrition is a worldwide dilemma, while governments link the problems and identify similar solutions in order to reduce the numbers of deaths stemming from malnutrition and nutrition-related diseases.

Table 1.1 provides a summary of the statistics of malnutrition (macro- and micronutrients) globally. Most deaths are related to the three common micronutrient deficiencies, namely iodine deficiency disorder (IDD), vitamin A deficiency (VAD) and iron deficiency anaemia (IDA). Malnutrition commences with the parents who lack governmental support structures, are deficient in education and knowledge of sound nutrition, have poor food sources and no income. Unfortunately, these problems are forced onto newborn children who proceed in life with minimal resources (Santos-Pais 1990).

The World Health Organization (WHO) (2004) indicated the importance of addressing the problem of malnutrition as it attacks the nervous and immune system, rendering little chance of hope. The per cent represents large numbers. For example, 12 million children died annually from malnutrition; 6 million deaths were preventable but the lack of knowledge and education reduced chances of early detection; 2,2 million children died from diarrhoea dehydration and 20 per cent from anaemia (InterAcademy Council 2002). According to the Jos University Teaching Hospital in Nigeria, malnutrition was responsible for 12,5 per cent of child deaths. The mortality rates were higher as figures reflect in-patients and not those dying at home. The total number of women affected yearly with anaemia was 585 000 (Nnakwe 1995).

Within South Africa, The Project for Statistics on Living Standards and Development undertook a study in South Africa in 1994 and estimated that 39 per cent of the population was vulnerable to food insecurity. Food insecurity refers to the inaccessibility of sufficient amounts of quality and quantity foods. Malnutrition is a cause of inappropriate food sources and poor quality (Elmadfa *et al.* 2003). Table 1.2 indicates a prevalence of malnutrition and micronutrient deficiency statistics, since one of every two South African children consumes less than half the basic requirement of vitamin (vit.) A, vit. C, calcium, iron and zinc (DoH 2002). The Micronutrient Initiative (MI) and UNICEF (2004) have published a report, which indicated that the child death rate due to IDA and VAD in South Africa was 6 000 per year. Surveys by the South African Vitamin A Consultative Group (SAVACG 1996) showed that 10,6 per cent of primary school children are micro-deficient (MI & UNICEF 2004). For children aged 0 to 6 years, the prevalence of micronutrient deficiencies in South Africa (1997) was low, with indications of low mean levels for vitamin A and iron. The SAVACG study indicated that 33,3 per cent of children in South Africa had marginal vitamin A deficiency, with iron deficiency being prevalent in 21 per cent. In the SAVACG studies, the prevalence of anaemia in primary school children was only 10 per cent, while iron deficiency anaemia was only 5 per cent (Oldewage-Theron 2001).

Table 1.1: Global malnutrition statistics (including micronutrient deficiencies).

MALNUTRITION PROBLEM	**REFERENCES**
• 20 million children malnourished and 150 million underweight.	Santos-Pais (1990)
• 40% of women suffer from anaemia whereas 50% are pregnant.	Bellamy (1998)
• 20 million babies are born mentally impaired due to iodine deficiency.	UNICEF (2001)
• 40% of children under 5 years have immune system disorders due to vitamin A deficiency.	UNICEF (2001)
• 50 000 women die annually during childbirth due to iron deficiency.	
• 100 million children suffer from blindness and impaired immune system functions.	Bellamy (1998)
• 55% of child deaths are linked to malnutrition.	Bellamy (1998)
• Less than 40% of crop land was facing complete failure.	UNICEF (2003)
• 33,3% of children between 6-71 months are deficient in vitamin A.	The Micronutrient Initiative and UNICEF (2004)
• 21,4% of women are anaemic with 10% of children being iron deficient.	The Micronutrient Initiative and UNICEF (2004)
• Only 10% of infants are breastfed for 3 months whereas 48,3% are bottle-fed.	The Micronutrient Initiative and UNICEF (2004)
• 50% of children aged 1-6 years consume inadequate sources of vitamin A.	The Micronutrient Initiative and UNICEF (2004)
• One third of all child deaths are related to IDA.	The Micronutrient Initiative and UNICEF (2004)
Child deaths per year related to VAD and IDA.	
• Angola 34 000	
• Botswana 500	
• Cameroon 10 500	
• Ethiopia 51 000	
• Kenya 23 500	
• Nigeria 82 000	
• Zimbabwe 4 900	

Table 1.2: Malnutrition statistics within South Africa.

MALNUTRITION PROBLEM	REFERENCE
• R5 million defrauded in 1995 by creating 20 'ghost schools'.	Department of Health (DoH) (2005a); Hendriks (1997)
• Not enough food is taken in by children with one in every five being under-nourished.	Medical Research Council (MRC) (2001a)
• 10% of all children are underweight.	Medical Research Council (MRC) (2001a)
• 21,6%of children aged 1 to 7 years are stunted. Toddlers are physically stunted.	Labadarios (2002)
• 10,3% of children aged 1 to 7 years are underweight.	Labadarios (2002)
• One in every two children consumes less than half the basic requirements of vitamin A, vitamin C, riboflavin, vitamin B6, foliate, calcium, iron and zinc.	Labadarios (2002)
• IDD is common in rural children.	DoH:2002
• In 1998, 7,6% of children aged 1 to 9 years were overweight.	DoH:2002
• 10,6% of primary school children in rural areas are iodine deficient.	The Micronutrient Initiative and UNICEF (2004)
• 6 000 child deaths annually due to VAD and IDA.	The Micronutrient Initiative and UNICEF (2004)

1.2 Under-nutrition

Under-nutrition is a condition resulting from a person's inability to obtain enough calories and other nutrients to meet his/her needs over a period of time (Pongpaew & Schelp 1997). The resulting deficiency presents as one or more of the following: 1.) underweight, which is classified as low weight-for-age; 2.) stunting referring to low height-for-age; 3.) wasting, a combination of the above mentioned, implying low Body Mass Index (BMI) for age; 4.) and other conditions such as protein-energy malnutrition (PEM), iodine deficiency disease (IDD), iron deficiency anaemia (IDA) and vitamin A deficiency (VAD) (Mahan & Escott-Stump 2000). Under-nutrition is associated with deficit in behaviour and development of the brain's anatomy, neurochemistry, and metabolism (Black *et al.* 2005).

This paradox of over- and under-nutrition, as well as the range of micronutrient deficiencies of public health significance, require complementing strategies and an integrated approach to ensure optimal nutrition for all South Africans. The situation is further complicated by the many causes of malnutrition, which could be direct influences such as inadequate food intake, or underlying reasons such as household food insecurity, or even a lack of resources (DoH 2002).

1.2.1 Underweight

Low weight-for-age is reflected by a low body mass relative to age and is classified when the Z-score is below the median by < -2SD (WHO 2004). The factors influencing underweight in children at the household level include: a) food security factors such as poverty, transfer of income and access to food through production in the households; b) the care given by the mother, which depends on her educational status; c) health facilities, sanitation and safe drinking water (MS Swaminath Research Foundation 2004; WHO 2002b).

Globally there are between 130 and 183 million children weighing less than the age requirements. The FAO indicated that East Africa has the highest rate of undernourished people, 83 per cent of the whole of sub-Saharan Africa. Southern Africa is at 37,1 per cent whilst West and Central Africa have 30,7 per cent and 45,1 per cent respectively (FAO 2005b; Santos-Pais 1990; Sparrow 2002).

Studies within South Africa by Steyn *et al.* (2005) revealed that on a national level the prevalence of underweight children was 8,8 per cent. The anthropometrical findings of the SAVACG survey indicated that one in 10 children, aged six – 71 months, were underweight. Of all children aged six to 71 months, 10 per cent are underweight (SAVACG 1996). Within the context of this study, underweight is prevalent in nine to 15 per cent of the primary school children, aged six to 13 years, within the informal settlement, Eatonside (Napier 2003).

1.2.2 Stunting

Stunting occurs when the Z-score is below the median by more than -2 standard deviations (< -2SD). Stunting is seen as a failure to reach linear growth and is prevalent in children with suboptimal health and/or nutritional conditions (WHO 2004). High levels of stunting amongst the population are associated with poor socio-economic conditions, resulting in chronic food shortages and occur when there is more competition in the household for food (WHO 2004). Stunting commences by the age of three months and slows down at the age of three years (WHO 2004). Low height-for-age accounts for 226 million stunted children globally (Food and Agricultural Organization (FAO) & International Life Science Institute (ILSI) 1997). In 1997, WHO showed that information drawn from 32 African countries indicated a large per centage of pre-school children suffering from low height-for-age (stunting). The number of children stunted was higher in rural than in urban areas across Africa (InterAcademy Council 2002).

As a reflection of long-term under-nutrition, stunting is prevalent in 19,3 per cent of children aged 12 to 108 months within South Africa. In rural areas the highest rate of stunting occurs, being 23,8 per cent, of which 25,6 per cent was on commercial farms (Steyn *et al.* 2005). The National Food Consumption Survey (NFCS) showed that nearly one of five children aged one to nine years was stunted. Amongst children aged six to 71 months, one in four was stunted (Labaradios 2002). The number of stunted children, aged six to 71 months, was one in five (SAVACG 1996). Although South Africa is a middle-income country, persistent social and economic problems have forced many people to live in poverty. In 1994, national surveys consistently found that a quarter of all children were stunted, with as much as 40 per cent in many rural areas (Witten *et al.* s.a.). Studies completed by Napier (2003) indicated that the prevalence of stunting amongst primary school children within an informal settlement in South Africa was 30 per cent for children aged six to 13 years. This study focuses on addressing the problem of stunting amongst the primary school children within the informal settlement.

1.2.3 Wasting

Wasting refers to low BMI for age and occurs when the Z-score is below the median by < -2SD (Elmadfa *et al.* 2003).

Severe wasting, caused by weight loss associated with acute starvation and/or severe disease, results in the child becoming underweight and is classified as the inability to reach linear growth (WHO 2004).

Statistics indicate that there are annually 67 million children born wasted across the world (FAO 2002). According to the NFCS wasting is an indication of acute, current under-nutrition, which is not common in South Africa, with a prevalence rate of 3,7 per cent for children aged 1 to 9 years. Within the informal settlement, the focus of this study, wasting is prevalent in 22 to 31 per cent of the children aged six to 13 years of age (Labadarios *et al.* 2005b).

1.2.4 Protein energy malnutrition

Protein energy malnutrition (PEM) is a condition characterised by the lack of the energy providing macronutrients, i.e. carbohydrate, fat and protein. PEM is associated with poor weight gain, slow linear growth and behavioural changes such as irritability, anxiety and attention deficits (Grigsby 2003). Protein deficiency tends to have a greater effect on overall energy metabolism and the body's growth and defence system. This state results in a number of possible syndromes including 1) growth failure and 2) kwashiorkor (Mahan & Escott-Stump 2000). Children with chronic illnesses frequently have anorexia, which leads to inadequate food intake. Increased inflammatory burden and metabolic demands can increase caloric needs, while any chronic illnesses that involve the liver or small bowel affect nutritional intake, as the digestive system is impaired with dysfunction absorption (Grigsby 2003).

PEM results physically in decreased subcutaneous tissue. The areas most affected are legs, arms, buttocks and face. Oral changes include papillary atrophy and cheilosis, while the external skin becomes dry with hyper-pigmented plaques over areas of trauma. The nails become rigid, and hair thin and brittle while turning dull brown and reddish (Nnakwe 1995; Grigsby 2003).

PEM accounts for 161 million children world-wide, as well as 50,6 million wasted children under the age of five (WHO 2002a). About 33 per cent of people in Sub-Sahara Africa are undernourished, whereas in Asia the figure is only 15 per cent. During 1995, WHO reflected that 300 million children have some form of growth retardation and that 20-75 per cent of many children in developing countries under the age of 5 years have suffered from PEM (InterAcademy Council 2002). PEM affects every fourth child in Asia, Africa and Latin America. The number of children with PEM is 70 per cent in Asia, 26 per cent in Africa and 4 per cent in Latin America (WHO 2003). Within South Africa, in the informal settlement which is the focus of this study, Napier (2003) identified that children aged six to 13 years were consuming only 60 per cent of the energy requirements per day and 70 per cent of protein, indicating a shortage of between 30 and 40 per cent.

1.2.5 Micronutrient deficiency

1.2.5.1 Vitamin A deficiency

Vitamin A deficiency, IDD and IDA are common amongst women and children throughout the world. Severe vitamin A deficiency leads to partial or total blindness. VAD also causes retarded growth, as there is loss of appetite, weight loss and failure to thrive. Children are more likely to become ill and prone to infections, due to lowered resistance, especially in the gastrointestinal and respiratory tracts (Rodriguez-Amaya 2000).

1.2.5.2 Iodine deficiency

Iodine deficiency is characterised by swelling of the thyroid thus forming goitre. Only one-third of the iodine in food is absorbed and this is regulated by the thyroid hormone, which maintains a healthy balance between supply and demand (Williams 1990). Deficiency of iodine occurs but is relatively rare, especially in industrialized countries due to iodine fortification of salt. It is estimated that over 1,5 per cent of persons in the world live in regions of environmental iodine deficiency and are at risk of IDD (Sustain 2002). Iodine deficiency is the greatest single cause of preventable brain damage and mental retardation (WHO 2002a; Jooste 2000; DoH 2002). Hypothyroidism leads to fatigue, drowsiness and muscle weakness. Amongst women, iodine deficiency can also increase the risk of breast cancer (Jooste 2000).

1.2.5.3 Iron deficiency

Iron deficiency anaemia (IDA) causes a decrease of red blood cells in the blood, secondary to hookworms or gastrointestinal disease that interfere with iron absorption. However, iron deficiency can be present before actual anaemia develops. Actual anaemia develops once iron deficiency becomes more severe (Medic8 2005). Iron deficiency anaemia is due to low iron absorption resulting from diarrhoea, intestinal disease or total gastrectomy (Mahan & Escott-Stump 2000).

IDA is associated with hookworms, malaria, genetic blood disorders, impaired growth and cognitive development of a child resulting in an intelligence quotient (IQ) lower by nine points, inadequate muscle function, fatigue, low immunity, congestive heart failure, increased susceptibility to infections and schistosomes, which are intestinal helminths. Helminthes are known to cause iron deficiency whilst suppressing the appetite and causing energy loss and other inflammatory responses (Mahan & Escott-stump 2000; Oldewage-Theron 2001; WHO 2001). Co-ordination and balance become retarded, along with withdrawal symptoms and hesitation (Bellamy 1998).

IDA has increased due to inadequate intake of food, low income, poor food choices and the low absorption rate due to the interference of other dietary components (Oldewage-Theron 2001; WHO 2001). Iron deficiency can occur with lead poisoning, though generally amongst children by poor food intake (Medic8 2005).

IDA is prevalent in 40 per cent of the world's population. Iron deficiency and the debilitating effects of anaemia afflict 3,5 million people of all ages worldwide. (Sustain 2002). The prevalence rate of iron deficiency in South Africa is less than 40 per cent (Oldewage-Theron 2001). Vitamin A, iron and iodine deficiencies are referred to as hidden hunger, which can lead to negative mental development and learning ability (Van Stuijvenberg *et al.* 1997).

1.2.5.4 Zinc deficiency

Zinc is an emerging deficiency across the world. Connective tissue disorders are identical to the symptoms of zinc deficiencies. Zinc deficiencies are related to male reproductive disorders, celiac disease, and abnormalities in collagens (Simmons 2000).

Zinc is a vital mineral, which stimulates the activity of approximately 100 cells within the body. Zinc supports the immune system and speeds up the wound healing process. Zinc also assist in maintaining sense of smell and taste and DNA synthesis. Inadequate supply or poorly absorbed zinc leads to growth retardation during pregnancy, childhood and adolescents. Zinc deficiency is identified by growth retardation (stunting), diarrhea, loss of appetite and weight loss (Clinical Nutrition Service 2005). Within the context of this study, the children within the informal settlement consumed on average 30 per cent less zinc than the required EAR (Napier 2003) and this can be contributing to the prevalence of stunting and wasting. The quantity and quality of food taken in on a daily basis does not supply sufficient nutritional value.

1.2.5.5 Other associated malnutrition conditions

Other diseases associated with under-nutrition and low socio-economic factors includes tuberculosis (TB), foetal alcohol syndrome and cancer (Walker 1995). Marasmus occurs when protein and energy levels are depleted or minimal. Pellagra is a shortage of the amino acid tryptophan, which results in the 3 Ds, namely dermatitis, dementia (confusion) and diarrhoea (InterAcademy Council 1995).

1.3 Over-nutrition

Over-nourishment is a disease of affluence that implies excess, or in the case of poverty, the result of diets based on high fat and/or carbohydrate content. The energy supplied to the body is therefore in excess of the requirement and stored as fat. The disease includes overweight, obesity and diseases of life-style, which can be classified as hypertension, coronary heart disease, cancer and diabetes. Overweight occurs when the body mass index (BMI) is above age-specific reference values or is above the median by > 1Standard Deviation (SD), a BMI of 25-29,9 kilograms per square meter (kg/m^2). The BMI is calculated by dividing the weight, in kilograms, by the height squared, in meters. Child obesity continues into adulthood to cause diseases such as cancer, coronary heart disease, diabetes and hypertension (Mamabolo *et al.* 2005; Mahan & Escott-Stump 2000).

1.3.1 Obesity

Obesity is defined as an excess of body weight, caused by total energy consumption exceeding the daily requirements, for age-specific references, by > 2SD of the median. Body Mass Index (BMI) is used to determine the risk of obesity in individuals. The desired range for adults is 20 to 24,99 kg/m². Overweight is classified as the range of 25 to 29,99 kg/m² and obesity from 30 kg/m². Values above 40 kg/m² indicated "morbid" obesity. Obesity in children develops later into diseases of lifestyle, namely hypertension, diabetes and coronary heart disease (Mahan & Escott-Stump 2000; Walker *et al.* 2002; Kruger *et al.* 2005; Mamabolo *et al.* 2005).

Mary Bellizi, an expert for the International Obesity Task Force (IOTF), has estimated that 22 million of the world's children under five are overweight or obese (Collins 2000-2005). Particular studies in Africa, according to Neville Rigby, Public Affairs Director IOTF, indicated that 0,7 per cent of children show features of malnutrition, but over 3 per cent are overweight or obese (Collins 2000-2005). More than 25 per cent of four-year-olds in Egypt are overweight. Obesity rates are also more than 25 per cent among children aged 4 to 10 in Chile, Peru and Mexico (Collins 2000-2005). Children in the United States have unhealthy eating habits. Since the 1980s, the number of overweight children there has doubled with the current overweight statistics indicating 11 per cent of US children (The Georgia Mateljan Foundation 2002-2005). Wang *et al.* (2002) determined the rate of obesity to be higher in the US, Brazil and China. In 1997, Brazil showed a 13,9 per cent rate of obesity amongst children in comparison with 4,1 per cent in 1975, whilst the Unites States had a 25,6 per cent obesity rate in 1994 in comparison with 15,4 per cent in 1988. In 1997, children in China had an obesity rate of 7,7 per cent in comparison with 6,4 per cent in 1991.

Childhood obesity has emotional consequences, since many overweight children suffer from psychological stress, poor body image and low self-esteem (The Georgia Mateljan Foundation 2002-2005).

Studies conducted through the NFCS, in South Africa, indicated that 7,6 per cent of children in urban areas between the ages of 1 to 9 years were overweight. Nationally, the total number of children being overweight was 6 per cent (Labadarios *et al.* 2005b). On a national level the prevalence of overweight and obesity, rose to 19 per cent for children aged 12 to 108 months (Steyn *et al.* 2005). Urban areas had the greatest prevalence to overweight and obesity.

Obesity prevention initiatives should focus on children in order to ensure the adoption from an early age of a healthy lifestyle. All programmes should aim to empower individuals/groups to take responsibility for food choices and behaviour modifications (Kruger *et al.* 2005).

In the context of this study, over-nutrition has been highlighted because the community being examined had subjects who were stunted in early life and therefore had a reduced adult height. There is evidence showing that overweight and obesity is present amongst some stunted (short-for-age) children and adults in South Africa (Labadarios *et al.* 2005b). These individuals are therefore prone to the double burden of disease i.e. infections and communicable disease and other disease of under-nutrition as well as communicable disease in later life. Obesity amongst children is a growing cause for concern. The reasons for childhood obesity include a general decrease in physical activity, since children spend more time with video games, computers or television; powerful genetic factors if both parents are obese; poor diets; tobacco and alcohol abuse and the importance of foetal nutrition, since babies, small at birth or during infancy, have a higher rate of cardio-vascular disease and diabetes than do adults. (Walker *et al.* 2002; Summerfield 1990).

1.4 Addressing malnutrition

Malnutrition can be addressed by implementing the following strategies globally and in South Africa (Mahan & Escott-Stump 2000):

- Food aid programmes: These have been implemented since the 1930s, but only a handful have been successful due to mismanagement of funds and insufficient training of food providers. The implemented feeding programmes are intended for school children through improving their nutritional status (discussed in a Chapter 2).
- Supplementation: This is costly and requires long-term use to develop maximum absorption (discussed in a Chapter 2).
- Fortification: This is a food-based strategy, which has been applied to various products through government laws. In order to boost sales and consumption, manufacturers are applying the enhancement of additional nutrients.
- Food-based strategies: These allow for community participation and ensure that the products used are grown naturally while being culturally acceptable. A food multi-mix is regarded as a food-based approach to alleviating malnutrition due to criteria that require the use of common ingredients available in the community and that such are cultural ly acceptable.

In South Africa the Department of Health (DoH) applies seven strategies or focus areas in order to define and improve the nutritional status of its entire people (DoH 2002). Through fortification of staple food products, the beneficiaries and intended groups of the population include health workers, people living with nutrition-related diseases, pregnant and lactating women, children and caregivers and promoters. In addition, vitamin A supplementation programmes are provided to children younger than five years as well as post-partum women and people with special dietary needs. The latter include:

- Disease-specific nutritional support, treatment and counselling, which encompasses nutrition and dietetic practices for the prevention and rehabilitation of nutrition-related diseases.
- Growth monitoring and promotion, which entails the regular measurement, recording and interpretation of a child's growth over time.
- Nutrition promotion in order to facilitate the objectives of nutrition in general and of the Integrated Nutrition Program (INP) in particular; nutrition education to improve the nutritional status of the population, so as to prevent nutrition-related diseases and improve the quality of life; nutrition advocacy in order to support a nutritional cause or issue.
- Micronutrient malnutrition control, which involves activities to prevent, reduce or manage the dietary deficiencies of vitamins and minerals through direct supplementation, dietary diversification and fortification with micronutrients of commonly consumed foods.
- Food service management, which includes the activities of planning, development, control, implementation and evaluation of, and guidance in relation to suitable food service systems (i.e. procurement, storage, preparation and service of foods and beverages) for the provision of balanced nutrition to groups in the community and public institutions for healthy and/or ill persons.
- Promotion, protection and support of breastfeeding comprising of such activities: to promote, protect and support breastfeeding; to ensure that practices and behaviours in health care settings that always protect, promote and support breastfeeding; to ensure continued breastfeeding for up to 24 months of age with the introduction of appropriate

complementary feeding at 6 months of age; to provide appropriate information and adequate support to mothers/caretakers where breastfeeding is contra-indicated, thus to enable them to make decisions on feeding option for their infants and ensure that the choice is carried out successfully.

- Ensuring household food security, by means of nutrition-related activities that help to find adequate access for households to foods of good quality to satisfy the dietary needs and ensure a healthy, active life of the household throughout the year (DoH 2002).

A recommendation was made by the local government to assess the situational analysis of the Eatonside community, an informal settlement in the Vaal Triangle with 1 261 households. The community was labelled as being the poorest of poor communities. Studies undertaken by Oldewage-Theron *et al.* (2005) indicated that the nutritional status of children within the Eatonside community was based on the economic situation of each family, which enforced the poor nutritional intake. The results indicated that a majority of the respondents (adults) had been without a job for more than three years (59 per cent), and 10 per cent were 60+ years of age. As an indicator of poverty, over half of the households had an income of less than R1 000 per month. Only six per cent of the respondents and 20 per cent of their spouses were employed. Given that the average household size was 4,9 individuals, the families had an equivalent of R2,90 per person, per day to spend on all three meals. Because of low expenditure per day, per person, there is a higher consumption of maize meal (403g per day by the children) as it is cheap and easily available (Oldewage-Theron *et al.* 2005). Therefore, the financial situation, number of family members present and gender of the food provider also have an affect on the nutritional status of the children, as the latter are obliged to consume staple food products, which are both low in cost and easily available.

Within the context of this study, the nutritional status of the children within the informal settlement was clearly a result of poor income and this provided the impetus to formulate a multi-mix. The concept involves improving the nutritional status of the targeted age group with the combining of scant food sources and of low monetary cost, to obtain maximum nutritional intake.

The aim, or expected outcome of this project, was to address malnutrition amongst the primary school children within Eatonside, by developing a multi-mix, which would be easy to use, consumed daily and incorporated into household recipes, while providing acceptable taste, good flavour and high nutritional value. The Vaal University of Technology (VUT) Researchers have assisted the community with nutrition education and agricultural support, with the aim of improving the nutritional status and well-being of the community members. Vegetable gardens have been established and a school feeding program exists within the primary school, for nine to ten year old children. This study dealt with the focus of food diversification, with emphasis placed on a food-based strategy. Some of the key activities of the DoH for 2005 and 2006 (Bowley 2005/3), include the improvement and strengthening of nutrition supplementation and the enhancement of the technical role of nutrition in food security interventions. This study, aimed to reduce the underlying cause of malnutrition and food insecurity, by improving the nutritional status of children aged six to 13 years with the strengthening of food intake, through the combination of staple ingredients and a multi-mix, providing maximum nutritional value with small quantities.

1.5 Purpose of this study

Malnutrition in the Vaal Triangle is the focus of studies undertaken at the VUT as well as this study. South African studies on situational analysis within informal settlements in Gauteng have not been conducted as such and are being undertaken by the Food and Nutrition Research Centre at VUT. A project was undertaken by the Food and Nutrition researchers to determine the situational and nutritional status of a randomly selected group within Eatonside, an informal settlement in the Vaal Triangle. The research centre currently participates in research projects to empower the community of Eatonside with knowledge and basic food sources (i.e. vegetable gardens), thereby improving the nutritional status of the children, pregnant women and the elderly.

Eatonside is a small urban community whose young children, aged six to 13 years, attend the Setlabotsja Primary School, which is the only school in the community. Research completed by Napier (2003) at the Setlabotsja Primary School indicated that malnutrition was increasing among children aged six to 13 years. When comparing statistics of 2002 and 2003 (Table 1.3), the number of children at risk of becoming malnourished was considerably higher after considering weight, age and height comparisons. Boys and girls had a higher occurrence of malnutrition in 2003 than 2002 (Napier 2003). The prevalence of wasting, 22-31per cent, was extremely high when compared to other South African studies showing three to four per cent prevalence of wasting (Labadarios *et al.* 2005b).

Table1.3: Prevalence of malnutrition at Setlabotsja Primary School for 2002 and 2003 (Napier 2003) N*=147

Underweight (≤-2SD)	**2002**	**2003**
Boys	13,5%	9,3 %
Girls	12,0%	15,2%
Stunted (≤-2SD)	**2002**	**2003**
Boys	19,2%	31,2%
Girls	16,8%	30,3%
Wasted (≤-2SD)	**2002**	**2003**
Boys	25,7%	31,0%
Girls	10,8%	22,9%

A 24-hour recall was completed (Napier 2003) amongst the primary school children and revealed (Table 1.4) nutrient-deficient intakes. When comparing the nutrient intake with the estimated average requirements (EAR), results indicated that the primary school children aged six -13 years, consumed 30 per cent less zinc, 27 per cent less protein intake, 83 per cent below the requirements for calcium, while energy levels were 38 per cent below requirements.

Table 1.4: Setlabotsja Primary School, nutrients deficient in the diet measured by QFFQ's and 24 hour recall (Napier 2003)

Nutrient	Intake	EAR*	%**EAR
Calcium (mg)	219,9	1300	16,9
Energy (kJ)	5990	9572	62,5
Iron (mg)	5,8	5,8	100
Magnesium (mg)	212,4	200	106
Phosphorus (mg)	623	1055	60
Selenium (µg)	17,8	35	50,8
Total Protein (g)	39,6	54	72,2
Vit.. A (µg)	460	445	101,0
Vit.. C (mg)	27,7	39	71,02
Vit.. D (µg)	2,4	5	48
Vit.. E (mg)	8	9	88
Zinc (mg)	4,9	7,0	70

*EAR=Estimated average requirement; **per centage.

Napier (2003) provided a list (Table 1.5) of the most purchased and consumed items within the community. In order of consumption the products ranged from maize, to beverages and fruits. More than one meal per day was consumed by 8 out of 10 households. The staple food item from the list is maize, consumed either stiff or soft. The only protein sources include fried eggs and beans consumed with *samp*, which were 15^{th} and 17^{th} on the list with portion sizes of 42,22 grams (g) and 24,70 g respectively. The portion sizes are small in quantity and low in nutrient value.

Table 1.5: Top 20 food items consumed, measured by QFFQ's and 24 hour recall, in Eatonside (Napier 2003)

Item	Average portion (g*) per day
Maize meal cooked, stiff	403,84
Tea, brewed	203,24
Maize meal cooked, soft	136,83
Milk, full fat/whole fresh	47,22
Bread/rolls brown	56,27
Mabella/sorghum cooked	78,92
Cold drink squash, diluted	52,8
Rice, white cooked	39,28
Coffee, brewed instant	80,50
Maize meal cooked, crumbly	87,26
Tea *rooibos*, brewed	221,44
Apple average, raw	27,59
Bread/rolls, white	29,1
Sugar, white granular	8,8
Samp and beans	42,22
Tomato and onion, stewed	17,83
Egg, fried in sunflower oil	24,70
Cold drink, carbonated	66,18
Orange, raw, peeled	30,94
Macaroni, spaghetti cooked	39,74

*grams

It is clear from these results, that malnutrition amongst children is a challenge for nutritionists in this area. The immediate causes of malnutrition include disease and inadequate dietary intake, the latter being the case in this community.

Furthermore, when evaluating the underlying factors causing malnutrition within Eatonside, (Oldewage-Theron *et al.* 2005) household food insecurity, illiteracy of the mothers, and limited access to health services, were factors found present and as these form part of the UNICEF framework, it could have contributed to the malnutrition present amongst the primary school children in this community. The basic causes of malnutrition include economic structure and lack of resources. The majority of the households in this community live in zinc structures (89,9 per cent) with three to four rooms, (41,5 per cent). Furthermore poverty was identified as a major problem as 94 per cent of the respondents were unemployed and only 43 per cent of the households had an average monthly income of between R501 and R1 000 (Oldewage-Theron *et al.* 2005). Thus, most of the factors contributing to malnutrition are present in this community and interventions are needed to address the situation.

Within the context of this study, children aged six to 13 years within an informal settlement were shown to consume 30 per cent less than the daily requirements for protein and energy (Napier 2003). Despite the fact that recent studies completed by Napier (2003) within the informal settlement showed no prevalence to vitamin A, iron and iodine deficiency, it is none the less important to provide adequate amounts of iron, vitamin A and iodine for the longer term in order to prevent further deficiencies. Therefore, the focus of this study is to apply the food multi-mix (FMM) concept in order to provide at least one third of the daily requirements for not only energy and protein, but also for other nutrients such as iron, vitamin A and zinc, in order to reduce the problem of malnutrition.

The context of this study dealt with the development of a multi-mix to address and reduce the increasing problem of wasting, which was prevalent in 22-31 per cent of the scholars, and being underweight, which was prevalent in nine-15 per cent, in addition to the micronutrient deficiencies of calcium, zinc, protein and energy. The extent of being underweight was considerably less yet the problem needed to be addressed.

1.6 Objectives of the study

As identified by Napier (2003), the nutritional problem within Eatonside showed poor nutrient intake and malnutrition. This project was undertaken to assist in addressing the problem of malnutrition.

The primary objective was to develop a multi-mix, which could supply at least one-third of the daily nutrient requirements for children aged six to 13 years, based on the results indicating an average of 30 per cent required to meet these needs. Although all nutrients work in conjunction with one another, the specific nutrients targeted with the multi-mix were calcium, zinc, protein and energy. The importance of these and other nutrients is discussed in Chapter 2.

The secondary objective was to ensure that the multi-mix was affordable, considering the low-income status of the community; convenient as the multi-mix required ease of preparation and adaptability to form other recipes; palatable, culturally acceptable and of a high nutritional value. This objective could be achieved by considering items from the Top 20 list (Napier 2003) of most purchased and consumed items, and combining them with scant food sources within the community. The ingredients were to be locally available and affordable. Amuna *et al.* (2000) has explained that even in poor communities, it is possible to combine scant food resources in a cost-effective way so as to formulate multi-mixes, which without fortification would meet energy, protein and micronutrient needs.

1.7 Conceptual Framework

Qualification: **PHASE 4:** (D Oosthuizen)	**M.TECH** M.Tech Dissertation. Article.
PHASE 3: **Development Phase** (D Oosthuizen)	Food multi-mix recipe development and sensory evaluation. ↑ Food multi-mix chemical analysis, cost analysis and shelf-life testing ↑ Food multi-mix preparation
PHASE 2: **Criteria formulation** (D Oosthuizen)	Food multi-mix formulation ↑ Needs analysis for children aged six to 13 years ↑ Proposal
PHASE 1: **Problem Statement**	Nutritional requirements of children aged six to 13 years (NICUS 2005) ↑ Study of problem (Napier 2003) ↑ Over-nutrition Under-nutrition ↑ ↑ Literature background

Figure 1.2 Conceptual framework

Figure 1.2 indicates the conceptual framework of this project. Phase one involves identifying and defining the problem. The objectives and aims of the study are identified in Phase two with the focuses of the food multi-mix (FMM) formulation as a possible solution. Multi-mix formulation entails defining, and understanding the criteria for multi-mix formulation and theoretically combining food sources until the nutritional objectives are achieved. Phase three provides the methodology behind the formulation of the FMM, which refers to the preparation, chemical analysis, recipe development, sensory evaluation and shelf-life testing. It remains important to refer back to the completed literature study, which indicates the nutritional requirements and the criteria involved with multi-mix formulation. This prevents deviation from the stated objectives and assists in achieving the aims and goals set out during the planning stages.

1.8 Organization of the report

Chapter 2 forms part of phase one, which requires a study of the literature concerning dietary requirements of children, factors influencing their choices and possible steps for reducing malnutrition. Chapter 3 combines phase two, which includes the methodology pertaining to product and recipe development, and sensory evaluation. Chapter 4 represents the final phase, which is a summary of all the results with the discussions, conclusions and recommendations presented in Chapter 5.

CHAPTER 2: LITERATURE SYNOPSIS: FOOD, HEALTH AND CHILDREN

2.1. Factors affecting the nutritional status of children

The nutritional status of children and their daily food intake are ultimately determined by the level of food insecurity, implying quantity and quality, and a family's and/or primary caregiver's food choices, based on ingredients available and their cost. The health of children may also affect their nutritional status, whether they are exposed and susceptible to disease and if care is provided. Illness and disease also play an important part in food intake. Acute viral or bacterial illnesses require greater fluid intake as well as the higher intake of certain nutrients. Children tend to have a suppressed appetite during periods of illness. Therefore it is vital to ensure the intake of nutritious foods (Mahan & Escott-Stump 2000). The nutritional status at a community level is dependent on the nature of government and welfare involvement, as realised through the development of clinics, agricultural and feeding programmes (Tefft *et al.* s.a.). Studies completed in Botswana indicated that a higher prevalence of malnutrition was present in female-headed households. The children of smaller households have improved nutritional status (Gobotswang s.a.).

2.1.1 Role of staple food items in the diet of children

A staple food is one that is consumed regularly and in such quantities that it becomes a dominant part of the diet and supplies a major source of energy and nutrient needs. The staple food item does not necessarily meet the needs of children. Rather, a variety of foods is required. In most countries, staple foods are well adapted to the growth conditions in their source areas. Staple foods can be tolerant of drought, pests or soils low in nutrients. Therefore farmers tend to rely on staple crops in order to reduce risk and increase the resilience of their agricultural systems. Most people living within poor circumstances consume either rice, wheat, maize, sorghum, roots and tubers and animal products such as meat, milk, eggs and fish in small quantities. Rice feeds almost half of humanity, while roots and tubers are important staples to over 1 000 million people globally, with 40 per cent in sub-Saharan Africa. Roots and tubers are a good source of carbohydrates, calcium and vitamin C but are low in protein (FA0 (UN) 2005).

A study completed by Steyn and Badenhorst (1993), provided a classification of the items most consumed by Pedi children in South Africa aged six -14 years. . Staple food items identified by Steyn in Lebowa, Gauteng and the Western Cape were similar to the items identified by Napier (2002) in the Eatonside community. The items, which differed in Steyn and Badenhorst (1993), were cooked chicken with only one per cent frequency of intake and cooked cabbage and *morogo*, at 32-45 per cent frequency of intake. The average intake per child of maize meal was 810g, white bread, 30g, brown bread, 263g and fried egg and sugar at 23 g per day. The studies proved the importance of staple items within the diet due to low cost and availability. When comparing Lebowa with Gauteng and the Western Cape, although the items consumed varied, the staple foods remained the same. Pedi children had a very high mean daily intake of refined cereals (1 053g), with a very low mean intake of added fat (7g) and dairy products (30g) (Steyn & Badenhorst 1993).

The National Food Consumption Survey (NFCS) indicated that the most commonly consumed food items in rural areas amongst primary school children are maize flour, sorghum flour (maltabella), wheat flour (bread), dry beans, peas, sugar and vegetables which were mainly cabbage, spinach, pumpkin, sweet potato, onions and carrots. Children aged six to nine years consumed

630g of cereal daily. A total of 57-58 per cent of the children consumed vegetables, whereas less that three per cent consumed beverages, alcohol and spices. Table 2.1 provides a comparison between rural and urban children of the most consumed food items. Urban children have a lower consumption in cereals and vegetables in comparison with rural children. This could be due to the higher consumption of maize and fresh vegetables grown in home-gardens within rural areas (Labadarios 2002).

Table 2.1 Food comparisons between rural and urban children (Labadarios 2002).

n=817		
Product	**Rural intake in %**	**Urban intake in %***
Cereals	99,8	72,1
Sugars	79,8	85,1
Vegetables	46,8	44,5
Meats	36,0	52,2
Vegetable Oils	34,8	45,3
Milk	32,1	48,8
Roots	22,3	25,5
Pulses	16,1	12,7
Fruit	13,2	20,9
Fish	7,2	8,7
Eggs	7,7	12,5
Soup	6,2	5,0

*percentage

2.1.2 Daily nutrient requirements of children aged six to 13 years

Growth in children is slow but steady. After school, there are extramural activities and recreational programmes which influence the growth process and nutritional requirements. Additional influences such as adults, teachers and sport idols have an effect both mental and physical on choices during meal times (Mahan & Escott-Stump 2000).

Table 2.2 details all the vital nutrients and their functions within the body (Mahan & Escott-Stump 2000). Table 2.3 provides a detailed breakdown of the daily requirements of children aged six to 13 years. When considering the multi-mix to be developed, the emphasis is placed on calcium, protein, zinc and energy. Murphy and Poos (2002) provided an explanation of the Dietary Reference Intakes and how individuals need to consider the correct reference when completing a nutritional analysis. The term Dietary Reference Intake (DRI) refers to a set of four-based references by which quantitative estimates of nutrient intakes are assessed. This study focuses on EAR, which is defined as the intake that meets the estimated needs of a nutrient of 50 per cent of individuals in a specified gender group at the given life stage. The Recommended Dietary Allowance (RDA) is defined as the average daily dietary intake level meeting the required nutritional value of 97-98 per cent of a specified gender group at the given life stage. When considering the EAR of the children aged six to 13 years, dietary reference tables are divided into two groups, namely four to eight years and six to 13 years. For the purpose of this study, the highest value of both groups will be used to create a guideline for the development of the multi-mix.

Table 2.2 Nutrients and their functions (Mahan & Escott-Stump 2000).

NUTRIENT	FUNCTION WITHIN THE BODY
Fat soluble vitamins	
Vitamin A	Essential for normal growth, development and maintenance of epithelial tissue. Essential for the integrity of night vision. Helps provide normal bone and tooth development
Vitamin D	Essential for normal growth and development and bone development. Influences the absorption and metabolism of phosphorus and calcium.
Vitamin E	A strong antioxidant, which protects red blood cells from haemolysis. A vital role in epithelial tissue maintenance and prostaglandin synthesis.
Vitamin K	Aids in the production of pro-thrombin, a compound required for normal clotting of blood.
Water-soluble vitamins	
Biotin	Involved in the synthesis and breakdown of fatty acid.
Foliate	Essential for biosynthesis of nucleic acids and normal maturation of red blood cells.
Niacin	Acts as a metabolism? of carbohydrates and amino acids. Assists with tissue respiration.
Pantothenic acid	Essential for the intermediary metabolism of carbohydrate, fat and protein.
Riboflavin	Essential for growth. Plays an enzymatic role in tissue respiration and acts as a transporter of hydrogen ions.
Thiamine	Essential for growth, normal appetite, digestion and healthy nerves.
Vitamin B12	Involved in the metabolism of single carbon fragments. Vital role in the metabolism of nervous tissue and foliate. The vitamin is related to growth.
Vitamin B6	Aids with amino acid breakdown. Essential for normal growth and aids in the conversion of tryptophan to niacin.
Vitamin C	Maintains intracellular cement substance with preservation of capillary integrity. Very important for immune system responses, wound healing and allergic reactions. Increases the absorption of non-heme iron.

Macronutrients	FUNCTION WITHIN THE BODY
Calcium	Bones and teeth consist of 99 per cent calcium. Ionic calcium in body fluids is essential for ion transport across cell membranes. Also bonds with protein, citrate or inorganic acids. Allows for muscles to contract and relax.
Chloride	Serves as a buffer and enzyme activator. It is a component of gastric hydrochloric acid
Cobalt	Assists with normal cell function, particularly cells of bone marrow and the nervous and gastro-intestinal systems.
Copper	Found in all body tissue with the bulk located in the liver, brain, heart and kidneys.
Iodine	Synthesized in the thyroid gland, it functions in the control of reactions involving cellular energy.
Iron	There is 70 per cent in haemoglobin and about 25 per cent stored in the liver, spleen and bones. Vital for oxygen transfer and is present in certain enzymes. Iron helps fight illness and is needed for develop and function of the brain.
Magnesium	There is 50 per cent in the bones, while the remainder is within the cells. It is an activator of most enzymes and is vital for all body processes.
Manganese	Highest concentration in the bone, pituitary, liver, pancreas and gastro-intestinal tissue. Boosts the cells of the liver.
Phosphorus	About 80 per cent found in bones and teeth. It is a component of every cell and important metabolites.
Potassium	For carbohydrate and protein metabolism and assists with muscle contractions.
Selenium	Involved in fat metabolism, vitamin E and antioxidant function.
Sodium	Regulates the body fluid volume.
Sulphur	Functions as an anti-oxidant and as part of thiamine and biotin.
Zinc	Occurs in most tissue with great amounts in the liver, voluntary muscles and bone. Zinc is important for nucleic acid metabolism.

Table 2.3 Daily requirements for children between six and 13 years of age (IM 1997, 1998, 2002).

Nutrient		EAR* 4 to 8 years	EAR 9 to 13 years
Calcium	mg	800	1300
Carbohydrates	g	100	100
Energy	kJ	7316	9572
Fibre	g	25	31
Fluoride	mg	1,1	2,0
Iodine	µg	65	73
Iron	mg	4,1	5,8
Magnesium	mg	110	200
Phosphorus	mg	405	1055
Protein	g/kg/day	0,76	0,76
Selenium	µg	23	35
Vit. A	µg	275	445
Vit. B1	mg	0,5	0,7
Vit. B12	mg	1,0	1,5
Vit. B2	mg	0,5	0,8
Vit. B3	mg	6,0	9,0
Vit. B6	mg	0,5	0,8
Vit. C	mg	22	39
Vit. D	µg	5	5
Vit. E	mg	6	9
Vit. K	µg	55	60
Zinc	mg	4,0	7.0

*Estimated average requirement

2.1.3 Factors influencing food choices of children aged six to 13 years

Meal patterns are determined by the choices made. The known habits, likes and dislikes of individuals are developed during their early years and are carried into adulthood. The factors influencing food choices are categorised into two sections. The first is internal, i.e. the individual's criteria. The second is external, which includes the surrounding environment. Internal factors include sensory (smell, taste, flavour, appearance, sound), mental (expectations, experience, associations, knowledge) and physiological (illness and disease, hunger and appetite, age) characteristics. External factors include culture/religion, family environment, social trends, peer influences, group settings, finances, occasion, time and availability. Other factors that also have an effect include media messages, convenience and variety. These factors are more influential in communities with industrial and business developments, as the financial infrastructures are stronger (Bennion 1990).

Contrary to common belief, children do not have the ability to choose foods to provide a balanced diet. Parents and other food providers are responsible for offering a variety of nutritious and developmentally appropriate foods (Bennion 1990; Mahan & Escott-Stump 2000).

Parents need to investigate the quality of meals and snacks when enrolling their children at day-care centres, head-start programmes or schools. In addition to providing the child with optimal nutrients, a programme should offer food that is appealing, safely prepared, and appropriate, considering cultural and developmental patterns. Experiencing new foods, participating in simple food preparation, and planting a garden are activities that develop and enhance positive food habits and attitudes (Steyn & Badenhorst 1993).

School-aged children often consume snacks during school hours and in the evenings. As children grow older and acquire more money to spend, they tend to consume more snacks from vending machines, fast food outlets and local grocery stores. Studies completed by Steyn and Badenhorst (1993) suggested that nutrition programmes should be intended to improve the nutritional intake of school children aged six-14 years. Their survey reported that 19 per cent of school children spent R3,00 per week on sweets and cold drinks, whereas 10 per cent took a lunch box. Children were prone to snacking with high consumptions of maize, tea and brown bread. On a daily basis, maize porridge and brown bread were consumed in great amounts, while tea was the most frequently consumed beverage.

Choices in eating situations are determined by the combination of the state of the eating /provisioning environment prior to and during the choice experience, as well as the state of the individual prior to and during that time (Bell & Meiselman 1995).

With the factors of sensory characteristics (taste, smell, appearance and taste) and social environment (low income and poor parent education levels) surrounding the choices of food made in this informal settlement, where this project was undertaken, the focus of this study was to develop a multi-mix to be adopted into recipes which were appealing through the senses. Acceptance of the final product would be enhanced with the use of ingredients common to the cultural obligations, and community and cost effectiveness. With the high consumption of snack items amongst the children, providing a low-cost multi-mix recipe, would allow the child an opportunity to purchase a healthier alternative to the current snack item, i.e. Nik-Naks, which provide empty calories.

2.2 Addressing malnutrition

Malnutrition can be addressed through various strategies such as supplementary food aid, which consists of food supplied to communities through various organisations and government. Integrated Nutrition Programmes are set up by Departments of Health and organisations that rely on funding from government. Supplementation involves providing supplements to the community or specific groups. Food fortification has become mandatory in many countries, including South Africa where food is augmented with nutrients which are lacking in the product. Enriching implies augmenting nutrients already present within the foods. Food-based strategies are categorized as nutrition education, agricultural programmes and food diversification. This involves the education of communities in making healthier food choices, informing and providing assistance for the implementation of vegetable gardens and the use of common ingredients which are available to develop formulas to assist with malnutrition (Mahan & Escott-Stump 2000).

2.2.1 Supplementary food aid

One of the primary goals of food aid is to combat world hunger and malnutrition. Great attention is being given to expanding the role of food aid in meeting the full nutrient needs of ever-increasing numbers of refugees and displaced persons in emergency situations (Dexter 1995).

Food aid is an essential part of responses to emergencies that threaten life and the nutritional status of people (Bhatia & Thorne-Lynman 2001). Disaster Relief Agencies (Disaster Center 2005) are setup across the world with the involvement of the United Nations (UN). Some of the programmes include the UN Food and Agricultural Organisation, the UN World Food Program, the World Food Program, the World Health Organisation, the Save the Children Alliance, the Children's Aid Direct, the Food for the Hungry and the Salvation Army.

Food aid can be classified into three groups, namely project, programme and emergency. Project food aid is donated to support specific activities and projects. This includes work-for-food, school feeding and at mother-child nutrition centres. Programme food aid is the provision of food from a developed country to the government of a recipient country. Food aid emergency is the distribution of food during times of emergencies, such as war and famine. Emergency food aid consists of the distribution of food rations and feeding programmes to nutritionally vulnerable groups (Oxfam International 2005).

The advantage of food aid is the possibility of across-border assistance, providing food products and other items to people around the world. It could be a possible disadvantage that food aid relies on donations. The amount of assistance is dependent of the amount of support received. There may be inconsistencies if the supply is irregular and when donors are forced to divide the support amongst various aid programmes due to high disaster numbers (Dexter 1995; Disaster Center 2005).

In South Africa the Food Supplementary Aids Programme (Watson 2005) began in 1938, when the free milk-in-schools scheme was provided for whites and coloureds. In 1944, one free meal was provided in primary schools but by 1952, there had been a 40 per cent reduction in Native school feeding schemes. Whites, Natives and Indian children also benefited from this scheme. Other programmes included:

- 1939: Feeding provided to black schools.
- 1940: The National Council became involved in providing feeding on a national level. Only bread was subsidized by 1950.
- 1945: The Emergency Aid Programme (EAP) and Food Aid Programme (FAP) were combined and merged to 185 depots where low income food was purchased. Food was bought at a reduced cost and the government subsidized the remainder.
- 1945: The Department of Social Welfare (DSW) introduced the citrus fruit, deciduous fruit, milk and butter schemes. Pauper rations were divided amongst Whites, Coloureds and Indians in the Cape, Transvaal and Orange Free State.
- 1945-1946: The Department of Native Affairs (DNA) distributed food to African children in Ciskei. Milk and food rations were supplied to hospitals, schools and clinics in return for work, namely construction and repair of the dam.
- 1952: School feeding became subsidized.

- 1960s: Only milk and milk powder were subsidized by local governments for 66 local authorities.
- 1964: Fortification of maize meal (non compulsory) (Watson 2005).

The Joint Aid Management (JAM) currently focuses on areas that require nutritional feeding. The selected areas are rural areas with low income. JAM works closely with the DoH to conduct surveys revealing the tendency toward hunger, malnutrition and poor school attendance. School children aged 3 to 14 years are provided 100-150g of food rations per day, which provides 70-100 per cent of their daily requirements. A total of 5 000 children are being nourished through school-based feeding. JAM also participates in Health and Social Welfare Nutritional Programmes (JAM 2005).

In a joint venture with neighbouring countries, South Africa supplies food aid to other African countries. The Departments of Agriculture, Trade and Industry, Defence and Health contribute, through the World Food Programme (WFP), toward providing food aid to countries mainly to the north of South Africa. The country is an integral part of the Southern African food aid equation and stands to benefit from balanced development and improved food security (FDA 2002; Disaster Centre 2005).

2.2.2 Integrated nutrition programmes

Community-based food and nutrition programmes have been implemented in many countries with common nutritional or nutrition-related objectives. The purpose is to reduce the prevalence of malnutrition or improve household food security, or more specific objectives relating to a single micronutrient or a single nutrition activity such as the promotion of breastfeeding. On the one hand the success of a programme lies in its ability to achieve its objectives, which for a nutrition programme must mean improved nutritional status, while on the other side is its ability to sustain such achievements (FAO 2005a&b).

In South Africa, the Protein Vitamin Malnutrition (PVM) scheme was introduced in 1975 by the Department of Health (DoH). Powdered milk, which was fortified with vitamins and minerals, was supplied to children between the ages of one to six years. Poor results occurred due to the milk being unpalatable, a lack of commitment by the staff involved and no accountability for distribution within various institutions. The current scheme involves supplying full-cream milk powder, dry beans, maize meal porridge and energy rich foods for infants, children, pregnant and lactating mothers (Watson 2005).

The government intervened during 1985 and introduced an Emergency Food Scheme for those living in poor, high nutritional risk areas. During the years 1987 and 1988, 95 000 African children where assisted. The Committee for the Development of a Food and Nutrition Strategy for Southern Africa was established in 1989, and the Nutrition Development Programme (NDP) was initiated because of its recommendations (Watson 2005).

In 1990, R220 million was made available for food aid to groups at risk. Since then the programme has been awarded double the funds and exists as the National Nutrition and Social Development Programme (NNSDP). Food is provided as parcels or prepared meals and provides direct assistance with community development. The purpose is to help families living below the poverty line, children under the age of six years, the elderly, primary school children, the chronically ill and the unemployed (Watson 2005).

Another successful programme includes the Protein Energy Malnutrition (PEM) scheme. The responsibility includes providing supplementation to undernourished children younger than 6 years, underweight pregnant and lactating mothers, the elderly and the chronically ill (Watson 2005).

On 24 May 1994, former President Nelson Mandela introduced, the Primary School Nutrition Programme (PSNP) as part of the Reconstruction and Development Programme (RDP). The PSNP intended to alleviate temporary hunger in primary schools and address nutritional deficiencies. The programme has been given R496 million in funds since it commenced. The purpose is also to ensure community involvement and linking school nutritional conduct to other educational activities. The main objective is to lead to development within communities, including sustainability and multi-sectorial and interdisciplinary interventions. The National Integrated Nutrition Programme was developed when a committee was established in 1994, to address all the causes of malnutrition and stressed that all sectors needed to work in an integrated manner. It was decided that integration had to occur and the selected groups were children under six years of age, pregnant and lactating women at risk, primary school children from poor households, persons suffering from chronic disease and the elderly. The involvement came from the combination of various programmes in order to develop the Community Based Nutrition Programme (CBNP), which was made up of NNSDP and PSNP, with the Health Facility-Based Nutrition Programme (HFBNP) in conjunction with the PEM Scheme and Nutrition Promotion (McCoy 1997; Mametja 2003). Reports indicated that the school-feeding scheme collapsed in the Eastern Cape due to fraud and mismanagement. Thus, the collapse in the Eastern Cape had deprived some 1 million children of food at school (Sidley & Amner 1995). The survey indicated that between the years 1994 and 1995, the RDP Fund was 30 per cent less than the previous year, which meant that some 3,3 million children in 8 900 schools were assisted in comparison to 5 million in 13 000 schools in the previous year (Sidley & Amner 1995). McCoy (1997) indicated that the specific aims of the

PSNP were to improve education through micro-nutrient supplementation, improve health through parasite control/eradication, education concerning health and nutrition and enhancing broader development initiatives, especially in combating poverty. A suggestion was made to try to transform the PSNP from being a vertical feeding programme into a comprehensive school nutrition programme. It can be completed through integration as part of a broader combination of priority school health activities and as part of the national Integrated Nutrition Programme (INP) (McCoy 1997; Mametja 2003).

Such programmes are necessary in order to address the immediate, underlying and basic causes of malnutrition in South Africa. Certain results have not been obtained within South Africa, due to the lack of integration and other deficiencies in the planning process, as well as in the implementation and management of fragmented interventions. In 1990, the National Rural Development Forum (NRDF) was established using the national and regional Nutrition Task Force. The principles outlined in UNICEF's conceptual framework have been adapted with regard to strategies for improved nutrition of children and women. Integrated programmes are necessary in order to address the immediate, underlying and basic causes of malnutrition in South Africa (Santos-Pais 1990). The government is expanding the Child Support Grant and provides feeding to 4,6 million destitute children in 17 000 schools across South Africa. Unfortunately, this excludes most children under six years, i.e. some five million children. The school-feeding programme has recently moved from health to education (Reynolds 2005).

The Integrated Nutrition Programme (INP) was developed in 1994, with use of the UNICEF nutritional conceptual framework. The INP focused on eight areas, namely contribution to household food security; disease-specific nutritional support, treatment and counselling; growth monitoring and promotion; nutrition promotion, education, and advocacy; promotion, protection and support of breast-feeding; micronutrient and malnutrition control; food service management; and a nutritional intervention programme for the human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) and tuberculosis (TB). A recent review has shown success with certain aspects of nutritional policy and the development of guidelines for the improvement of the nutritional status of vulnerable groups (Labadarios *et al.* 2005a&b).

Since 1994, South Africa has addressed malnutrition through mandatory fortification of all maize meal and wheat flour, iodization of table salt, vitamin A supplementation, baby friendly hospital initiatives, development of food-based dietary guidelines, standardization of the 'Road to Health' chart, primary school feeding, which is currently managed through the Department of Education and the development of food service management guidelines (Bowley 2005).

The PSNP reaches approximately 5 million South African children in primary schools. Food supplement is given together with nutrition education. As a result children have been more eager to attend school as well as parents being willing to send their children to school as breakfast is provided for them (Rochè 2000).

Advantages to feeding programmes include the reduction in mortality rates due to malnutrition and nutrition-related diseases. Therefore, assistance is given for the growth and development of children. Interventions have been shown to have positive outcomes (DoH 2002). Creating more interventions improves the performance of those in place and allow for alteration. Interventions often suggest new ideas for pilot programmes (Elmadfa *et al.* 2001).

The disadvantages of feeding programmes can be outlined from the errors which occurred during past intervention programmes. Lack of support from food providers as well as lack of knowledge contributed to the failure of certain programmes. With relatively high monetary value involved, it allows fraudulent activities to occur if not properly controlled. The distribution process also requires strict controls (DoH 2002). Another common misconception is that a community-based nutrition programme employs a participatory approach and true participation is time-consuming (FAO 2005a, b).

2.2.3 Supplementation

Tablet supplementation is given to assist in meeting daily requirements and helps in building up the immune system, making the child stronger and resistant to common illnesses. A variety of tablets is available on the market, especially the range for children. Each has a different taste, shape and nutritional effect (UNICEF 2004).

In South Africa the Integrated Nutrition Programme (INP) provides vitamin A supplementation to children in schools. Those who lack vitamin A lose weight, fail to grow properly and are more likely to acquire infections and die from them (DoH 2005a).

Supplementation is made available to children and women of childbearing age with vitamin and mineral supplements in the form of low-cost tablets, capsules and syrups. According to UNICEF an advantage is that in industrialized countries, low-cost tablets assist in reducing micronutrient malnutrition in children and women of childbearing age. A disadvantage is the possibility of toxicity, which can occur when excess nutrients are consumed, particularly fat-soluble vitamins, i.e. vitamins A, D, E and K (UNICEF 2004).

2.2.4 Food fortification

According to the DoH (2005b), in South Africa food fortification is the addition of micronutrients to food. Food is fortified with nutrients to provide additional nutrients, which may not be present in the food. Fortification generally restores the original nutrient levels, while in some cases increases them. Fortification could also introduce additional nutrients not originally present in the food (Bagriansky *et al.* 2002).

Food enrichment refers to the addition of nutrients which already exist within the food, but are of low nutritional value or present in very small quantities (Bagriansky *et al.* 2002, DoH 2005b).

In 1994, Sasko introduced fortification of white, brown and whole wheat bread with thiamin, riboflavin, niacin, folic acid, pyridoxine and calcium. In 1995, the first compulsory fortified product introduced in South Africa was iodized salt. In 1996, the collaboration of vitamin A and iron fortification commenced at a consensus workshop. The NFCS identified three vehicles for food fortification, namely sugar, maize meal and wheat flour. In South Africa, the food fortification regulations are published in terms of the Act of Foodstuffs, Cosmetics and Disinfectants in the *Government Gazette*. As of 1 April 2003, it became mandatory to fortify maize meal, sugar and wheat with vitamins (DoH 2003a). The *Gazette* indicates the number of international units (IU) per gram to be added of vitamin A, thiamine, riboflavin, niacin, pyridoxine and folic acid. Maize (Table 2.4) and wheat flours (Table 2.5) are currently fortified to supply the following nutrients and percentages of RDA for children aged 10 years and older: vitamin A 31 per cent; thiamine 25 per cent; riboflavin 17 per cent; niacin 25 per cent; pyridoxine 25 per cent, iron 25 per cent and zinc 20 per cent. In 2004, the DoH Nutrition Directorate commissioned a follow-up study of children with the aim of monitoring the effect of fortification according to established baseline blood micronutrients levels in children aged 1 to 9 years. The results are still awaited (Labadarios *et al.* 2005b).

Since the staple food item of South Africans is maize meal, the advantage of food fortification includes cost effectiveness and the ability to reach a large number of people. The Industry Situational Analysis conducted a survey showing that at least 85 per cent of maize meal and 97 per cent of wheat flour could be fortified centrally (DoH 2003a&b). Fortification restores vitamins and minerals lost during manufacturing processes (Bagriansky *et al.* 2002).

Dr Manto Tshabalala-Msimang, during a launch of the National Food Fortification Programme, provided additional information to the benefit of food fortification: fewer children become ill or die at an early age; the growth of children improves and there is better performance at school, while adults experience increased strength so as to work longer and harder (DoH 2003a).

Fortification has the potential for wide population coverage and can assist in overcoming micronutrient deficiencies as it can involve a combination micronutrient (Mahan & Escott-Stump 2000).

Bellamy (1998) stated that food fortification has worked in industrialized nations and is inexpensive and effective. Food fortification is the addition of essential vitamins and minerals to regularly consumed foods. The UNICEF report is a request for the food industry to develop a market and distribute low-cost fortified food products and supplements and for governments to create a supportive legislative environment and standards enabling environments for the control of vitamin and mineral deficiency through education and legislation (UNICEF 2004).

Table 2.4 Fortification mix for maize meal (Super, special, sifted and unsifted) (DoH 2003b).

Fortificants and diluents	Micronutrient requirements (Per 1 kg meal)	Fortificant requirements (Per 1 kg meal)	Fortification mix (g/kg)
Vitamin A palmitate[1] (Activity: 75 000 mcgRE[2]/g)	2085 mcgRE	27.8000 mg	139.0000 g
Thiamine mononitrate (Activity: 78% min.)	2.1875 mg	2.8045 mg	14.0224 g
Riboflavin	1.6875 mg	1.6875 mg	8.4375 g
Nicotinamide/niacinamide	25.000 mg	25.0000 mg	125.0000 g
Pyridoxine HCl (Activity: 81% min.)	3.1250 mg	3.8580 mg	19.2901 g
Folic acid (Activity: 90.5% min.)	2.0000 mg	2.2099 mg	11.0497 g
Electrolytic iron[3] (Activity: 98% min.)	35.0000 mg	35.7143 mg	178.6714 g
Zinc oxide (Activity: 80% min.)	15.00 mg	18.7500 mg	93.7500 g
Diluent	-	To complete 200 mg	To complete 1 000 g

1. Protected, stabilized Vitamin A palmitate containing 75 000 mcg RE activity per gram.
2. Retinol equivalents (RE) = 1 mcg retinol = 3.33 IU (International units) vitamin A.
3. Elemental iron powder where more than 95% passes through a 325 mesh (< 45 microns particle size) made by an electrolytic process.

Table 2.5: Fortification mix for wheat flour (DoH 2003b).

Fortificants and diluents	Micronutrient requirements (per 1 kg flour)	Fortificant requirements (per 1 kg flour)	Fortification mix (g/kg)
Vitamin A palmitate[1] (Activity: 75 000 mcgRE[2]/g)	1786 mcgRE	23.8095 mg	119.0475 g
Thiamin mononitrate (Activity: 78% min.)	1.9444 mg	2.4929 mg	12.4644 g
Riboflavin	1.7778 mg	1.7778 mg	8.8889 g
Nicotinamide/niacinamide	23.6842 mg	23.6842 mg	118.4210 g
Pyridoxine HCl (Activity: 81% min.)	2.6316 mg	3.2489 mg	16.2443 g
Folic acid (Activity: 90.5% min.)	1.4286 mg	1.5786 mg	7.8927 g
Electrolytic iron[3] (Activity: 98% min.)	35.00 mg	35.7143 mg	178.5714 g
Zinc oxide (Activity: 80% min.)	15.00 mg	18.7500 mg	93.7500 g
Diluent	-	To complete 200 mg	To complete 1 000 g

1. Protected, stabilized Vitamin A palmitate containing 75 000 mcg RE activity per gram.

2. Retinol equivalents (RE) = 1 mcg retinol = 3.33 IU (International units) vitamin A.

3. Elemental iron powder where more than 95% passes through a 325 mesh (< 45 microns particle size) made by an electrolytic process.

The Micronutrient Initiative (MI) and UNICEF (2004) provided relevant information as to which food is defined as being suitable for fortification:

- Food that is affordable and regularly consumed by a significant proportion of the population, including low-income;
- Food that will not be affected by fortification;
- Food that does not react with additives in any adverse way;

- Food which preserves the vitamins and minerals during the shelf-life and cooking process.

The Medical Research Council (MRC) has implemented successful fortification programmes since 1995 (MRC 2001b). First was the fortification of biscuits with iron, iodine and B-carotene. As a result of using red palm oil in biscuits, vitamin A deficiencies were considerable reduced. Biscuits have a six month shelf-life (MRC 2001b). Secondly, cereal was fortified to determine the vitamin A and iron status of infants in poor communities with Kwazulu-Natal (KZN) (MRC 2001b). Third was an evaluation of the short-, medium- and long-term effect of iodisation of salt in primary school children in four communities across the Eastern Cape (EC) before mandatory iodisation in South Africa, and again after one, three and five years. The iodine status improved rapidly after one year, but took longer for goitres to regress (MRC 2001b). Fourth was a national survey of the iodine content of household salt in South Africa. Salt samples were obtained from a national sample of 2 043 households representing all the residential categories, and therefore of all socio-economic strata in the population, and analysed for the iodine concentration. The results indicated that although the national mean and median iodine concentrations are acceptable, significant geographical variation in iodine concentration was observed, and only 62,4 per cent of households used adequately iodised salt, sufficient to eliminate iodine deficiency and its consequences (MRC 2001b). Fifthly, an intervention study using fortified biscuits to address the micronutrient deficiencies within primary school children was undertaken. Results indicated biscuits to be a feasible, practical and effective way of improving the micronutrient status of primary school children (MRC 2001b). During a study by Richter *et al.* (1997), 55 undernourished South African children within rural communities between the ages of 7 to 14 years, were provided with a fortified cereal with milk and banana on a daily basis for six months. Results showed an improvement in cognitive and behavioural performance (Richter *et al.* 1997). Another successful programme included the study of the effects of iron, iodine and B-carotene fortified biscuits for primary school children (Van Stuijvenberg *et al.* 1999). The biscuits, which provided 60 per cent of RDA of beta-carotene, iodine and iron, were provided to children with a drink, containing 90mg vit. C, for a period of 1 year during school days only. The results indicated an improvement in micro-nutrient status, short-term memory and attention, and fewer illness-related absenteeism from school (Van Stuijvenberg *et al.* 1999).

2.2.5 Food-based strategies

2.2.5.1 Nutrition education

Promoting the education of children and their parents will assist in ensuring that correct choices are made and will help to identify nutritional deficiencies when they arise (Gobotswang s.a.). An opportunity exists to educate families concerning the importance of both sides of the energy-balance equation in order to have a positive effect. Parents and children need to work together in addressing malnutrition problems (Kloka 2003).

It becomes an ideal opportunity during the early years to provide nutrition education to children as this promotes positive attitudes concerning food. (Mahan & Escott-Stump 2000). The NIRU (MRC 2001c) has proven through a community-based research project in Langenbaan, South Africa, that health monitoring and identifying the nutritional status of preschool children has improved the status of the preschool children over a period of time (MRC 2001c).

In South Africa a nutritional labelling education programme should be implemented to promote the correct choice of foods so as to eliminate nutrition-related disease (Anderson & Coertze 2003). Studies conducted by Anderson & Coertze (2003) indicated that consumers required more nutritional information on products in order to assist with:

- understanding the format of labelling used to present nutritional information;
- understanding of terminology used on food labels, and to inform them of the functions and sources of nutrients present;
- understanding the relationship between diet and disease;
- providing information concerning key issues such as reduction in body weight, fat, and salt and the increase in fibre;
- teaching the consumer how to include food groups such as red meat that are related to health issues.

The Food Advisory Consumer Service (FACS) was launched in January 1995, as the first independent nutrition consumer service. Its purpose is to supply consumers with relevant and scientifically correct information on food and nutrition issues. FACS prepares information leaflets, posters and position papers concerning important and critical food issues. FACS is also an education medium, and its material is used for training purposes at community level. It is operated through the DoH and Food Science and Nutrition and Education Departments. FACS is currently a member of the Food Legislation Advisory Group (FLAG) and also involved in Codex Alimentarius, the Joint FAO/WHO Food Standards Programme (FACS 2005).

The NFCS plays a very important role in nutrition education in South Africa. By providing health workers with information regarding both the quantity and quality of foods consumed, the nutrition education tools and interventions can be based on documented evidence of food consumption in the country (DoH 2002). The South African food-based dietary guidelines (SAFBDG) were developed in order to motivate a positive, practical, affordable, sustainable and culturally sensitive approach to food choices for South Africans over the age of seven years (Vorster *et al.* 2001). Guidelines are provided to help decrease the prevalence of chronic conditions such as heart disease, cancer, diabetes and obesity (Mahan & Escott-Stump 2000). Based on the NFCS of 1999, the guidelines are established on the existing consumption of locally available foods and address identified nutrient-related public health problems. The guidelines are adapted for groups with special dietary needs. The guidelines are based on available and affordable foods which are widely consumed, and encourages environmentally sound agricultural practices. The guidelines can be used to form the basis of nutrition education in South Africa, but they require regular review. The FBDGs consist of 11 short, clear and simple messages (Vorster *et al.* 2001, DoH 2002).

- Enjoy a variety of foods.
- Be active.
- Make starchy foods the basis of most meals.
- Eat plenty of fruit and vegetables.
- Eat dry beans, peas, lentils and soya often.
- Meat, fish, chicken, milk and eggs can be eaten every day.
- Eat fats sparingly.
- Use salt sparingly.
- Drink plenty of clean, safe water.
- If you drink alcohol, drink sensibly.
- Take food and drinks containing sugar sparingly and not between meals.

The idea of providing proper nutritional education has always been an important factor but difficulties continue to occur due to the lack of structure, support and funding. Problems arising within communities, which hinder the effort of reducing malnutrition, include:

- Hunger, poverty and population growth, the more mouths to feed, the greater the poverty.
- High use of fats and oils.
- Pollution.
- Losses of food-producing land, development of more housing and cities.
- Loss of ozone layer.
- Extinction of fauna and flora (Kloka 2003).

Community participation may change during education presentations. Existing groups may feel threatened as a result of the participation of community members in making decisions about activities and resources. It is important to keep communities interested and request their involvement in resource allocation, to prevent loss of interest and participation (Cerqueira 1991). Important aspects in achieving participation are motivation and good staff management. Motivation is assisted by a system of regular advice to staff and communities and through recognition of achievements. A participatory monitoring system will itself provide some advice to the community, but for effective progress and efforts, community participation must form part of a larger process (FAO 2005b).

Nutrition education assists care-givers to make better choices and allows for better use of food resources. One advantage to paternal income/education is the improvement of living standards to a point where the family can meet minimum caloric needs (Tefft *et al.* s.a.). Nutrition education is enhanced by the implementation of awareness campaigns, which encourage behavioural adjustment that can lead to improved nutritional status (Kloka 2003).

2.2.5.2 Agricultural programmes

Rural development constraints have been based on a long history of discrimination, forced removals and *apartheid*. Forced removals to the former homelands led to over-population. Agricultural development has been a link to international market supply. The Government now assists by providing employment-intensive policies and small farmer strategies with the aim of ensuring capacity-building within communities. Presidential Lead Projects (PLPs) has already established 12 water projects, nine land reform projects and agricultural programmes for school feeding. In summary, the agricultural programmes are implemented in order to empower communities and schools to implement vegetable gardens, to encourage self-reliance and business opportunities (RSA 2005a.). The Land Redistribution for Agricultural Development Programme (LRAD) was designed to provide grants to black South African citizens to have access to land specifically for agricultural purposes. The advantage of the programme includes helping previously disadvantaged people in rural areas and improving living standards by enabling them to run effectively their own large or small farms. Other agricultural programmes currently in progress through government include the Comprehensive Agricultural Support Programme (CSAP), Land Care Programme, Household Food Production, Food Security and Starter Packs and Irrigation, Rehabilitation and Development Programme (RSA 2005b).

During the Statistics South Africa (StatsSA) survey of 2000, it was identified that 195 402 households in Limpopo, (approximately 20 per cent), farm in order to supply the main source of food for the household. Eastern Cape surveys indicated that 169 765 households, (12 per cent of all households), farm in order to supply the main source of food, with Mpumalanga at 8 per cent of rural households, 54 511 farming in order to supply food as a main source (Watson 2005).

The NIRU (MRC 2001c) proved in a study that home-garden programmes with higher consumption of yellow fruit and vegetables, improve the vitamin status of a rural community in a village in KZN

Food-based strategies ensure that knowledge is provided through education so as to help communities to implement vegetable gardens. By improving farming methods within communities, a self-help principle is provided, which will assist each family to support itself and prevent malnutrition to a large extent. School and community involvement in farming and vegetable gardens can be combined through educating school children and their parents. Providing more farming opportunities will also improve the financial status within the family structure (Mahan & Escott-Stump 2000). Community-grown school food together with a child rights programme allows communities to realise a goal they value most, that all children are in proper schools, that they are fed and that the young go to school (Reynolds 2005).

2.2.5.3 Food diversification

Food diversification is classified as a food-based strategy, which assists in preventing micronutrient malnutrition in the long-term. The same aim of reducing malnutrition is used to describe functional foods, which is a concept implying food components that have an ability to influence the body's functions so as to help improve the state of well-being and health while reducing the risk of disease. Functional food does not imply only one food type. Functional food can be a natural food in which one of the components has been naturally enhanced, a food to which the component has been added to provide benefit and a food that has components which are bio-available for maximum absorption. Functional foods are labelled accordingly, whether there is a positive affect on one or more functions in the body and in amounts that can normally be consumed in the diet (Ashwell 2002).

The basic principles of functional foods can be described for a multi-mix. A food multi-mix (FMM) is a combination of various ingredients intended to achieve maximum nutritional value. The criteria are to ensure that the ingredients, which comprise the staple food item(s) within a country or community, are combined to be cost effective, nutrient-rich and culturally acceptable. It involves transforming traditional food items into enriched food mixes for poor communities (University of Greenwich 2004). A multi-mix contains components of high nutritional value, focusing on specific nutrient deficiencies, while with the nutritional criteria of the multi-mix formulation, maximum absorption occurs with specific portion sizes.
A food multi-mix is regarded as a food-based strategy. The advantages include the following:

- It will ensure better choices and consumption of naturally rich food sources.
- Preventive, cost-effective, sustainable and income-generating.
- Culturally acceptable and feasible to implement.
- Promote self-reliance and community participation.
- Foster the development of sustainable, environmentally sound food production systems.
- Build alliances among government, consumer groups, the food industry and other organizations the better to achieve the shared goal of preventing micronutrient malnutrition (Amuna *et al.* 2000, Mahan & Escott-Stump 2000, Zotor 2002).

2.3 Food multi-mixes as a strategy for addressing malnutrition

2.3.1 Introduction to multi-mixes

A multi-mix is a combination of more than two ingredients (Cameron & Hofvander 1987). The aim of a multi-mix is to supply a specific consumer with a product, which can be added to a meal to boost nutrient needs or provide nutrients that are lacking. A challenge to finding suitable food vehicles and the right fortification compound also depend on cultural hindrance, expense and sustainability (Amuna *et al.* 2000).

"We are using our understanding of the science of nutrition and the composition of foods to create nutrient-enriched foods" (University of Greenwich 2004). Malnutrition can be addressed if communities are taught to combine traditional cereals, legumes, fruits when appropriate and affordable with animal products in the form of traditional nutrient multi-mixes (University of Greenwich 2004).

High-fibre multi-mixes inhibit the absorption of iron and digestibility of protein in foods. Cooking has positive effects of food, by killing bacteria, improving taste and making the product more edible and digestible (Amuna *et al.* 2000). Certain vitamins may be lost when cooking food extensively, while drying results in a loss of vitamin C and foliate. On the other hand germination and fermentation improve legume digestibility and increase the vitamin content of beans. By drying the multi-mixes, it ensures that storage life is prolonged. Beans have an advantage in helping to lower the risk of diseases such as coronary heart disease and cancer (Gopaldas *et al.* 1974; Amuna *et al.* 2000).

2.3.1.1 Criteria for multi-mix development

Criteria for multi-mix development were identified by Gopaldas (1974) (Table 2.6) and should be kept in mind when planning to develop a systematic formulation for multi-mixes.

During October and November 1972, 15 weaning multi-mixes where formulated at Bilpark Village, in the Ratlam district of India. All formulae met the nutritional criteria. Roasting was ideal for cereal-legume-oilseed multi-mixes and increased shelf-life and digestibility (Gopaldas 1974).

Table 2.6: Ten (brief) criteria for systematic formulation of multi-mixes

1. Surplus and availability of raw food commodities at community levels. 2. Cost. 3. Nutritive value. 4. Shelf-life. 5. acceptability 6. Tolerance by the selected group. 7. Flexible composition. 8. Processing. 9. Form of product. 10. Safety and hygienic handling.

Work completed in India proved that a low-cost and acceptable multi-mix can be made with cereals, pulses and oilseeds . The inclusion of oilseeds was to make a more nutrient-dense formulation, while their omission was to reduce cost (Gopaldas *et al.* 1974). Malted multi-mixes involve three important steps (Table 2.7) toward ensuring organoleptic acceptance and good taste:

Table 2.7: Three steps to ensure organoleptic acceptance and good taste (Gopaldas 1974)

1. Steeping, i.e. soaking all seeds for a period of 12 hours under strict humidity and temperature controls.
2. Germination, i.e. wrapping the seeds in damp muslin for germination at strict temperature controls for 24-48 hours.
3. Roasting and milling, various products required different times and temperatures.

2.3.1.2 Storage and shelf-life

Most storage studies were conducted at room temperature over a period of 28 days (Gopaldas 1974). The maximum limit for moisture content was set at 14 per cent. For oilseeds shelf-life becomes less. It is important to consider correct preparation methods, especially when considering available space in communities. Nutrient composition of eight multi-mixes ranging from combinations of processed soybeans, cowpeas, maize, sorghum, yams, cocoyam, plantains and sweet potatoes were examined after sprouting, cooking and fermentation. The samples were dried and milled to fine flour. The rations were 65 per cent cereal, 30 per cent legume and 5 per cent starchy staple (Nnam 2000). Results are provided by Nnam (2000), namely in soybeans the protein, lipid, energy, fibre and calcium levels were higher. The multi-mixes developed were reported to have higher protein and energy levels than commercial cereal for infants.

Cameron and Hofvander (1987) further developed the multi-mix formulations for weanlings, from the studies of Gopaldas (1974) and created a food square (Figure 2.1), which is a useful concept when teaching how to choose ingredients for multi-mixes.

Dr. Francis Zotor, a medical biotechnologist from the University of Greenwich, United Kingdom, began the FMM project as part of his PhD studies by using the findings of Gopaldas (1974) and Cameron & Hofvander (1987) to further develop the concept of the multi-mix to assist in addressing malnutrition within poor communities.

Food choices of FMM are always made when socio-cultural and religious commitments are obeyed. The choice of the FMM is also affected by the appropriateness, which includes appearance, texture, taste and digestibility.

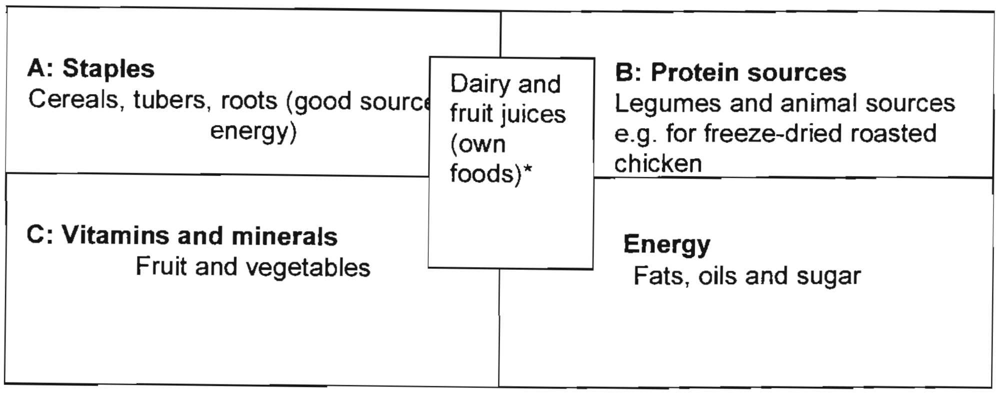

Figure 2.1 Adapted food square used as a guide for the formulation of the multi-mix (Cameron & Hofvander 1987).

* Cameron & Hofvander (1987) formulated this food square for weanlings and used breast milk and formula milk. The multi-mixes will thus be supplements to the available household meals.

2.3.1.3 Formulation of a multi-mix

There are three stages of the operating principles in FMM formulation (Cameron & Hofvander 1987; Amuna *et al.* 2000; Zotor 2002):

- Stage 1: a four-step procedure for selection of ingredients includes selecting ingredients from the staple food source; selecting an ingredient from a protein source; selecting ingredients which will supply ample vitamins and minerals; and selection of an ingredient which can supply fat.

- Stage 2: This involves identifying limiting nutrients of the target group of consumers and making a list of the foods most commonly consumed and knowing whether these sources are locally available and economical. The total FMM should not be of more than five ingredients. A standard portion for 100g FMM is used. Using the food composition table, find a proportion of nutrient per weight selected. Determine the total energy content by multiplying the carbohydrates and protein by 16,8 kJ and fat weight by 37,80 kJ.
- Stage 3: the formulation should yield an Energy Density (ED) between 15,12 – 18,90 kJ/g (3,6 – 4,5 kcal/g) so that small quantities can be consumed daily yet still provide maximum nutrient benefit. The Index Nutrient Quality (INQ) should exceed or be equivalent to 1.0 so as to ensure a good quality of the product. The INQ is calculated by dividing the amount of nutrient in 4 200kJ of food with the allowance of nutrient per 4 200kJ of a reference food. The amount of nutrient is measured in grams and the allowance of nutrient is taken from the recommended Dietary Reference Intake (DRI) also measured in grams (Zotor 2002).

Once the ingredients have been combined, the ingredients are processed into powder form and a chemical analysis is completed in order to determine the theoretical estimation of the experimental nutrient content. The multi-mix is then incorporated into recipes for sensory analysis, which will determine the ultimate recipes (Cameron & Hofvander 1987; Amuna *et* al 2000; Zotor 2002).
In the context of this study, it was vital to define and understand the criteria for multi-mix development to ensure the accurate development of a multi-mix which could address the problem of malnutrition within the informal settlement.

2.4 Processes required for the food multi-mix development

With the main objectives of this study involving the development of a multi-mix to address malnutrition amongst six to 13 year old primary school children, it was vital to understand the concepts addressing all aspects of the formulation process, the processes involved in actual preparation and implementation through recipe development and sensory evaluation, and to ensure the acceptability of the multi-mix. Understanding the criteria for multi-mix formulation and the various literatures on standardising of recipes and sensory evaluation processes, would ensure that the formulation of the multi-mix would meet the requirements for classification as a multi-mix, the expectations of the consumers and the achievement of the primary purpose of the study.

2.4.1 Food drying

Food drying is part of Stage 3, wherein the multi-mix is prepared before biochemical analysis can be completed. Food processing and preservation are the processes to transform raw food items into edible food products to last for a longer period of time. It also allows food to be kept longer due to less spoilage of the food items occurring. The process also allows for maintaining of nutrients and in some forms the improvement of the nutritional value, i.e. raw apples have an iron content of 0,12mg/100g. When dried the iron increases to 1,4 mg/100g. Food drying is one of the oldest methods of preservation. The modern food processing and preservation was initiated in 1809 by Nicolas Appert, a French chef who searched for better ways to provide food to the army (Wolf *et al.* 1990; James 1999).

2.4.1.1 Sterilization

Nicolas Appert devised a method for sterilizing food in tightly sealed glass bottles. Technology allowed for wider options for preserving food items. Food drying is also ideal for back-packers and camping. Drying will not be able to replace canning and freezing because the texture, colour and taste is maintained in these processes. Drying of food still preserves nutritional value and provides good value snacks (Wolf *et al.* 1990; James 1999).

2.4.1.2 Drying

According to Wolf *et al.* (1990) and Troftgruben (1977), the process of drying involves reducing water content over a low, consistent temperature for a specific period of time. The process involves cleaning the item, treating with sulphur when necessary then allowing it to dry. The process is completed by pasteurization of the food item and allowing it to cool. The advantage is that no micro-biological growth occurs and no chemical reaction takes place. Mould grows at lower moisture levels than do bacteria. Therefore, it is important to ensure that the dried food has cooled completely before placing it in an airtight container (Troftgruben 1977; Wolf *et al.* 1990)

2.4.1.3 Pasteurization

Foods are dried at a temperature of 65°C. When dried then pasteurization occurs for 15 minutes at a temperature of 85°C. Certain food items may be blanched, which allows for better colour and flavour retention (Vierra 1996; Taylor-Davis & Stone 2003). Unfortunately two nutrients are not able to withstand the heat, which are Vitamins A and C. Vitamin A is also diminished when exposed to light (Mahan & Escott-Stump 2000). The nutritional value diminishes considerably, whereas other nutrients are enhanced, as is the energy, e.g. raw apples contain 218,4 kJ per 100g and when dried the value is 1 202,60 kJ per 100g. The quality of the dried food is not as high as is a fresh food item. Fish has a high conversion rate of 454g fresh to 300g edible dried. The quality deteriorates gradually (Vierra 1996; Taylor-Davis & Stone 2003). Cereal grains are the seeds of cultivated grasses. Cereals are the staple food of people in developing countries, providing as much as 75 per cent of their total caloric intake and 67 per cent of total protein intake. Tomatoes are regarded as a fruit. There are many edible parts of vegetables and the nutritional values of fruits and vegetables are very high. It is advisable to wash them due to pesticides and sprays applied by farmers (Vierra 1996; Taylor-Davis & Stone 2003).

Preparation is important so as to prevent any spoilage or damage by the growth of fungi. Cleaning and sanitizing prevents contamination. Food may already be contaminated on arrival at a kitchen or can become so during preparation as a result of cross-contamination from other infected sources (Vierra 1996; Taylor-Davis & Stone 2003).

The methods used for food preservation include sun-drying, food dehydrators, convection ovens, freeze-drying, curing, canning, additives, freezing and vacuum sealing (Vierra 1996; Taylor-Davis & Stone 2003).

Factors affecting the drying time of food items (Vierra 1996; Taylor-Davis & Stone 2003) are:

- Size: the food needs to be processed into like-sized pieces. This will ensure equal time for drying, while avoiding moisture content within a certain portion.

- Temperature: if it is too high then the outer layer becomes dry and scorched whereas the centre remains moist.
- Capacity: do not exceed the limit of the method used. Consider the method as well as cost and space in relation to the amount of food to be dried.
- Speed: food drying requires patience. Do not try to hasten the process as the product will not dry evenly.
- Humidity and ventilation: ensure that the air circulation is evenly dispersed by allowing enough space between each drying tray. The oven door needs to remain slightly open so as to prevent steam from condensing.

The pre-treatment for drying foods includes washing and in some instances removing the stalk end. In the case of carrots, it is to be topped and tailed, whereas with spinach the larger stalk should be removed. Where relevant, some fruit needs to be treated with sulphur, or blanched as with certain vegetables. The skins of guavas should to be cracked (Vierra 1996; Taylor-Davis & Stone 2003).

All dried foods should, if possible, be crushed then stored in air-tight containers. This will require less storage space. Of course, this depends on how the food is to be prepared and in what recipe it will be used. Dried food items can be stored at room temperature for four to six months. When dried food is to be used, it is advisable to soak it for two hours, whereby one cup of dried is added to one-and-a-half cups of water. The dried food item can absorb double the quantity of water in weight. It is not recommended to dry eggs, fish, poultry or meat. In this instance curing and smoking is to be preferred (Vierra 1996; Taylor-Davis & Stone 2003).

The method to be used in this study involves hot air drying. Air is circulated by blowers and the food is placed on trays, parallel to one another and at least one-and-a-half inches apart. The food needs to be stirred every 30 minutes and the trays circulated on the shelves. The time is dependent on the characteristics of the material being dried, the temperature and humidity. Initially the water from the surface begins to evaporate. Vierra (1996) indicated that drying involves the diffusion of water into water vapour. It is therefore vital to keep the oven door open slightly (Vierra 1996; Taylor-Davis & Stone 2003).

The dryness is determined by sampling a piece which should be dry and brittle. It should crumble when pressed between two fingers. Vegetables should have a moisture content of only five per cent and fruit 15-20 per cent. Methods by which to measure moisture include the Dean and Starke Procedure (Vierra 1996) which requires the following:

- Food is mixed with chemicals in a flask.
- The flask is attached to a condenser and an oven.
- The mixture is heated.
- The water or moisture condenses into the graduated tube and read.
- This is a good procedure for items with high oil content.

James (1999) suggestes that when presenting the data regarding dried food items for scientific purposes, it is advisable to do so accurately by using graphs and tables, including symbols and separated equally per item. Accuracy can be achieved through

- the quality of the equipment;
- cleanliness and proper handling of equipment;
- accurate replication;
- implementing various tests to cross-reference.

Dried foods analysed through titrimetric analysis, gravimetric procedures, solvent extraction, refractometry and polarimetry (Vierra 1996; Taylor-Davis & Stone 2003).

The multi-mix formulation was based on the combining of scarce food sources to provide a nutrient-enriched multi-mix. The multi-mix was to be in powder form which lead to the necessary studies on the processes of dehydration. This resulted in an understanding of the practical application of the dehydration process to ensure the retention of maximum nutrients, extended shelf-life and accuracy with the procedures.

2.4.2 Food Safety

Hazard Analysis Critical Control Point (HACCP) can be defined as the analysis of a hazard, identifying critical control points and implementing control measures of corrective action. HACCP involves 7 principles: 1) analyse the hazard; 2) identify critical control points; 3) establish preventive measures with critical limits for each control point; 4) establish procedures to monitor the critical control points; 5) establish corrective action to be taken when monitoring shows that a critical limit has not been met; 6) establish procedures to verify that the system is working properly; 7) establish effective keeping of record so as to document the HACCP system (Gouws 2005). HACCP involves the safety measures which are adhered to within various facilities. It involves all aspects of the building, premises, and equipment and production procedures.

Food safety is required within a food environment, which implies minimal or no growth of pathogenic organisms. The advantages of HACCP and food safety measures include the identification of and focus on hazards so as to prevent food contamination; it ensures more efficient and effective government overseeing through record-keeping; it places responsibility on food safety and reduces barriers of international trade (Gouws 2005).

2.4.3 Recipe development

Buchanan (1993) provides a well-defined explanation of a recipe. The recipe itself is a blueprint for food production. It allows for ease and accuracy in preparation. For a recipe to be successful, it should be:

- REPRODUCIBLE: it is written so that it can be repeated with consistent results;
- EASILY PREPARED: the steps should be in logical sequence to produce appropriate end results;
- CONCISE: brief but comprehensive enough to furnish needed information;
- INTERESTING: the recipe should be appealing and well presented;
- PLEASING TO THE SENSES: the end result should stimulate the appetite and provide satisfying flavour and aroma with appropriate texture and oral feel;
- ECONOMICAL: not only in monetary value but also in human and material resources.

Standardisation of recipes is the optimum goal. It allows for accuracy and reliability in recipe development. Results can be disappointing when shortcuts are taken. The following advantages appear during the standardisation of recipes: 1) the quality of food is consistent promoting uniformity; 2) the yields are predictable, thus ensuring exact portions control; 3) satisfaction of customer as well as the person preparing the food; 4) efficient purchasing procedures as well as inventory control; 5) efficient and effective use of costs and time as labour can be planned and costs budgeted, and 6) more job satisfaction for the food provider as there is less probability of guess work and poor quality (Buchanan 1993, USDA *et al.* 2002).

Standardizing the recipes for this study would ensure accuracy during preparation and consistent results: portion sizes and uniformity. This study focused on the development of a multi-mix for the entire Primary School. Providing food for large numbers becomes easier with standardized recipes. One of the outcomes would be to further this study and implement the multi-mix as a part of an intervention programme. The aim is then to educate the food providers to prepare the recipes on a daily or weekly basis to supply to the learners. The recipes require standardizing to ensure easy understanding and consistent results. The recipes must also be based on ingredients which are available, low in cost and frequently consumed in the households (Cameron & Hofvander 1987).

2.4.4 Sensory evaluation

Sensory evaluation of food means appraisal through the use of senses, subjective, organoleptic or objective estimation. Sensory evaluation is a scientific discipline used to measure, analyse and interpret reactions to foods consumed when perceived through the senses of sight, smell, taste, touch and hearing. Sensory analysis involves the interpretation of responses (Stone & Sidel 1990).

Subjectivity refers to one's own opinion whereas objectivity refers to outside opinion. A product is subjectively evaluated whilst preparation is underway. Organoleptic evaluation refers to consumers evaluating the product and summarizing the data in order to identify the best product and market strategy. Objective evaluation involves the use of laboratory instruments (machinery and chemistry). Instead of evaluating the colour of carrots or spinach, the amount of carotene of chlorophyll is measured. The consistency can be determined as well as the pH. This type of testing does not involve the human senses. Instrument testing is cost-effective, faster and ensures quality control. A food item becomes palatable when it is both acceptable and agreeable to the senses. The sensory impressions include smell, appearance, taste, flavour and texture (Daniel 2000; Thomas 2002).

The intention is to prepare foods which appeal to the eye and senses. This can be achieved by understanding and evaluating certain characteristics when food is received, i.e. quality and colour (Daniel 2000, Thomas 2002). Sensory evaluation evolves as new trends in the market provide for competition, new brands, convenience and pricing (Stone & Sidel 1990). In the context of this study, the primary objective was to develop a multi-mix which could appeal to the eyes and senses. It was necessary to understand the different sensory characteristics of food as this was an important aspect to ensure acceptability of the multi-mix and recipes.

2.4.4.1 Smell

When interpreting smell the reference is to the odour, which is detected through the nose. Any food item that has an unpleasant smell will be refused immediately. The smell of items during preparation will also affect the individual when eating if the smell is offensive (Daniel 2000; Thomas 2002).

2.4.4.2 Flavour and taste

Flavour is a sensory characteristic, which is often understood as taste. Flavour is a complex of sensations. There are four taste sensations involving the taste buds on the tongue: sweet, sour, bitter and salty. Flavour is a blend of aroma and taste. The flavours of some foods when raw are readily perceived as 'natural'. When cooked certain non-flavour substances are produced, i.e. cauliflower and cabbage. The tantalizing aromas arising during the baking of bread are examples of flavoured substances produced by heating. The flavour of food should be acceptable so that a product can be consumed, e.g. dried sugar beans are insipid if roasted. Examples of flavour include metallic or fruity, whereas taste may be sweet or sour. Flavour can be divided into odour received through the nose, taste through the taste buds and oral feel. Taste-blind refers to being unreceptive to certain tastes, which are also affected by concentration. Taste-tired means that eating heavy foods results in the taste buds being unable to classify thoroughly. Some foods may have little or no flavour so an enhancer is added, e.g. MSG (Daniel 2000; Thomas 2002).

2.4.4.3 Texture

The texture refers to the feel on the tongue, e.g. creamy or smooth. The sensation involved in touch and feel is called tactile sense. Texture can be explained as being lumpy, granular, sticky or smooth. It also refers to the brittleness and ease of chewing. Five primary characteristics of texture include hardness, cohesiveness, viscosity, elasticity and adhesiveness. Texture also implies the physical and chemical interaction in the mouth from the initial perception on the palate, the first bite, through mastication and finally swallowing (Daniel 2000; Thomas 2002).

2.4.4.4 Appearance

Appearance refers to colour, form and size and is referred to as the appeal to the eye. Texture and appearance refer to the visual perception and colour (Bennion 1990).

2.4.4.5 Tasting panels

According to Thomas (2000), a tasting panel should comprise 5 to 15 experienced individuals who check for sensory evaluation and quality. Carpenter *et al.* (2000) suggests a minimum of 8 to 20 individuals for sensory evaluations, provided that they are trained. Judging panels are time-consuming and costly but they provide more information and accuracy. Sensory panels use sight, taste, smell, feel and hearing to assess foods. The purpose of sensory panels is to indicate preference of product A or B and the potential acceptability of and differentiation between products (Thomas 2002).

The requirements of an assessor will be determined ultimately by the type of evaluation completed. The basic requirements for a person taking part in sensory evaluation include availability and willingness to participate, good health, the ability to perform the task, which implies good knowledge of tasting and understanding of the purpose of the exercise, and they should not chew gum, eat, drink or smoke at least 30 minutes before the sampling session. This ensures a lesser degree of bias (Carpenter et *al.* 2000; Thomas 2002).

The method of testing is also affected by the qualification of members and aim of the experimenter. It is important to remember that tasting panels need to be trained in sensory evaluation procedures and that they have a sound understanding of the product. According to Thomas (2002) ideally 80 or more panellists should participate when no form of training is provided and/or none has been received through tertiary studies. Carpenter *et al.* (2000) suggest a minimum of 70 unqualified assessors. It is advisable to use a comparison of similar samples on the market. If ingredients are substituted, then it is suggested to have the original to compare with the new product (Carpenter *et al.* 2000; Thomas 2002).

Consumer testing is also relevant, though the experimenter should ensure that preliminary training has been completed. Sensory evaluation can be completed by using a hedonic face scale wherein the image represents the emotions and is rated with a score. Scoring can occur from 1 to 9 and less, when the highest score registers a liking while the lowest indicates a dislike. A question as to the possible frequency of consumption is usually asked in order to assess the estimated sales of a product.

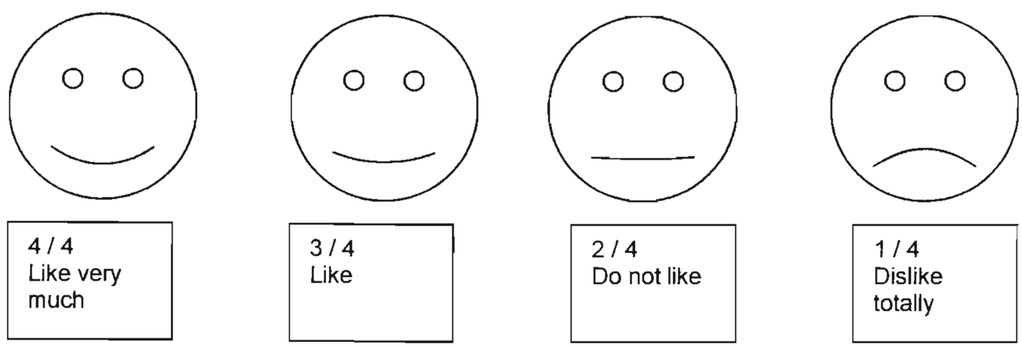

Figure 2.2 Four point hedonic face scale.

Daniel (2000) recommends the following conditions during sensory evaluation sessions:

- No interruptions or distractions;
- The environment should be quiet and comfortable;
- Use individual booths to avoid any form of contact or discussion;
- Make use of uniform lighting;

- The sessions should be held away from the preparation area;
- Samples should be standardized;
- All samples should be entirely uniform (size, temperature and type of container).

According to Thomas (2002), product testing can assist a business in the following ways:

- Achieve product superiority
- Ensure good customer satisfaction
- Monitor products available and potential threats
- Reduce cost and processing
- Evaluate shelf-life testing
- Allow for comparison between perception and quality
- Provide guidance and research for new product development
- Monitoring of product quality
- Predict acceptance.

It is important that a company budgets for product testing. Companies that invest in continuous product testing have higher market retention and sales. Product testing will be successful if recipes are standardised and the information obtained is correctly interpreted, when tested within the targeted environment and when there is proper execution of the evaluation process (Thomas 2002).

A tried and tested method for sensory analysis includes rating of appearance, odour, texture, taste and flavour. Such ratings indicate acceptability on a scale of excellent to inedible. The test of food is mass production that is passed through a sensory panel. The product can be nutritional but not meet the economic criteria of the intended group. If the texture, smell and flavour are good then the product may yet be a success (Daniel 2000; Thomas 2002).

Data are collected and analysed directly or with modification. Modification or transformation refers to the combination of categories or the grouping of non-numeric data. All data modifications and the reasons when appropriate should be reported. Missing data may require special mention in a report. Results are present within the body of a report and may be summarised in the form of graphs, diagrams, tables or descriptive statistics. Computer programmes are available to assist with the capture of sensory data and statistical analysis (Carpenter *et al.* 2000).

2.4.5 Shelf-life testing

Micro-organisms are rarely noticed by the naked eye but they exist throughout the environment. The advantages of some micro-organisms is that the process of decomposition, e.g. compost, is rapidly increased; beer, wine, bread and pickles are fermented during preparation; yeast provides ample vitamin B complex nutrients when submitted to heat and many mushrooms (fungi) are a source of food. The disadvantages of other micro-organisms include disease to humans and animals when consumed, food spoilage resulting in rotting and discoloration and industrial problems such as drain blockages due to growth within. Farm foods such as fruit and vegetables contain enzymes, which cause biochemical changes such as ripening. The aim of food processing and packaging is to improve or maintain their quality. It is important to ensure proper control of climate throughout the shelf-life testing to prevent micro-organism levels exceeding quantities allowed for human consumption (Parry & Pawsey 1992).

Microbiological Quality Control (MQC) refers to testing that ensures neither food-borne disease nor food poisoning will result from consuming the product. Microbiological data gathering takes 24 hours. Thus, careful analyses will reveal the possible growth rate of micro-organisms so that manufacturers can thereafter provide a possible sell by date on the products. Microbiological testing is important for products that require bacterial actions, e.g. cheese, yoghurt, beer and wine. There are two questions to be asked before the testing of certain products regarding 1) whether the reliability of a single test is sufficient or if there should be multiple tests and 2) what is the source of the sample and its analysed representation (Parry & Pawsey 1992).

The basic method for MQC is:

1. Take the sample.
2. Put into container.
3. Transport to laboratory.
4. Take out sub-samples.
5. Mix and dilute.
6. Make several dilutions.
7. Culture organisms in the sample.
8. Examine results.

According to Parry and Pawsey (1992), the techniques available to a microbiologist for MQC, include:

1. Direct observation. Using the naked eye to monitor changes in colour and texture.
2. Counting of organisms. These methods require taking samples and counting either the total number of organisms (living and dead), the total or estimated number of living organisms.
3. Analyses for specific organisms.
4. Using activity of the micro-organisms to indicate their presence and/or numbers.
5. Analyses for the presence of microbe products such as toxins.

6. Undertaking tests that involve exposing a microbe population to certain environmental circumstances and observing the reaction.

In the context of this study, the multi-mix had to be tested for shelf-life, firstly because the households within the community had no form of refrigeration, which meant that any food items would be exposed to higher micro-organism growth at room temperature, resulting in shorter storage times and secondly, if implemented as an intervention, it would be necessary to determine how regularly the multi-mix had to be prepared.

2.5 Conclusion

The nutritional status of the children within the informal settlement needed to be addressed as the prevalence of wasting, underweight and stunting in the informal settlement was high. Although government and the Department of Health implemented food aid and intervention programmes previously, another approach needed to be considered for addressing malnutrition. Food aid programmes and intervention programmes are dependent on food supply from organisations or people outside the households and literature has shown that mismanagement of funds, poor support structures and lack of interest resulted in failures. The staple food item of the community, maize, currently fortified, was not providing sufficient nutrients to meet the daily requirements of the primary school children. Given the poor economic situation of the community it was vital to determine what choices were made and how assistance could be provided to enhance those choices without further fortification. Agricultural development was present within the community, with the growing of vegetable gardens in the school. Food providers were trained and currently prepare the food provided at the school, as part of other studies within the community. This provided an opportunity to find a solution and use the current resources, food providers and vegetable gardens to assist in addressing the problem of malnutrition. This project involved the use of a food-based strategy to address malnutrition, as it implied the use of agricultural development, growing of vegetable gardens, in conjunction with education, the promotion of healthier food choices and nutrition within the school curriculum, to develop a diverse food strategy. The concept of the multi-mix stemmed from the use of scarce food sources, within communities, and combining them to develop nutrient-enriched recipes. The concept required the use of local ingredients which were culturally acceptable and cost effective.

CHAPTER 3: METHODOLOGY

3.1 Introduction

Figure 3.1 is a summary of this study, which resulted in the development of a multi-mix. The conceptual framework (Figure 1.2) indicates the processes of this project. Therefore Figure 3.1 is part of phases two and three (Stages 2 and 3), which entail the criteria formulation and actual development of the multi-mix.

PHASE 1: PLANNING (D Oosthuizen)

- Literature survey on malnutrition and the situational analysis of Eatonside, with the community in focus (Oldewage-Theron *et al.* 2005; Napier 2003)
- Identification and comparison of relevant food composition tables with the Top 20 list (Napier 2003).
- Dietary data analysis and interpretation (Napier 2003).

PHASE 2: FORMULATION (D Oosthuizen)

- Submission of proposal.
- Needs analysis to determine daily requirements.
- Establishing the criteria for the development of a multi-mix and formulation (formulation, EAR and selected groups).

PHASE 3: PREPARATION, CHEMICAL ANALYSIS AND SENSORY EVALUATION OF RECIPES (D Oosthuizen)

- Preparation of the multi-mix (processing of ingredients, weighing proportions and blending).
- Analysis of formulated multi-mix (subjecting formulated mix to chemical analysis so as to ascertain nutrient levels and comparison with theoretical values).
- Preparation of multi-mix recipes and packaging for the taste panel.
- Sensory analysis.
- Shelf-life testing.

Figure 3.1 Flow chart for multi-mix development (Amuna *et al.* 2004).

3.2 Planning and formulation

Phase 1 and 2, the process of planning and formulation, started with the identification of nutrients lacking in the diets of children aged six to 13 years. This was based on a study undertaken in the Eatonside community, amongst the primary school children, where the results of Napier (2003) indicated a shortage of energy, zinc, calcium and protein intake, as well as a wasting and underweight (Table 1.3). The EAR was determined for the age group of six to 13 years. A study completed by Wentzel-Viljoen (2003) indicated that nutrition-related programmes, in South Africa, should focus on providing a minimum of 25 per cent of the daily nutritional requirements, EAR of selected groups. This guideline was used in conjunction with the top 20 food list (Napier 2003) to form the basis to the formulation of the multi-mix for this study.

The nutritional value of each ingredient was determined by means of the Food Composition Tables of South Africa (Langenhoven 1991). The ingredients, which had higher levels of the selected nutrients zinc, calcium and protein, were highlighted and considered for the formulation of the multi-mix. The main ingredient was identified as the staple food item of the community and South Africans, namely maize meal. The remaining ingredients were based on cultural acceptability, cost and availability within the community. Although the other ingredients were not all part of the Top 20 list, the cultural acceptability was undoubted as these ingredients were available and consumed in various African cultures and the community.

Zotor (2002) provided information pertaining to two very important criteria in multi-mix formulation, namely INQ and ED (definitions on page 61). The following questions were taken into account when formulating the multi-mix (Amuna *et al.* 2000):

- Which cereals, legumes, grains, roots and tubers form the major staples and carbohydrate sources?
- Which potentially energy-dense food groups are locally available?
- Which vegetables, fruits, pulses and nuts are locally available?
- Which are the sources of vegetable oils, dairy products, eggs and other animal products, what is their seasonal accessibility and affordability?
- Which techniques of food processing, storage and distribution are used?
- Which socio-cultural and religious factors govern food choice, processing and food habits?
- What are the appearance, texture, taste, digestibility and appropriateness of the product?
- Food quality and safety issues?

A multi-mix was formulated based on the nutritional requirements and theoretical nutrient values determined through a software program, Dietary Manager®, which used the food composition tables of South Africa in order to determine each ingredient's nutritional value. The multi-mix formulation required maintaining the correct energy ratio from the macronutrients, namely proteins (15-20 per cent), carbohydrates (50-55 per cent) and fats (30 per cent) (Mahan & Escott-Stump 2000).

3.3 Preparation of food multi-mix

Phase 3 consisted of the preparation of the multi-mix, through the drying process, and a chemical analysis so as to ensure adherence to the objectives of obtaining one-third of the daily requirements. The multi-mix was then incorporated into recipes for sensory evaluation. The multi-mix was also analysed for shelf-life.

The principles of food safety were to be applied during this study through the preparation of the multi-mix. The aim was to follow strict safety measures to prevent any form of cross-contamination. Surfaces and equipment were sanitised, and personal hygiene was adhered to at all times. This included the wearing of a hat, gloves, mask, laboratory jacket and the washing of hands with every new step or process. Safety was also maintained by the use of oven gloves. The food was cooled to room temperature before further processing.
Food safety measures were also taken to prevent any form of cross-contamination and to ensure maximum shelf-life.

3.3.1 Drying of ingredients

The first step was to prepare a shopping list and purchase the ingredients needed for the drying process in order to develop the multi-mix. The ingredients were collected and a preparation area established. All ingredients were listed and weighed throughout the drying process, i.e. wet weight before processing and then compared to dried weight at the end of the process.

The list of ingredients was as follows:

- Lucky Star: Pilchards in tomato sauce (6 x 425g);
- Fresh carrots (2kg);
- Spinach (2 bunches) (2kg);
- Iwisa maize meal (fortified) (43g);
- Sugar beans (17g).

Each ingredient was individually dried as the moisture content varies. The temperature was kept constant at 65°C and pasteurisation occurred after the drying process and was applied for 15 minutes at 85°C to ensure a low micro –

organism count. Most micro-organisms cannot withstand a temperature above 72°C. Each ingredient was cooled before grinding to powder.
The maize was used as supplied. It is suggested to roast the maize before grinding to enhance the digestibility and reduce cooking time when incorporated into the recipe.

The sugar beans were obtained from a kitchen on the VUT premises, where the beans were used to bake blind, which is the process used, when baking the bases of pastry cases before a filling is added. As a result, the beans had already been roasted. It was decided to use them as is for the purpose of this study. The beans were ground and put to one side. The collection weight was equivalent to the ground weight. The only variance was due to spillage during grinding and packaging. For future reference, beans bought from the retailers, require soaking before adding to dishes or roasting for the purpose of multi-mix preparation. Due to a compound known as phytate that is present in beans, it is necessary to roast the beans to improve digestibility of the micronutrients. Phytic acid, or phytate, is a phosphorus containing compound, found in the outer husks of cereal grains, which binds with minerals and inhibits absorption. The compound binds with the micro-nutrients, which makes it less digestible and can not be broken down in the body. The compound's function is diminished by roasting, resulting in less binding of micro-nutrients and more absorption within the body (Mahan & Escott-Stump 2000).

The pilchards were removed from the tin and weighed. The sauce had been retained and mixed with the fish. The weight was 2 440 g. This mixture was flaked and placed on a baking tray to bake for 198 minutes at 65°C. The colour changed to a darker reddish-brown colour and a distinct fish smell was present. Pasteurisation took place for 15 minutes at 85°C. During the grinding process, 10g spillage occurred yielding the final dried weight at 500g.

The carrots were rinsed before being topped and tailed. Once finely grated, the carrots were blanched for 6 minutes in a combo-steamer, before drying. The carrots were dried at 65 °C for 180 minutes and pasteurised at 85°C for 15 minutes. The colour of the carrots, after the drying process, was pale orange and they were brittle.

The spinach was rinsed and large sections of the stalks removed. The leaves were placed whole in the drying oven at 65°C for 111 minutes. Immediately, the spinach leaves became discoloured to a dark green on exposure to the heat. The leaves began to shrink as the moisture content diminished.

The times were standardised by experimentation, by the researcher, before the ingredients were dried for the multi-mix. The ingredients were measured in the ratio specified in the formulation and placed in a coffee grinder to grind to powder. The ingredients were then thoroughly mixed. A second attempt was made for the drying of the ingredients. The carrots were not blanched before drying and the spinach was finely chopped before drying. The ratio of fresh and dried was determined by weighing the ingredients before and after the drying process. This provided a ratio of fresh and dried values. Table 3.1 provides standardisation results of the experimental drying processes. For the purpose of this study, an average will be used.

Table 3.1: Standardisation results of the experimental drying processes

INGREDIENTS (ATTEMPT ONE)	FRESH WEIGHT (g)	DRIED WEIGHT (g)	WASTAGE (g)	TIME (minutes)
Maize meal	42	42	0	0
Sugar Beans	17	17	0	0
Carrots	2 000	210	80	180
Spinach	2 000	115	530	111
Pilchards in tomato	2 440	510	0	198
INGREDIENTS (ATTEMPT TWO)	**FRESH WEIGHT (g)**	**DRIED WEIGHT (g)**	**WASTAGE (g)**	**TIME (minutes)**
Maize meal	42	42	0	0
Sugar Beans	17	17	0	47
Carrots	4 500	470	240	119
Spinach	7 000	814	3 590	95
Pilchards in tomato	2 975	676	0	183

g-grams

3.4 Nutritional analysis of the food multi-mix

A software program, Dietary Manager®, based on the Food Composition Tables of South Africa (Langenhoven *et al.* 1991), was used to assist with the final theoretical calculations of the multi-mix. All of the ingredients in the program were coded. The process commenced with the identification of the codes for each ingredient of the multi-mix. Dietary Manager® required the ingredients to be keyed in as fresh weights and therefore the ratio of fresh and dried was used. The ingredients were then added to a recipe analysis section of the program so as to determine their theoretical nutritional value. The data analysis was done for children aged six to 13 years old. The summary provided a comparison of the theoretical nutritional value of the multi-mix with the RDA of children. The focus of the study dealt with the use of EAR and therefore, the researcher did a manual comparison between the nutritional analysis (Dietary Manager®) and the EAR for children aged six to 13 years. When considering the selected nutrients, protein, calcium, zinc, and energy then the necessity of meeting 25 per cent of the nutritional requirements was achieved. The only nutrient not meeting the requirement of 25 per cent was energy which remained at 16 per cent.

The following factors had an influence on the nutrient value of foods (Amuna *et al.* 2000):

- Methods of processing: for the purpose of this study, it was important to retain the nutrients within the foods, so hot air drying was used at a controlled temperature to minimise nutrient losses.
- The time length and methods of storage: the multi-rnix required a longer storage period due to the lack of refrigeration within the informal settlement. Dehydration extended the shelf-life.
- Food preparation techniques: The ingredients were dehydrated and therefore already cooked which allowed for convenience and easy incorporation into recipes. Drying foods also enhances certain nutrients.
- Exposure to heat, air and light: vitamin A and C diminished when exposed to heat, with vitamin A also diminishing when exposed to light.
- Interactions between inhibitors and promoters in the mix: the roasting of the beans ensured the easier digestibility of the micro-nutrients.

3.5 Chemical analysis

The methods used in a chemical analysis are summarised in Table 3.2 (Oldewage-Theron 2001; Oldewage-Theron & Amuna 2002; Amuna *et al.* 2004). For analytical purposes the multi-mix was analysed in 100g-powder, as this was the minimum weight required for the analysis and the standard weight for multi-mix development. The oil was omitted from the original multi-mix formulation and 1g added to each of the other ingredients. The Agricultural Research

Council (ARC) Livestock Business Division, an accredited laboratory using standardised procedures, completed the nutritional analysis. For the preparation of recipes, oil was added at 5g resulting in 1g being deducted from each of the other ingredients of the multi-mix formulation. For comparative purposes and to assess the accuracy of the results, the nutrients protein, magnesium, zinc and iron were chemically analysed at VUT, following the same procedures as described below (Oldewage-Theron 2001 ; Oldewage-Theron & Amuna 2002; Amuna *et al.* 2004).

3.5.1 Micronutrient content

3.5.1.1 Minerals

Calcium and iron levels were determined by atomic absorption spectroscopy (AAS) whilst copper, magnesium and zinc were established by the inductively coupled plasma mass spectrometry (ICP-MS). AAS involves thermal digestion in concentrated nitric acid, which releases the minerals bound in the multi-mix sample. This allowed for the determination of minerals. Light of a suitable wavelength for particular elements was shone through the flame, while atoms absorbed some of this light in the multi-mix. The amount of light absorbed was proportional to the concentration of the element in the solution. The procedure commenced with 1.0g of multi-mix sample, which was placed in 2,5 x 3,0cm boiling tubes and weighed using an analytical balance. High-grade nitric acid was measured to 10ml and added to each boiling tube. Anti-bumping granules were added, and the level of nitric acid marked. Once digestion was completed then the sample was further diluted and readings determined.

3.5.1.2 Vitamins

Vitamins A and C, the B-vitamins and foliate were measured by Higher Performance Liquid Chromatography (HPLC). High-performance liquid chromatography (HPLC) is a form of liquid chromatography which separates compounds that are dissolved in solutions. Compounds are separated by injecting a plug of the sample mixture onto the column. The different components in the mixture pass through the column at different rates due to differences in their partitioning behaviour between the mobile liquid phase and the stationary phase.

3.5.1.3 Other

The other nutrients were based on the estimates of the Dietary Manager® programme.

3.5.2 Protein content

Proximate analysis allows for specific assays that are available for determining the quantity of proteins available in foods. A standard curve was prepared using a stock standard nitrogen solution to determine the protein. Each sample, blank and reference material was digested. Samples were prepared by thermal digestion in concentrated sulphuric acid. Samples of 0,5g were weighed and placed into boiling tubes. Cupric sulphate pentahydrate 0,2g and anti-bumping granules were added. Concentrated sulphuric acid 10ml was added cautiously and digestion occurred for 180 minutes until the digest turned green. The level of concentrated sulphuric acid was topped to 10ml. When the digests were cooled, they were transferred into 250ml volumetric flasks and made up to volume with distilled water.

3.5.3 Fat content

The fat content was determined by using the acid hydrolysis method. Hydrochloric acid was used to digest the samples while fat within the sample was released. Ether was added to dissolve the fat and the sample was heated, from which the ether evaporates leaving the fat.

3.5.4 Ash and moisture content

The ash content was determined by heating the sample in a furnace at 550ºC to remove the inorganic matter. The moisture content was calculated in the weight as a percentage loss of the initial sample when the multi-mix was heated in an oven at 105ºC. The water content was measured by chemical reaction. The Karl Fisher titration involved the reaction of water to iodine and sulphur dioxide providing a reading by which the moisture content can be interpreted. Lastly was the direct reading instrument where water present in the food items produced a gas when mixed with a chemical. The result was measured in kPa (from a pressure gauge). Lastly was the instrumental method where electrical water meters are used. This method is cheap, easy to use and the readings are direct though not accurate (Vierra 1996).

3.5.5 Energy and carbohydrate content

The total carbohydrate content (sugar, starch and dietary fibre) was derived using the following calculations (refer to formula (1)):

$$\% \text{ carbohydrate} = 100\% - (\% \text{ fat} + \% \text{ protein} + \% \text{ moisture} + \% \text{ ash}) \quad (1)$$

The energy content was determined by the energy-derived method using the Atwater factors. The principle assumes that 1g protein = 16,8 kJ, 1 g carbohydrate = 16,8 kJ and 1g fat = 37,8 kJ.

Table 3.2 Methods for chemical analyses of multi-mixes to determine the nutrient content (Oldewage-Theron 2001; Oldewage-Theron & Amuna 2002; Amuna *et al.* 2004).

Nutrient	Method	Basic principle
Protein	Adapted Kjedahl (modified Berthelot reaction)	Acid is used to release nitrogen in the sample, which is then measured and used to derive protein value by using a conversion factor.
Fat	Acid-hydrolysis	Acid is used to release fat in the sample, and ethers are then employed to remove the fat.
Ash	Direct	Organic matter is removed by heating the sample in a furnace at 550°C.
Moisture	Drying	Water is evaporated by drying the sample in an oven at 105°C.
Carbohydrate	Derived	100% - (% protein + % fat + % ash + % moisture).
Energy	Derived	(Protein X 16.8 kJ) + (Carbohydrate X 16.8 kJ) + (Fat X 37.8 kJ).
Minerals (Ca & Fe)	Atomic absorbance spectroscopy (AAS)	Sample is digested in acid to release minerals. AAS atomises sample then passes a beam of radiation through it. Absorption is measured at wavelength corresponding to mineral of interest.
Minerals (Cu, Mg, Zn)	Inductively coupled plasma mass spectroscopy (ICP – MS)	Sample is digested in acid to release minerals. ICP-MS ionises sample, then separates ions according to mass and counts the ions.
Vitamins (B's, A, C & folate)	High performance liquid chromatography (HPLC)	A procedure for the separation of non-polar solutes. Non-polar solutes are chromatographed on a column having a non-polar liquid immobilized on an inert matrix. A more polar liquid that serves as the mobile phase is passed over the matrix, solute molecules are eluted in proportion to their solubility.
Vitamins (other)	Theoretical calculations	Standard food composition tables and Food Finder/Dietary Manager® ®.

Usually all the analyses are undertaken in triplicate. The mean is then calculated to determine actual nutrient values. The ARC is an accredited laboratory, using standardised procedures and for the purpose of this study, an assumption was made that the results would be accurate, and only one analysis would thus suffice. This decision was supported by the high cost of R6100,00 per analysis.

ED and INQ were calculated (refer to formula (2) & (3)) based on the nutritional analysis (Zotor 2002). The INQ is measure by:

$$INQ = \frac{\text{Amount of nutrient / 4 200kJ}}{\text{Reference of nutrient / 4 200kJ}} \qquad (2)$$

i.e. Calculate the INQ for vit. B2 if the experimental results indicate 0,2 mg per 100g at 1 583 kJ. EAR is 1 mg per 9 571 kJ

$$INQ = \frac{0{,}53}{0{,}44}$$

$$= 1{,}2$$

$$ED = \frac{\text{Amount of energy from the multi-mix (kcal)}}{\text{Weight of product (g)}} \qquad (3)$$

i.e. Calculate the ED for 100g multi-mix with an energy value of 423 kcal.

$$ED = \frac{423 \text{ kcal}}{100 \text{ g}}$$

$= 4{,}23$ kcal/g - the total is then converted into kilojoules

3.6 Cost analysis of the food multi-mix

The studies undertaken by Oldewage-Theron *et al.* (2005), indicated that an average household in Eatonside had an average of R2,90 per person per day to spend for all three meals. It was vital to develop a multi-mix which was below that cost in order to allow other food items to be purchased. The cost was calculated with the use of receipts obtained during the purchases of the ingredients. The ingredients were purchased at a local retailer. Once the ratio between fresh and dried had been determined, the multi-mix formulation was converted into fresh ingredient form and costs calculated according to the weights and price per unit.

3.7 Recipe development

The final products developed with the food multi-mix were 1) peanut butter biscuits, 2) sweet muffin, which contained grated apple and 3) savoury muffin which contained sautéed onions. Other products developed included *vetkoek*, pumpkin fritters, corn bread, soft porridge and/or gravy and various biscuits.

The recipes were chosen on the basis of the importance of cultural acceptability, foods most commonly purchased and consumed (Table1.5: Top 20 food items consumed), palatability and cost implications. The nutrients which were lacking in the diets of the children, aged six to 13 years, namely protein, energy, calcium and zinc were also considered. Four sensory evaluation sessions occurred. The recipes for the first session were based on snack items, i.e. biscuits and muffins. Members of the Food and Nutrition Department at VUT made a request to consider other recipes, as biscuits could not be interpreted in an intervention as a healthful option to food choices. It was also decided to replace the amount of ingredients added to the multi-mix, to yield smaller portions, and to develop more substantial recipes, *vetkoek* and pumpkin fritters. The responses lead to a third evaluation, which comprised snack items, as well as more substantial products, with the expected outcome in the final evaluation to comprise recipes which had smaller yield and fewer ingredients added to the multi-mix. The final evaluation was also based on the responses during the first evaluation of preferences of snack items. The multi-mix was formulated to supplement the diet and not replace any meals.

3.8 Estimated nutritional value of the recipes

The nutritional value was calculated by taking the value of 100g of the final formulated multi-mix, as calculated according to the information provided by ARC, and determining the nutritional value of the added ingredients of the various ingredients using the South African food composition tables. The two values were then combined for each recipe in order to determine the theoretical nutrient value, for the total recipe, through the Dietary Manager®. The nutritional value of the recipes was then compared with the EAR of children aged six to 13 years in order to determine whether the objectives were achieve, namely to obtain one-third of the daily nutritional requirements.

3.9 Sensory evaluation

The sensory evaluation for the different recipes (refer Section 3.8) will be described here. A summary is provided in Table 3.3, a list of products evaluated and the number of evaluators. Annexure A and B show samples of the questionnaires used during the sensory evaluations. School children were primarily used as the consumers for the multi-mix and evaluation sessions completed by professionals was necessary to assess the overall quality as well as the inability of the children to interpret the flavour and feel characteristics.

The first sensory evaluation was held at the primary school, with 20 children aged between 6 and 13 years. It was decided to commence with one class in order to determine whether the choice of recipes was correct. Individuals were placed in rows of four, with each row seating five. Each scholar was handed a glass of water, pencil and sensory evaluation form. With the assistance of a teacher, it was discussed with them that no verbal interaction and physical contact was allowed to take place. Children rinsed their mouths with the water provided. The sensory evaluation form was explained to the teacher who interpreted all the information for the children. The questionnaires consisted of the hedonic face-scale, which allowed the children to explain best their emotions concerning the product to be evaluated. Each face had a rating of 1 out of 4 to 4 out of 4, in which 1 indicated very bad whilst 4 meant very good. The items evaluated were:

1. Chocolate biscuits
2. Mealie meal muffins
3. Peanut butter biscuits
4. Coconut drops

The second evaluation was conducted by nine professionals in the field of food technology. The multi-mix was integrated with the following recipes:

- Pumpkin fritters
- *Vetkoek*
- Soft porridge

The third evaluation session included recipes for savoury muffins, stiff *pap* (porridge), peanut butter biscuits and maize bread. The multi-mix was used as a main ingredient, with the minimal addition of other components to ensure correct portion size. Five individuals in the profession evaluated.

A final sensory evaluation among 56 primary school children was completed at the school to assess the acceptability of the final recipes. During each recipe evaluation, a small number of children preferred not to sample. This resulted in 55 children completing the evaluation form for the second recipe being muffins with apple, and 52 for the third recipe being muffins with onion. The evaluation form was shortened and simplified in order to make the process easier for the children. They were required to evaluate the three recipes based on appearance, taste and smell. Flavour and feel were omitted due to the childrens' inability to understand the concepts, which they interpreted as feeling with the fingers. The results were indicated on the hedonic face scale. The final question asked whether the each child would consume the product again. The results of like and dislike were based primarily on the last question. It was explained in detail to the children how to complete the evaluation form, while some children repeated the explanation so as to confirm understanding. The children were asked to provide honest answers and not to copy from others.

The data were analysed directly with no modifications being needed. The scores were based on the ratings of each face, with final marks being given for each sensory characteristic. The final question of consumption in the future was used as an indication of the acceptability of the product as being liked or disliked.

Table 3.3 List of products evaluated and number of evaluators

RECIPES TESTED	NUMBER OF SENSORY EVALUATORS	RECOMMENDATIONS
Sensory analysis 1 Chocolate biscuits Mealie meal muffins Peanut butter biscuits Coconut drops	20 primary school children	Portion size unrealistic Preferred sweet recipes
Sensory analysis 2 Pumpkin fritters Porridge (soft)/gravy *Vetkoek*	Nine professionals	Use yeast as a raising agent Portion size too large Too high oil content
Sensory analysis 3 Stiff porridge Savoury muffins Peanut butter biscuits Corn bread	Five professionals	Muffins and biscuits were good Corn bread to dense Acceptable portion size
Sensory analysis 4 Peanut butter biscuit Sweet and savoury muffins	56 primary school children	Acceptable in terms of taste, appearance and smell Definitely consume again

3.10 Shelf-life testing of the food multi-mix and recipes

ARC completed the shelf-life study of the multi-mix at room temperature for a period of 28 days, with measurements and analysis being completed on days zero, three, seven, 14, 21 and 28. The temperature was based on the fact that the community members had no form of refrigeration within their homes (Oldewage-Theron *et al.* 2005).

An aliquot of 10g of sample was removed aseptically from the bag of powder at the time of each analysis. The samples were homogenized in a Stomacher 400 (DHK Pty. Ltd.) with 90ml of diluent (buffered peptone water). The samples were analysed for total aerobic plate counts on tryptone soy agar and incubated at 25°C for approximately three hours and for coliform and *E.coli* count on a violet red bile 4methylumberlifery-βD-glucuronide (MUG) agar and incubated at 37°C for approximately 2 hours. Analysis of *B.cereus* (plated out on *B.cereus* selective base agar with egg yolk and *Bacillus cereus* supplement, incubated at 37°C for approximately 2 hours) and *S.aureus* (plated out on Baird Parker agar with egg yolk tellerie, and incubated at 37°C for approximately 3 hours) were done on only the first day of the shelf-life test.

The final recipes were delivered to ARC-Microbiology and kept at room temperature. A 5g sample was aseptically removed from each product. The samples were then homogenized in a Stomacher 400 (DHK Pty. Ltd.) with 45ml of diluent (buffered peptone water). The samples were plated out for total aerobic count on tryptone soy agar and incubated for 72 hours at room temperature, and for yeast and mould on Rose Bengal agar and incubated for 72 hours. The muffins were plated on days 0, 1, 2 and 3, whereas the biscuits were plated on days 0, 2, 4 and 7.

CHAPTER 4: RESULTS

4.1 Formulation of the food multi-mix

The formulation of the multi-mix was based on the following criteria of a) composed of ingredients locally available and most commonly consumed, b) consisting of ingredients which were acceptable in the relevant culture, and c) being cost effective, and d) maintaining the minimum requirements for INQ and ED.

Table 4.1 provides a detailed list of the ingredients, which made up the multi-mix. They included maize, being the staple food item of South Africa and the particular community at 403g consumed on a daily basis, combined with various vegetables, namely carrots, spinach, which were grown within the vegetable gardens, and a legume (sugar beans), which is consumed with samp and a protein source (pilchards). The pilchards are a common ingredient found within the households in the community. It was identified during the formulation stage that the energy value of the multi-mix was below the nutritional requirement of one-third, thus oil was included in the multi-mix formulation.

Table 4.1: Formulation of the multi-mix

INGREDIENTS	WEIGHT OF DRIED INGREDIENTS (g)
Maize, 96% extract	42g
Sugar beans	16g
Carrots	15g
Spinach	12g
Pilchards in tomato sauce	10g
Sunflower oil	5g
TOTAL	**100 g**

g - grams

The total weight of the multi-mix was standardised at 100g. The ingredients sent for analysis to ARC are reflected in Table 4.2. The analysis could only be done in powder form. The oil was therefore omitted and 1g added to each of the other ingredients. Figure 4.1 is a picture of the multi-mix which was sent to ARC for analysis.

Table 4.2: Formulation of the multi-mix sent to ARC

INGREDIENTS	**WEIGHT OF DRIED INGREDIENTS (g)**
Maize, 96% extract	43g
Sugar Beans	17g
Carrots	15g
Spinach	13g
Pilchards in tomato sauce	11g
TOTAL	**100 g**

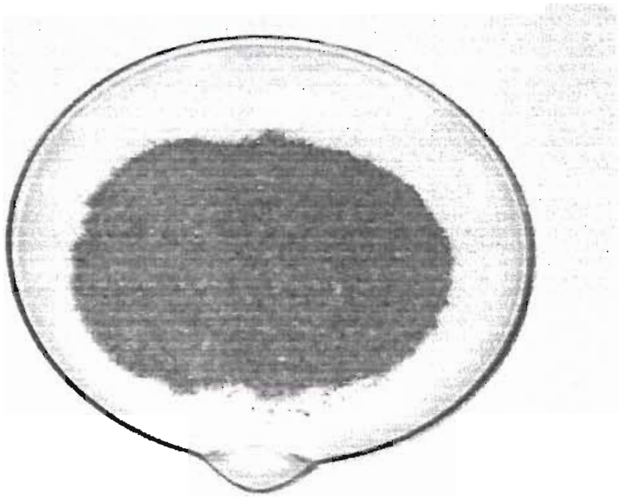

Figure 4.1: Picture of the multi-mix sent to ARC

4.2 Changes during the drying of the food multi-mix ingredients

All the ingredients were dried at 65°C and pasteurisation occurred after the drying process for 15 minutes at 85°C. Table 4.3 provides a summary of the fresh and dried weights of the ingredients as well as the ratio of dried to fresh for both attempts with the mean used for the purpose of this study.

Table 4.3 Comparison of fresh and dried weights with mean for dried weight per gram and fresh weight per gram

	ATTEMPT ONE			ATTEMPT 2			
INGREDEINTS	FRESH(g)*	DRIED(g)	RATIO	FRESH(g)	DRIED(g)	RATIO	MEAN RATIO
Maize	42	42	42:42	42	42	42:42	-
Sugar Beans	17	17	17:17	17	17	17:17	-
Carrots	2 000	210	1:9,1	4 500	470	1:10	1:9,5
Spinach	2 000	115	1:8	7 000	814	1:8	1:8
Pilchards	2 440	510	1:4,8	2 975	676	1:5,3	1:5,1

g-grams

When all the ingredients had been dried, the texture became very brittle. The ingredients crumbled under light pressure. The discoloration was characteristic of the item dried:

- The bright orange of the carrots turned to a pale orange.
- The green spinach leaves became a very dark green.
- Tomatoes turned a dark reddish brown.
- Pilchards became an unpleasant dark brown colour.

4.3 Nutritional analysis of the food multi-mix

The ingredients for the nutritional analysis by Dietary Manager® were based on fresh samples as depicted in Table 4.4.

Table 4.4: Theoretical multi-mix formulation for the theoretical analysis by the Dietary Manager® program

INGREDIENTS	WEIGHT OF DRIED INGREDIENTS (g)
Maize, 96% extract	42g
Sugar beans	17g
Carrots	146g
Fish	54g
Oil	5g
Spinach	221g

The nutritional analysis according to the Dietary Manager® is reflected in Table 4.5. The objective of achieving one-third of the nutritional requirement had been met for all nutrients except energy at 17 per cent. The nutrients of focus had a theoretical nutritional value of calcium, 40 per cent of the EAR, Zinc at 54 per cent of the EAR and protein achieving 46 per cent of the EAR.

Table 4.5: Dietary Manager® nutritional analysis of the multi-mix

Nutrient	UOM#	Multi-mix	% of EAR*
Animal protein	gm	10,1	-
Calcium	mg	523	40
Copper	mg	0,86	-
Energy	kJ	1 671	17
Iron	mg	11,59	231
Magnesium	mg	292	199
Phosphorus	mg	485	45
Total protein	gm	25,03	46
Vit B3	mg	7,8	87
Vit A, retinol equivalents		5394	1 000
Vit B1	mg	0,49	70
Vit B2	mg	0,92	115
Vit B6	mg	0,994	124
Vit C	mg	26	67
Vit D	µg	4,30	86
Vit E	mg	3,93	44
Zinc	mg	3.80	54
Energy contribution:			
Carbohydrate	%	58	
Protein	%	25	
Fat	%	12	
Refer to Annexure G; *Estimated average requirement; #Unit of measurement.			

ARC analysed the multi-mix, which excluded the oil, and provided the results listed in Table 4.6. The guideline for moisture content of multi-mixes is a maximum of exceed 14 per cent (Amuna *et* al. 2000). This developed multi-mix contained only 8,95 per cent moisture and fulfilled these requirements. The analysis provided information on nutrients relevant to the studies. The nutritional value of calcium and zinc were above 40 per cent. Protein was within the 30 per cent objective. Slight variation occurred with the experimental nutritional results, as indicated in Table 4.6.

Table 4.6: Nutritional analysis of multi-mix by ARC

Analysis	UOM*	Multi-mix	% of *EAR
Ash	%	6,06	
Calcium	mg/100g	543	41,7
Carbohydrates	g/100g	63,25	
Copper	mg/kg	5,94	
Dry Matter	%	91,05	
Energy	kJ/100g	1 493	16
Fat (Acid hydrolysis)	%	2,40	
Folic acid	µg /100g	2 350	940
Iron	mg/kg	139,33	240
Magnesium	mg/100g	237	118
Moisture	%	8,95	
Protein	%	19,34	
Vit. A	mg/100g	0,09	20
Vit. B1	mg/100g	0,28	40
Vit. B12	µg/100g	40	
Vit. B2	mg/100g	0,19	24
Vit. B6	mg/100g	0,56	70
Vit. C	mg/100g	2,55	7
Zinc	mg/kg	80,25	114

*UOM- unit of measurement; ARC-Livestock Business Division; %Per centage; EAR-Estimated Average Requirements

The nutrient recovery refers to the amount of nutrients retained during the preparation process in comparison to the estimated values. When the comparison between the estimated and experimental nutritional values indicates a variance, this is due to the loss of nutrients during the preparation stages. Vitamins A and C are not resistant to heat, while vitamin A also diminishes when exposed to light. The comparison between the estimated and experimental nutritional values is reflected in table 4.7. When the variance between the experimental and estimated nutrients values of all nutrients is above 90 per cent, and then it is safe to say that for future multi-mix formulations, a chemical analysis is not required as the food composition table results are sufficient. If the recovery is high for only specific nutrients, then the latter applies too. The recovery for the nutrients of target protein, energy, calcium and zinc were below 90 per cent, except for calcium at 104 per cent and zinc at 211 per cent. The protein and energy values were 89 and 77 per cent respectively.

Table 4.7 Comparison of estimated and experimental nutritional values

Nutrient	**UOM#**	**Estimated**	**Experimental**	**Recovery %**
Animal protein	gm	10,1	-	
Calcium	mg	523	543	104
Copper	mg	0,86	0,5	58
Energy	kJ	1 671	1493	89
Iron	mg	11,59	13,93	120
Magnesium	mg	292	237	81
Phosphorus	mg	485	-	-
Total protein	gm	25,03	19,34	77
Vit. B3	mg	7,8	-	-
Vit. A	mg	486	0,09	0
Vit. B1	mg	0,49	0,28	57
Vit. B2	mg	0,92	-	-
Vit. B6	mg	0,994	0,56	56
Vit. C	mg	26	2,55	10
Vit. D	µg	4,30	-	-
Vit. E	mg	3,93	-	-
Zinc	mg	3.80	8,02	211
Energy contribution:		**Estimated**		
Carbohydrate	%	58		
Protein	%	25		
Fat	%	12		
*Estimated average requirement; #Unit of measurement; %per centage				

The oil had to be included into the formulation, during recipe preparation. When the nutritional analysis was calculated for the formulation it was decided to take

95 per cent of the results from ARC and add the remaining oil. Oil only had an affect on the fat and energy content. The micro-nutrients were not affected. For the purpose of recipe development, 95g of the multi-mix was used with the inclusion of 5g oil. Energy was the nutrient which was below the minimum requirements in the multi-mix at 1 601kJ, (16 per cent). With the energy below the 30 per cent stated in the objective, the goal was to meet the energy requirements with the inclusion into recipes. It also posed the question to whether the 100g portion would be sufficient.

Table 4.8 is an indication of the energy supplied by macronutrients for the multi-mix. There is slight variance among the minimum requirements (Mahan & Escott-Stump 2000).

Table 4.8: Macronutrient energy supply

NUTRIENT	Per centage (actual)	Theoretical (Mahan; Escott-Stump 2000)
Carbohydrates	63%	50-55%
Protein	13%	15-20%
Fat	24%	30%

Table 4.9 indicates the value of INQ and ED of the multi-mix. Values of 1,0 for INQ indicates good quality nutrients within the multi-mix. The ED is required between 15,12 – 18,90 kJ/g (3,6 – 4,5 kcal/g). The ingredients of focus will be indicated. The INQ indicated calcium at 1,1 and zinc at 2,8. Protein totalled 1,0 which shows that the quality of the nutrients was very good. The ED supplied by the multi-mix was 16,07 kJ/g, which is in line with the recommendations.

Table 4.9 INQ and ED of the multi-mix

NUTRIENT	ED
Multi-mix	16,07 kJ/g
NUTRIENT	**INQ**
Calcium	1,1
Zinc	2,8
Protein	1,6

The chemical analyses were completed at VUT. The nutrients analysed were protein, zinc, iron and magnesium. There were variations (Table 4.10) of the ARC analysis that could be results of a) the method used for analysis, b) the dilution ratio used, which has an effect on the actual count and / or c) the multi-mix not being mixed properly. All the results from ARC were used for the purpose of this study. The VUT results were compared with the ARC analysis and variances based on ARC results.

Table 4.10: Comparison between ARC and VUT chemical analysis

NUTRIENT	THEORETICAL	LAB 1 (ARC)'	LAB 2 (VUT)"	VARIANCE (g & (%)
Protein (g*/100g)	25,03	19,34	22,46	+3,12 (16,13)
Zinc (mg#/100g)	3,80	8,02	3,05	-4,97 (61,97)
Iron (mg/100g)	11,59	13,93	15,90	+1,97 (14,14)
Magnesium(mg/100g)	292	237	238	+1,0 (0,001)

*g-gram; #-microgram;"Vaal University of Technology; 'Agricultural Research Council

4.4 Cost analysis of the food multi-mix

Table 4.11 indicates the cost of the multi-mix analysed through ARC, whilst Table 4.12 indicates the cost of the multi-mix to be used for providing a nutritious meal/snack. There is a R0,05 price variance due to the oil. The price is within the R2,90 which is available within the community per day, for all three meals.

Table 4.11: Cost of multi-mix sent to ARC

Analysis (100g)	Weight	Fresh	Unit	Unit cost	Actual
Maize, 96% extract	43g	43g	kg	4.00	0.20
Sugar beans	17g	17g	kg	4.99	0.10
Carrots	16g	145g	kg	4.90	0.75
Spinach	13g	104g	kg	1.30	0.20
Pilchards in tomato sauce	11g	54g	kg	4.37	0.30
				Total	**R1.55**

Table 4.12: Cost of multi-mix as formulated for presentation in recipes

Analysis (100g)	Weight	Fresh	Unit	Unit cost	Actual
Maize, 96% extract	42g	42g	kg	4.00	0.20
Sugar Beans	16g	16g	kg	4.99	0.10
Carrots	15g	136g	kg	4.90	0.70
Spinach	12g	96g	kg	1.30	0.15
Pilchards in tomato sauce	10g	49g	kg	4.37	0.25
Oil	5g	5g	kg	6.50	0.10
				Total	**R1.50**

4.5 Final recipes for the food multi-mix

The recipes were standardised with a multi-mix portion of 100g. Although the additional ingredients, added to each recipe, do not comply with the concept of multi-mix, for sensory analysis purposes 100g portions were used. The portion size can be substituted to accommodate the age group. Each recipe takes 30 minutes preparation time and utensils needed include baking tray, muffin tin, oven, mixing bowls and spoons, measuring spoon and cups, grater and scale.

SAVOURY MUFFIN (onion)

(3-5 small muffins);

100 g Multi-mix

10 g Oil, sunflower

150 ml Water

30 g Onion, sautéed

1 Egg, medium, beaten

2 tsp Baking powder

1 tbs Sugar, white

1. Soak the FMM with 5g oil and water and allow to stand for a few minutes.
2. Sauté the onions with the remaining oil.

3. Add the remaining ingredients, whisk together, and place in a greased tin. Bake for 12-15 minutes at 190°C.

Total cooked yield: 290g

SWEET MUFFIN (apple)

(3-5 small muffins)

100 g Multimix

10 g Oil, sunflower

150 ml Water

30 g Apple, whole, grated (red)

1 Egg, medium, beaten

2 tsp Baking powder

1 tbs Sugar, white

1. Soak the FMM with oil and water and allow to stand for a few minutes.
2. Grate the apple and mix with the FMM.
3. Add the remaining ingredients, whisk together, and place in a greased tin. Bake for 12-15 minutes at 190°C.

Total cooked yield: 290g

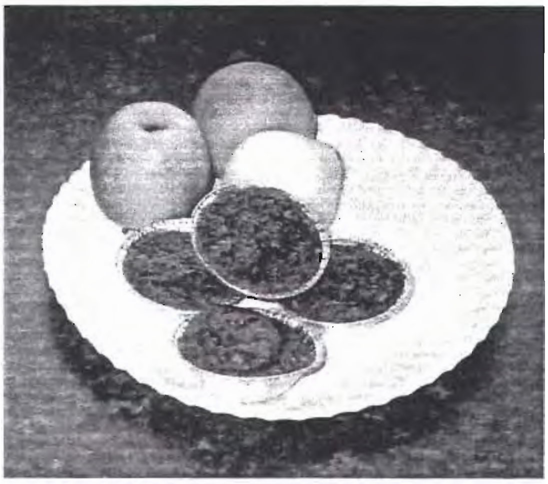

Figure 4.2: Picture of muffins made with multi-mix

PEANUT BUTTER BISCUITS
(10 biscuits)

100 g Multimix
10 g Oil, sunflower
50 ml Water
1 Egg, medium, beaten
60 g Peanut butter (smooth)
1 tsp Baking powder
42 g Sugar, white
½ tsp Vanilla essence

1. Soak the FMM with oil and water and allow to stand for a few minutes.
2. Whisk the remaining ingredients together until well mixed and add to FMM mixture.
3. Form small balls and place on a greased baking tray. Bake for 12 minutes at 190°C.

Total cooked yield: 200g

Figure 4.3: Picture of peanut butter biscuit made with multimix

4.6 Nutritional content of the recipes

The objective, with the multimix, to obtain one-third (30 per cent) of the daily requirements of children for the particular nutrients calcium, zinc and protein and energy was met with the exception of the adjusted portion sizes. Table 4.13 provides the theoretical nutritional value of each recipe. The nutritional value is calculated by the addition of the actual nutritional results of the multimix with the nutritional value of the ingredients added. A comparison with Table 4.14 indicates the theoretical per centage of nutrients obtained when compared with the EAR of children aged six to 13 years.

Table 4.13: Nutritional value of recipes with 100g multi-mix

NUTRIENT	SAVOURY MUFFIN	SWEET MUFFIN	BISCUIT
Energy (kJ)	2 037	1 986	2 016
Protein (g)	24,36	23,53	23,56
Fat (g)	13,1	12,29	12,55
Carbohydrates (g)	62,03	61,7	62,87
Calcium (mg)	544,9	540,9	539,9
Iron (mg)	14,12	14	13,95
Magnesium (mg)	231	230	233
Phosphorus (mg)	101	87	86
Zinc (mg)	8,29	8,19	8,2
Vit. A (µg)	164,5	153,5	146,5
Vit. B1 (mg)	0,33	0,33	0,32
Vit.B2 (mg)	0,43	0,22	0,38
Vit. B3 (mg)	4,9	4,9	5,2
Vit. B12 (µg)	0,5	0,5	0,4
Vit. C	0	2,4	2,4

The combining of the multimix with the other ingredients to form the muffins definitely increased the nutritional value. The inclusion of egg boosted the protein levels in the muffins by one to two grams whilst the fat content almost doubled. The micro-nutrients had minimal changes with zinc increasing by 7,8 per cent and iron with 6,82 per cent. Baking powder was used as a raising agent and provided insignificant nutritional value. The inclusion of apple and onion raised the protein levels by one to two grams per recipe.

The inclusion of peanut butter within the biscuit also increased the protein, fat and carbohydrate levels by similar percentages. The inclusion of additional oil assisted in raising the total energy value for all the recipes.

Table 4.14: Comparison of nutritional value of recipes with EAR of children aged six to 13 years

NUTRIENT	EAR	SAVOURY MUFFIN	SWEET MUFFIN	BISCUIT
	%	%	%	%
Energy (kJ)	9 572	21	20	21
Carbohydrates(g)	100	62	61	62
Calcium (mg)	1 300	42	41	40
Iron (mg)	5.8	243	241	240
Magnesium (mg)	200	115	115	116
Phosphorus (mg)	1 055	10	8.2	8.1
Zinc (mg)	7	113	117	121
Vit. A (µg)	445	37	35	33
Vit. B1 (mg)	0,7	47	47	46
Vit. B2 (mg)	0,8	53	27	47
Vit. B3 (mg)	9,0	54	54	58
Vit. B12 (µg)	1,5	33	33	27
Vit. C	39	0	6	6

*Per centage of EAR

Table 4.15 provides a comparison between the nutritional content of the multi-mix and the recipes, with the inclusion of the multimix. The nutrients of focus energy, protein, zinc, calcium and iron improve with the addition of a few ingredients. Unfortunately the standard portion size of 100g will not meet the one-third energy requirement for energy.

Table 4.15: Comparison of nutritional value of multi-mix and recipes with the inclusion of the 100g multi-mix

NUTRIENT	FMM*	SAVOURY MUFFIN	SWEET MUFFIN	BISCUIT
Energy (kCal)	1 587	2 037	1 986	2 016
Protein (g)	18,4	24,36	23,53	23,56
Fat (g)	7,3	13,1	12,29	12,55
Carbohydrates (g)	60,1	62,03	61,7	62,87
Calcium (mg)	515,9	544,9	540,9	539,9
Iron (mg)	13,2	14,12	14	13,95
Magnesium (mg)	225	231	230	233
Phosphorus (mg)	0	101	87	86
Zinc (mg)	7,6	8,29	8,19	8,2
Vit. A (µg)	85,5	164,5	153,5	146,5
Vit. B1 (mg)	0,3	0,33	0,33	0,32
Vit. B2 (mg)	0,2	0,43	0,22	0,38
Vit. B3 (mg)	4,9	4,9	4,9	5,2
Vit. B12 (µg)	0	0,5	0,5	0,4
Vit. C	2,4	0	2,4	2,4

*Food multi-mix.

4.7 Sensory evaluation of the food multi-mix

Annexure A and B provide the questionnaires given to the children and professionals. The children were provided crayons and asked to colour in the face which best suited their feelings.

The sensory evaluation of the mealie meal muffin for the first evaluation was as follows:

1. 13 out of 20 liked the product;
2. 6 out of 20 disliked the product;
3. One child was indecisive;

4. Two said that they would again choose the product over the others.
Of the four items tested, the biscuit and muffin seemed favourable.

Figure 4.4 indicates the sensory evaluation of the sweet muffin for all four sessions, and shows the acceptability of the recipe. The ingredients were varied to adjust to the recommendations. The final recipe yielded a better result. The results for the savoury muffin varied only in taste with 70 per cent of the children liking the taste yet preferring the sweet muffin.

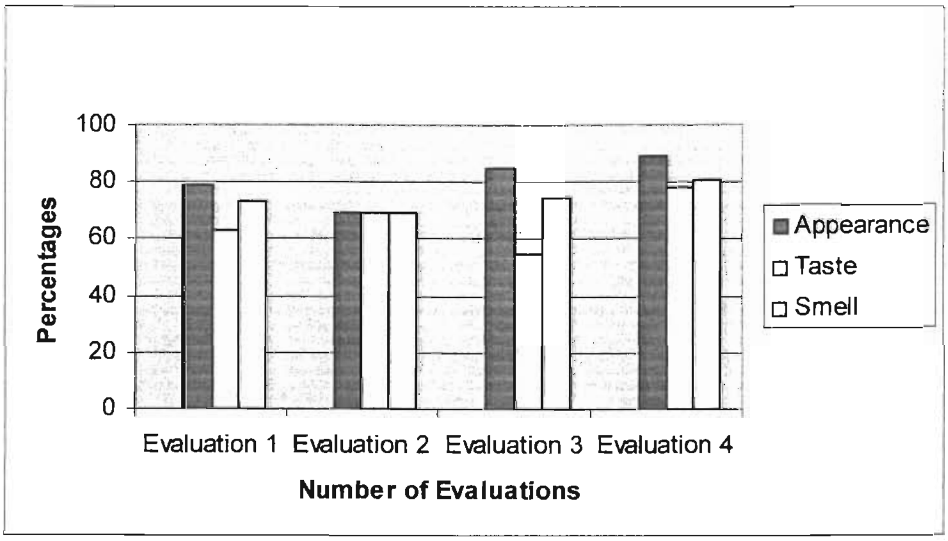

Figure 4.4: Muffin ratings during four evaluation sessions

The muffins were prepared for a professional evaluation. Unfortunately due to preference, four individuals chose not to evaluate the soft porridge, while one individual preferred not to rate the *vetkoek*. The results showed the muffin rating at 69,2 per cent while the pumpkin was rated at 71,4 per cent. The *vetkoek* received an overall rating of 75,1 per cent with soft porridge at only 52,0 per cent.

In the third sensory evaluation the peanut butter biscuit was rated on an average score with comments referring to the dryness of the biscuit and insufficient peanut butter flavour. During the first session the biscuit was regarded as an insufficient recipe for the multi-mix but was later re-introduced. Figure 4.5 indicates the ratings and percentages of the acceptability of the biscuit. The appearance, taste and smell improved when more peanut butter was incorporated in the final (fourth) evaluation session.

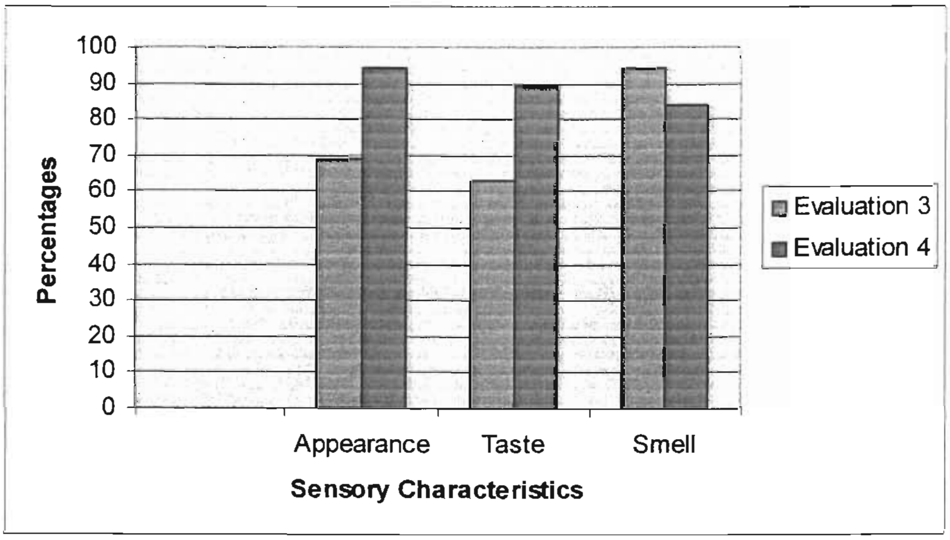

Figure 4.5: Peanut butter biscuit results during two evaluation sessions

The results for all the products assessed during the third evaluation were based on liking of 62 per cent for the muffin and 61 per cent for the biscuit.

The results (Figures 4.6 - 4.8) of the final evaluation session (Evaluation 4) indicated the peanut butter biscuit at 83,9 per cent liking the recipe, while 16,1 per cent disliked it. The muffin with apple received the highest score due to sweetness and flavour. The total number liking the muffin was 94,5 per cent, while 5,5 per cent disliked the muffin with apple. The muffin with sautéed onion received the lowest rate with only 73,1 per cent of the children liking the product, while 26,9 per cent preferred not to consume it again. The average score for the biscuit was 89 per cent, the muffin with apple was 88,7 per cent and the muffin with onions was 83,4 per cent.

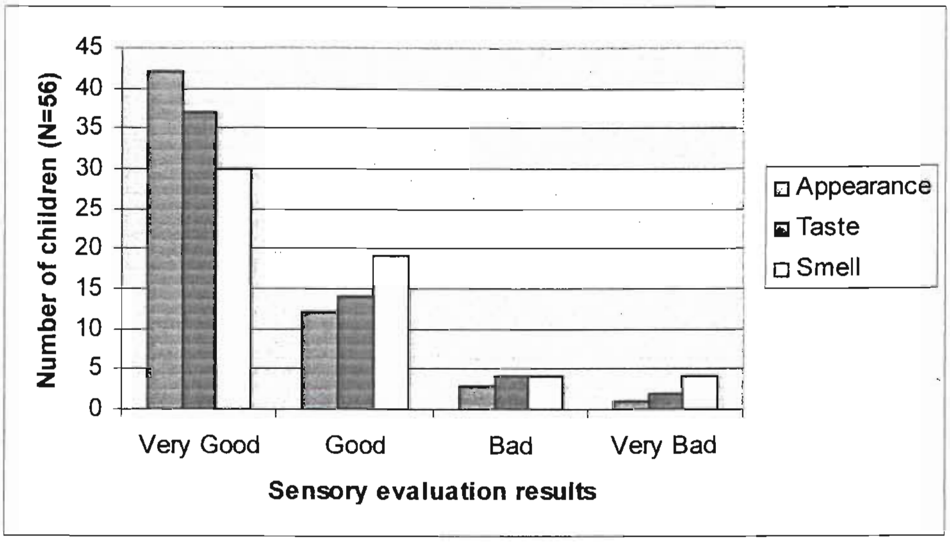

Figure 4.6: Final sensory evaluation of the peanut butter biscuit

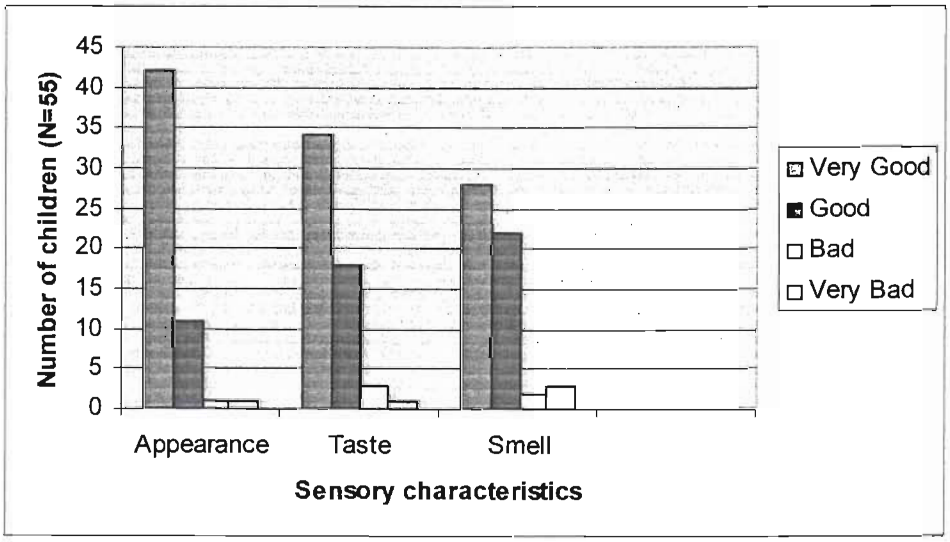

Figure 4.7: Final sensory evaluation of the muffin with apple

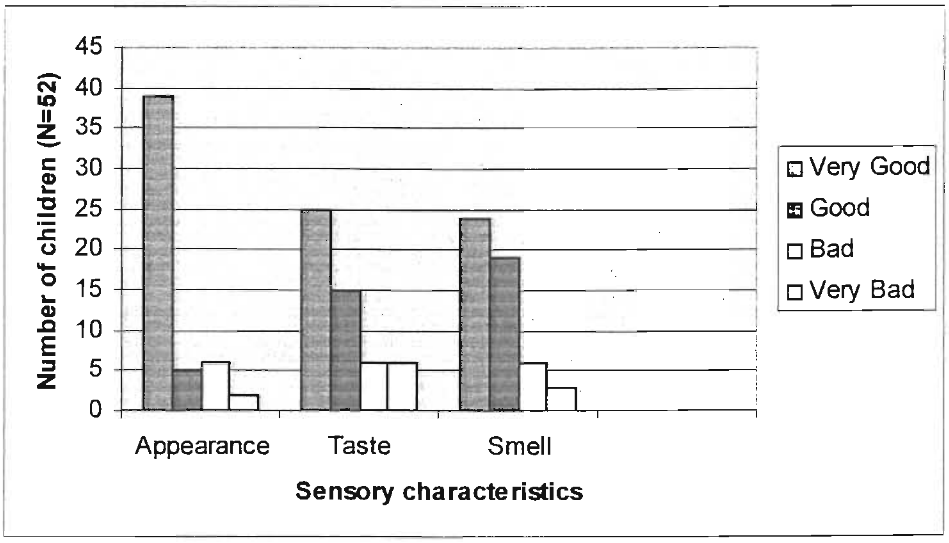

Figure 4.8: Final sensory evaluation of the muffin with onion.

The above-mentioned products where evaluated by the lecturers. The biscuit received 91,6 per cent overall, while the muffins with apple or onions both received 90 per cent.

4.8 Shelf-life results for the food multi-mix and recipes

The multi-mix was analysed for a period of 28 days and the results presenting a total aerobic organism count remained below log 4/g throughout the entire trial. The counts began at log 3.8/g on day 0 and remained between log 2/g and log 2.85/g on days 3, 7, 14 and 21, and again increased to log 3,6 on day 28.

The *Escherichia coli* (*E.coli*) and coliform counts remained beneath 10cfu/g throughout the entire trial. Neither *Bacillus cereus (B.cereus)* nor *staphylococcus aureus (S.aureus)* were detected on the first day of trial.

The nutritional powder had a 28-day shelf-life. The counts were very low throughout the trial. The presence of organisms was read at <10, which implies their absence. The number of colony forming units (Cfu) per sample was indicated as 6 850 Cfu on day 0, 120 Cfu on day 3, 523 Cfu on day 7, 250 Cfu on day 14, 700 Cfu on day 21 and 4 550 Cfu on day 28.

The final recipes yielded biscuits and muffins. The total bacterial count as well as the yeast and mould count for the biscuit remained low throughout the seven-day trial. The results indicated a total colony forming count of between 55 – 180Cfu/g, which is within digestible limits and the biscuit can be stored for a seven-day shelf-life period at room temperature.

The total bacterial count for the sweet muffin as well as the savoury muffin stored at room temperature increased from log 1,74/g and log 2,2/g respectively to more than log 6/g on the second day. The yeast and mould count remained very low throughout the trial.

Due to the high Cfu/g, the sweet and savoury muffins can be kept safely at room temperature for only a 24hour period.

CHAPTER 5: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

Strategies to address malnutrition include food fortification, the enhancing of food stuffs with vitamins and minerals not present within the food source; supplementation, which is the provision of tablets to targeted age groups; food aid programmes and nutrition intervention programmes, which rely on aid from welfare organisations and government to supply adequate food sources; and food diversification. Food diversification is categorized as a food-based strategy, which involves providing knowledge and assistance to communities to develop and successfully grow vegetable gardens and commence small farming development. The aim of food-based strategies is to reduce malnutrition in the long-term. Another solution, categorised under food-based strategies includes functional foods and multi-mixes. Functional foods comprise of component(s) that have an ability to influence the body's function to help improve the state of well being. The principles of functional foods are in conjunction with the criteria for multi-mix formulation. The multi-mix can be seen as one of many possible solution to address malnutrition.

The main objectives of this study were to 1) formulate a multi-mix which could supply one-third of the daily requirements for primary school children, aged six to 13 years, with the focus on energy, protein, calcium and zinc, and 2) to formulate a multi-mix which was culturally acceptable, affordable and of high nutritional value. The primary objective, which stated the development of a food multi-mix to address one-third of the nutritional requirements, has been obtained. When considering the nutrients of focus (protein, energy, calcium and zinc) the analysis showed that energy was totalled at 16,2 per cent, but with the inclusion of 100g of multi-mix into the recipes, i.e. peanut butter biscuit, the value was raised to above 20 per cent. The original formulation (100g) was altered to include oil so as to boost the energy levels, which provided only 16,3 per cent of the EAR. The portion sizes were reconsidered and calculated based on the two separate age groups. The portion size for the age group four to eight years of age is calculated by dividing one-third requirement (EAR), 2440,20 kJ (581 kcal) with the total energy value of the multimix 1 601 (381,19 kcal), per 100g, and multiplying with 100. Therefore the portion size for four to eight years of age become 152,42 g, which was rounded off too 150g. The same calculations apply for the age group nine to 13 years, where the portion size was 199,29 g, becoming then 200g. The nutritional supply for protein, zinc and calcium remained above 40 per cent with the total energy supply providing a minimum of 30 per cent, as the stated objectives. Annexure C provides the nutritional value of 150 g and 200 g portions compared to the one-third of EAR for the specific age groups.

When provided in recommended portions of 150g and 200g, the energy value becomes sufficient to achieve the one-third requirement. Zinc and calcium both provided more than 40 per cent of the EAR. Zinc was present from the inclusion of spinach, pilchards and beans in the multi-mix. The ED proved by the 100g multimix to be within the minimum requirements of 15,12 – 18,90 kJ/g (3,6 – 4,5 kcal/g), at 16,01 kJ/g ((3,83 kcal/g) whilst the INQ was above 1,0 for all the targeted nutrients, implying good nutrient content.

The second objective of developing a culturally acceptable and affordable multi-mix, consisting of ingredients common within the community was also achieved through the formulation. The ingredients included maize and beans, which are consumed daily, with the carrots and spinach grown within the gardens. Pilchards provided additional protein source and is an item commonly consumed within the households. The acceptance of the multi-mix by the children was proven through the sensory evaluation sessions, which provided scores averaging between 73 and 89 per cent. During a professional evaluation session, the final recipes scored an average of 90 per cent. The recipes into which the multi-mix was incorporated, was suitable for children to consume during the day, and also coonsisted of ingredients, which were locally available and most common within households. The results showed the preference to sweet items with no deviation to positive comments considering the distinctive colour of green, from the spinach. The cost of the multi-mix was within the R2,90 spent per day, at R1,50. Therefore it can be said that the objectives of this study have been achieved.

During the shelf-life testing of the multi-mix, the initial total aerobic count was higher on the first and last day of the trial, above log 3/g. This was due to the sample material not being uniform (thoroughly mixed). The sample consisted of different textured powder particles. This may have caused uneven cfu counts. It might be that a larger number of organisms were concentrated on the portion that was sampled on days 0 and 28. The biscuit recipes yielded a seven-day shelf-life whereas the muffins can be kept for only 24 hours.

5.2 Researcher's role in this project

The researcher was responsible for the following in this study:

- The literature study and proposal writing
- The developing of the criteria and formulation of the multi-mix
- Theoretical analysis of the multi-mix
- Development and standardisation of recipes
- Developing and testing of the measuring instrument for sensory analysis
- Training of tasting panels
- Conducting sensory evaluation sessions and interpreting data.

The microbiological testing and chemical testing were contracted out as the researcher did not have any expertise in these fields.

5.3 Limitations

First was the lack of proper mixing equipment required for blending of the multi-mix. This resulted in uneven total aerobic counts throughout the shelf-life testing, as well as variations in the chemical analysis from the accredited laboratory and VUT.

Second was a lack of support from the researcher's employer in order to allow time-off for the chemical analysis to be done at the VUT, which resulted in the analysis having to be done by an accredited laboratory, which is a lengthy and costly process.

Thirdly, was the validity of the first sensory evaluation being questionable due to errors that occurred during completion of the questionnaires: 1) the time of day that resulted in most children being hungry on their way home, and 2) the inability of the children to distinguish between flavour and taste as well as the characteristics of feeling, which they assumed to be the feel on the fingers.

5.4 Conclusion

The stated objectives were to develop a multi-mix that addressed one-third of nutritional requirements based on the selected nutrients, for children aged six to 13 years, and to ensure that the multi-mix consisted of ingredients that were culturally acceptable, commonly purchased and consumed, while being cost-effective. The formulation of the multi-mix has proven that various combinations of ingredients can provide substantial nutritional value for specific age groups. The context of this study encompasses the strategies of the Department of Health, which include the improvement and strengthening of nutrition supplementation and the enhancement of the technical role of nutrition in food security interventions. This study can be beneficial, as part of an intervention to assist in reducing malnutrition.

The ingredients of the multi-mix consisted of commonly purchased and consumed items and complied with the basic formulation requirements. The main ingredient consisted of the staple South African food item of, i.e. maize, while the other ingredients accorded with cultural acceptability. The objective of a cost-effective multi-mix was achieved as the final formulation costs only R1,50, which is within the current spending available per person, per day on food, in the community. This objective is in line with the requirements set out by Cameron and Hofvander (1987) which states the requirements of a multi-mix and multi-mix products being of ingredients locally available, low cost and frequently consumed within the households.

Through the sensory evaluation it can be observed that the majority of children enjoyed snack items during the day. Although children prefer a sweet product, savoury items do not deter them from responding positively. The colour of the multi-mix had no relevance to the evaluation, as the children were familiar with spinach and the green colour associated with it. Zotor (2002) also found that through the sensory evaluation of the multi-mix products cakes, biscuits, bread and porridge, over 1 000 children in Ghana from a teaching hospital, responded in a positive manner to the sweet and savoury products. Gopaldas *et al.* (1974) discovered a higher acceptability of certain multi-mixes due to the overriding sweet factor in the products. Flavour became an irrelevant factor to the children at that point.

When considering the shelf-life of the multi-mix, according to ARC, may be stored for more than 28 days at 25°C. Less micro-organism growth occurs below 5°C. If refrigeration facilities become available, there is a possibility for longer storage periods. This implies that the food provider can prepare the multi-mix every second month, or quarterly.

To conclude, it is possible to develop a multi-mix that meets the criteria of 1) nutrient density, 2) consisting of ingredients local to the community and available, 3) culturally acceptable, 4) affordable and 5) palatable. This is in line with the studies of Nnakwe (1995) which stated that combining two or more staple sources was regarded as a possible solution to managing malnutrition. Although certain combinations had a low acceptance rate, once the nutritional benefits were highlighted and understood by the food providers, higher consumption occurred.

5.4 Recommendations

For future development, multi-mixes should be formulated either to focus on specific nutrient deficiencies within a community, or be formulated for hunger-stricken areas where an overall balance of all nutrients can be created. This would imply that for all nutrients the INQ should be above 1,0. Each nutrient has a vital role to play within the human body, some on their own and others in conjunction with one another.

When considering the criteria of a multi-mix, the formulation which focuses on all nutrients would be ideal but may be impractical due to the cost-effectiveness, which was an important objective at the beginning of this study. Provided that the costs are low, six ingredients may be acceptable. The availability and cost of the ingredients need to be considered at all times. Food items chosen for the multi-mix needed to be readily available. Food shortages may result in prices being raised, due to importing costs or alternative supplier deliveries.

During the formulation process it remains important to consider the implications of combining certain ingredients dependent on ratio, i.e. sugar beans, which tend to leave a bitter taste that can be detected in certain recipes. Food colour does not seem to be a matter of concern for the children, but should still be considered during formulation, as the final product should be visually appealing.

When energy values are below requirements of the stated objectives, then a recommendation can be made to incorporate some form of nuts. This will increase the protein and energy content but has an unfortunate and negative affect on shelf-life. Oil-based foods tend to deteriorate more rapidly due to becoming rancid.

Studies should be conducted on how best to implement the consumption of the multi-mix in an intervention programme to determine the impact of the multi-mix on the nutritional status of the children. This will determine the effect of a multi-mix in addressing and correcting nutritional deficiencies.

The portion sizes of the recipes prepared were standardied with 100g multi-mix. However, to meet the energy and nutrient levels required (30 per cent of EAR), a portion size of 150g and 200g of multi-mix for the age groups four to eight years and nine to 13 years respectively. More research is required to ensure the intake of these larger multi-mix portions, and to determine if the recipes will yield a total portion size that will be feasible and acceptable for children to consume.

A recommendation is also made to assess the compliance of the multi-mix over a longer period of time. Children had positive responses to the consumption of the recipe items during the evaluation sessions but an assessment needs to be made on compliance over an extended time period. This can be determined if the multi-mix is implemented for a minimum period of one year.

Due to the ease of preparation, an opportunity occurs to provide the multi-mix not only through a school feeding programme but also as part of a community intervention programme. Basic drying and mixing procedures can be used to prepare the multi-mix and recipes. Training the parents or food providers will, however, be necessary. Another multi-mix was formulated and presented at VUT during the Innovation Fund Competition 2005. The business plan emphasized the importance of child nutrition. The plan received first prize for the innovation, which can improve the nutrition of children in communities (see Annexure E).

Professionals made the following suggestions during the evaluation sessions which may be considered for future development of multi-mixes and their implementation into recipes: a) an alternative spice may be added to enhance the savoury (fish) taste, which will compliment the combined flavours of the FMM; b) in the *vetkoek* yeast can be used as an alternative, as it would impart a softer texture and more elasticity, as well as increasing nutritional value with B-vitamins. Yeast is locally available, inexpensive and found in most homes in the area. Although yeast cannot be used in the formulation, it may provide nutritious snacks/meals in a recipe that uses the multi-mix as the basis.

In conclusion, the multi-mix that meets the criteria of the formulation is a way to address and assist in reducing the prevalence of malnutrition and nutrition-related diseases. It has been shown that the multi-mix, developed through this study, can supply a minimum of one-third of the daily requirements of most nutrients. The multi-mix can assist in reducing food insecurity by providing good quality foods, which are in small quantities. Further research is, however, recommended.

CONFERENCE PARTICIPATION

A poster was presented at the 18th International Congress on Nutrition, 19 – 23 September 2005, ICC, in Durban, South Africa.

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ANNEXURE A

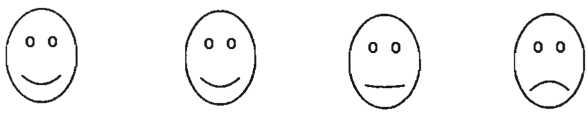
Sensory evaluation form used by schoolchildren

Very good (4/4) Good (3/4) Bad (2/4) Very bad (1/4)

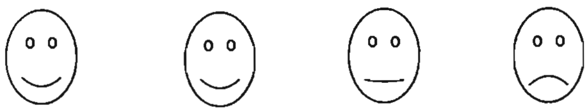
Please mark with a cross (X) on the face which best describes your feelings about the following:

RECIPE:……………………………………..

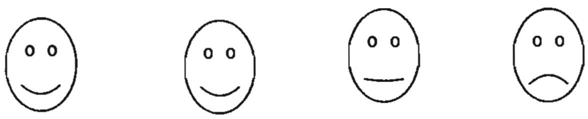
1. APPEARANCE



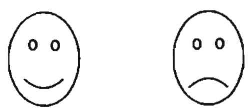
2. TASTE



3. SMELL



4. Would you eat it again?



YES NO

ANNEXURE B

Sensory evaluation form used by professionals

NAME:..
RATINGS:
....
....

Very good (4/4) **Good (3/4)** **Bad (2/4)** **Very bad (1/4)**

Please mark with a cross (X) on the face which best describes your feelings about the following:
RECIPE:...

4. APPEARANCE

5. FLAVOUR

6. TASTE

7. FEEL

8. SMELL

COMMENTS:
....

Adjusted multi-mix portion sizes, compared to specific age groups

NUTRIENT AND VALUE 100 g MULTI-MIX	150 g Multi-mix	1/3 of EAR of four to eight years	200 g Multi-mix	1/3 of EAR of nine to 13 years
Carbohydrate (g) 60,1	90,15	33,3	120,20	33,3
Calcium (mg) 515,9	773,85	266,67	1031,80	433,33
Magnesium (mg) 225,2	337,80	36,67	675,60	66,67
Zinc (mg) 7,6	11,40	1,33	15,20	2,33
Vit A (µg) 85,5	128,25	91,67	171,0	148,33
Vit C (mg) 2,4	3,75	7,33	4,8	13,00
Vit B2 (mg) 0,2	0,30	0,17	0,4	0,27
Vit B1 (mg) 0,3	0,45	0,17	0,6	0,27
Iron (mg) 13,2	19,80	1,37	26,4	1,93
Protein (g) 18,4	27,60	20,0	36,80	30,0
Energy (kJ) 1 587	2380,50	2438,67	3174,0	3190,67

ANNEXURE D

TEST REPORT 2004-S-426

This laboratory holds SANAS accreditation for analyses with an ASM number.
Results are expressed on a wet basis, therefore as samples were received.

Analysis	Accreditation number	Unit	Sample Number	
			1 : A – Vetkoek	2 : B – Multimix
Ash	ASM 048	%	1.88	6.06
Dry matter	ASM 013	%	60.50	91.05
Moisture	ASM 013	%	39.50	8.95
Fat (acid hydrolysis)	ASM 068	%	8.21	2.40
#Protein*		%	8.96	19.34
Folic acid		µg/100g	820	2350
Vit A		mg/100g	0.09	0.09
Vit B1	ASM 025	mg/100g	0.40	0.28
Vit B2	ASM 025	mg/100g	0.10	0.19
Vit B6		mg/100g	0.46	0.56
Vit B12		µg/100g	1.27	40
Vit C	ASM 057	mg/100g	1.27	2.55
#Calcium		mg/100g	117.23	543.00
#Magnesium		mg/100g	72.24	237.00
#Copper		mg/kg	1.43	5.94
#Iron		mg/kg	40.25	139.33
#Zinc		mg/kg	34.50	80.25
Energy (calculated)		kJ/100g	1161	1493
Carbohydrates (calculated)		g/100g	41.45	63.25

* For the conversion of nitrogen content to protein content the factor 6.25 was used.
# Analysis done by subcontracted laboratory

Innovation Fund Competition

2005 ANNEXURE E

This is to Certify that:

Mrs D Oosthuizen

Participated in the Competition,
and was part of a team that
was awarded

First Prize

As a prizewinner, participation in the
National Innovation Fund Competition follows.

Prof J.D. Pretorius
Dean: Research

26 October 2005
Date:

Vaal University of Technology

ANNEXURE F

BRENT'S ART AND LANGUAGE SERVICE CC

6 Carter Street, Vanderbijlpark 1911 * Telephone: 016 – 9325528
Fax: 086 675 4144 * e-mail: brentboy@lantic.net

CERTIFIED STATEMENT OF EDITING AND TRANSLATION

It is hereby certified that the M Tech thesis document:
"A food multi-mix to address malnutrition amongst primary school children living in Eatonside"
by Delia Oosthuizen.

has been edited by me.

B.Record BA (HONS), UED, NHDip, M.Tech.
5 April 2006

BRENT'S ART & LANGUAGE SERVICE CC Registration No. 2000/005438/23

DELIA7

ANNEXURE G

Press any key to continue...
VAAL nutritional analysis 2004.10.12

patient:DELIA7 for number of 'meals',days= 1
Surname:DELIA7
Sex:C Child Age: 9

Intake energy from : Carbohydrates= 58% Protein= 25% Fat= 12 %
Saturated fats 3%
Mono-unsaturated 2%
Poly-unsaturated 5%
% = percentage energy contribution towards the total energy intake 1671kJ

			average	Add for 100%,	RDA % ,	RDA	:'INQ'
Kilo calories		Kcal	401	1599	20%	2000	
Kilojoules		kJ	1671	6697	20%	8368	
*Total protein		gm	25.03	3	89%	28	2.5
Plant protein		gm	14.9				
Animal protein		gm	10.1				
*Total fat		gm	5.15				0.4
Saturated fatty acids		gm	1.26				0.3
Mono-unsaturated fatty acids		gm	1.05				0.3
Poly-unsaturated fatty acids		gm	2.19				0.5
Cholesterol		milligram	38				1.0
*Total available carbohydrate		gm	57.51				1.1
Dietary fibre		gm	14.3				3.8
Calcium	Ca	milligram	523	277	65%	800	2.6
Iron	Fe	milligram	11.59	-2	116%	10	4.4
Magnesium	Mg	milligram	292	-122	172%	170	5.2
Phosphorus	P	milligram	485	315	61%	800.0	2.4
Potassium	K	milligram	1889	-289	118%	1600.0	
Sodium	Na	milligram	459	-59	115%	400.0	1.2
Chloride	Cl	milligram					
Zinc	Zn	milligram	3.80	6	38%	10.0	1.4
Copper	Cu	milligram	0.86	0	86%	1.0	
Fluorine	F	milligram					
Iodine	I	micro gram					
Manganese	Mn	milligram	3.52	-1.52	176%	2.0	
Molybdenum	Mo	micro gram					
Selenium	Se	micro gram					
Vitamin A ,retinol equivalents			5394	-4694.3	771%	700.0	33.3
Thiamin	B1	milligram	0.49	0.5	49%	1.0	2.6
Riboflavin	B2	milligram	0.92	0.3	77%	1.2	4.1
Nicotinic acid	B3	milligram	7.8	5.2	60%	13.0	3.0
Vitamin B 6	B6	milligram	0.994	0.4	71%	1.4	3.3
Total folic acid	B9	micro gram	413	-312.9	413%	100.0	12.2
Vitamin B 12	B12	micro gram	0.0	0	0%	1.4	
Pantothenic acid	B5	milligram	1.06	2.9	26%	4.0	
Biotin	H	micro gram	2.6	27.4	9%	30.0	
Ascorbic acid	C	milligram	26	19.5	57%	45.0	2.3
Vitamin D	D	micro gram	4.30	5.7	43%	10.0	2.3
Vitamin E	E	milligram	3.93	3.1	56%	7.0	2.6
Vitamin K	K	micro gram					

ingredient list DELIA7 DELIA7 2004.10.12
total mass= 480.70 grams , energy= 1671kJ

			*%	kJ	Carbo.	Prot.	Fat	Cost 1
3543	BEANS, SUGAR DRIED R	17.00	14%	235	8	3	0	
4225	MAIZE MEAL, SPECIAL	43.00	40%	666	35	4	1	
8067	CARROT, COOKED	146.00	16%	274	11	2	0	
2557	FISH, PILCHARD IN TO	53.70	17%	285	0	10	3	
8071	SPINACH, COOKED	221.00	13%	210	4	7	1	

DELIA7

*% = percentage energy contribution towards the total energy intake

TOTAL COST 1 = 0.00 COST 3 = 0.00

Protein supplied 25% of the daily energy intake
Protein should supply between 10 - 20 % of RDA daily energy needs.
Fat supplied 12% of the daily energy intake
Fat should supply between 25 - 30 % of RDA daily energy needs.
(Poly./ Sat.) fat ratio 1.740 , Energy from fat= 195kJ
Carbohydrates contributed 58% of the daily energy intake
Carbohydrates should supply between 50 - 60 % of RDA energy needs.
The diet provided 14 g of dietary fibre.
The daily intake of dietary fibre should be between 30 & 40 g.
Ca / P ratio 1.079
K / Na ratio 4.117
no GI FACTORS

VAAL

ANALYSIS OF FOOD INTAKE

Surname	DELIA7 DELIA7		
Height	: 0 cm	Body mass :	0 kg
Sex	: Child	Age:	9

BODY MASS

1 ENERGY

Your sample diet provided 1671 kilojoules or 401 kilocalories.

Your (RDA) daily energy needs may be approximately 8368 kJ
This is correct only if you are very active
Your sample diet provided too little energy.

(See list of MAJOR FOOD REQUIREMENTS,section 1.)

2 CARBOHYDRATES

Your sample diet provided 58 g of carbohydrates,
which is equivalent to 12% of your (RDA) daily energy needs.
Carbohydrates should supply between 50 - 60 % of your daily energy needs:
You are ingesting too little carbohydrates.

You do not have too much refined sugar in your diet.

(See list of major food requirements,section 2.)

3 DIETARY FIBRE

Your sample diet provided 14 g of dietary fibre.
Your daily intake of dietary fibre should be between 30 - 40 g.
You need to add more fibre to your diet.

(See list of major food requirements,section 3.)

4 PROTEIN

Your sample diet provided 25 g of protein,
which is equivalent to 5% of your (RDA) daily energy needs.

Protein should supply between 10 - 20 % of your daily energy needs.

You are ingesting too little protein.

You should increase your intake of animal protein
as it is normally of a higher quality than plant protein.

(See list of major food requirements,section 4.)

ANNEXURE H

The formulation and development of a multi-mix for primary school children within an informal settlement, South Africa.

Oosthuizen, D., Napier, C., Oldewage-Theron, W.

ABSTRACT

A situational analysis in an informal settlement revealed that foods most commonly purchased and consumed were maize, tea, bread, rice, sugar and apple with protein sources, beans and eggs, 15^{th} and 17^{th} on the list and of small value, 42,22 grams and 24,70 grams respectively. Dietary analysis interpreted by Napier (2003) and anthropometrics indices revealed that children, between the ages of six and 13 years, were 17 per cent underweight (weight-for-age -2SD from the reference NCHS median), 12,7 per cent were wasted (BMI-for-age -2SD) and 18 per cent stunted (height-for-age -2SD). A literature study on malnutrition statistics, globally and within South Africa was undertaken. Further literature studies included a completed understanding of the effects of malnutrition, the role of staple food items, factors influencing choices and the requirements of children aged six to 13 years.

The primary objective of this study was to formulate a multi-mix which could supply at least one third of the daily requirements of primary school children aged six to 13 years within an informal settlement in Gauteng, South Africa. The secondary objective was to use the most common purchased and consumed ingredients to develop a multi-mix, which was convenient, culturally acceptable, adaptable into recipes, providing exceptional taste, flavour and of high nutritional value.

Foods were combined to determine the estimated macro- and micro nutrient balances required for the specific age group, based on the food composition tables of South Africa. The six ingredients were prepared and chemically tested to determine the experimental nutritional value. The multi-mix was adapted into recipes and evaluated by the children within the informal settlement, and professionals within the food industry. The multi-mix and recipes were then analysed to determine the shelf-life.

The results from the nutritional analyses showed nutrient values to be above 30 per cent of the EAR. The INQ of the targeted nutrients was above 1,0 and the ED at 3,7kcal/g, which was within the 3,6-4,5 kcal/g requirement. The sensory evaluation proved the favourable response to snack items with preference for sweet products. The final evaluation session resulted in scores of 83.9 per cent liking to the biscuit with the sweet muffin scoring 94.5 per cent liking, whilst the *savoury muffin at 73.1 per cent. The average scores for all three recipes were above 80 per cent. The multi-mix had a shelf-life of minimum one month, the biscuit, seven days and muffins, only 24 hours, at room temperature. The objectives of cultural acceptability had been achieved through the positive response from the use of ingredients within the community. The multi-mix had been cost effective with the final cost of R1.55 , which was within the R2.90 spend per person per day, for all three meals.*

The results indicated that a nutrient-rich multi-mixes can be developed to address a specific nutrient deficiency or a combination of nutrient deficiencies. The multi-mix formulation is labelled as food diversification, a food-based strategy. This approach falls in line with the current objectives of the Department of Health, in South Africa, to improve and strengthen nutrition supplementation and the enhancement of the technical role of nutrition in food security interventions. This study, aimed to reduce the underlying cause of malnutrition, food insecurity, by improving the nutritional status of children aged six to 13 years with the strengthening of food intake, through the combination of various scant ingredients, providing maximum nutritional value with small quantities.

Keywords: multi-mix, food insecurity, children, nutrient-rich .

INTRODUCTION

Malnutrition is classified as both over- and under-nutrition. Under-nutrition occurs when food, required for growth and development, is omitted or lacking and results in conditions such as micronutrient deficiencies, wasting, stunting and underweight (Mahan & Escott-Stump 2000, Klugman 2002). Over-nutrition is the condition where food is consumed in excess and leads to conditions such as obesity, cardiovascular disease, hypertension, diabetes, gallbladder disease, osteo-arthritis and some form of cancers in adulthood (The Georgia Mateljan Foundation 2002-2005).

The most vulnerable group is children. Children are at a higher risk, as this is the crucial stage of development. In young children, malnutrition reduces motivation and curiosity whilst also reducing play and exploratory activities.

Depending on the nutrient and the severity of deficiency, the consequences of malnutrition may include growth stunting, anorexia, susceptibility to infections, behavioural changes, and learning disabilities (Klugman 2002).

The effects of malnutrition include impaired mental and cognitive development by reducing the amounts of interaction children have with their environment, with their peers and with those who provide care (Bellamy 1998).

There is a high prevalence of malnutrition with one in every two children, in South Africa, consuming less that half of vitamin (vit.) A, vit. C, calcium, iron and zinc (DoH 2002). The Micronutrient Initiative (MI) and UNICEF (2004) published a report, which indicated that the child death rate in South Africa was 6 000 per year due to Iron Deficiency Anaemia (IDA) and VAD. Studies conducted through the National Food Consumption Survey (NFCS) indicated that 7,6 per cent of children between the ages of one to nine years, in urban areas were overweight. Nationally, the total number of children being overweight was 6 per cent (Labadarios 2002).

The National Food Consumption Survey (NFCS) indicated that the most commonly consumed food items in rural areas amongst primary school children are maize flour, sorghum flour (maltabella), wheat flour (bread), dry beans, peas, sugar and vegetables, namely cabbage, spinach, pumpkin, sweet potato, onions and carrots. Studies showed that 630g of cereal was consumed daily by children aged six to nine years of age. A total of 57-58 per cent of the children, consumed vegetables whereas less that 3 per cent consumed beverages, alcohol and spices (Labadarios 2002). The consumption of maize within the Setlabotsja Primary School, Gauteng, for children aged six to 13 years, averaged between 136-403g per day (Napier 2003).

Food diversification is classified as a food-based strategy, which assists in prevent micronutrient malnutrition on a long-term effect. The same aim, of reducing malnutrition, is used to describe functional foods, which is a concept implying food component(s) that have an ability to influence the body's functions to help improve the state of well-being and health and reduce the risk of disease.

Multi-mix development commenced in 1974, by Gopaldas, where certain criteria were created to ensure accurate multi-mix formulation. Cameron and Hofvander (1987) further developed the multi-mix formulations for weanlings from the studies of Gopaldas (1974) and created a food square (figure 1), which is a useful concept when teaching how to choose the ingredients for multi-mixes. It also assists with providing ingredient balance, from each food group, within the formulation and ensuring maximum nutritional value.

Another vital criteria to the formulation includes the nutritional requirements of a multi-mix which should yield an Energy Density (ED) between 3,6 – 4,5 kcal/g so that little quantities can be consumed daily and still provide maximum nutrient benefit. The Index Nutrient Quality (INQ) should exceed or be equivalent to 1.0 to ensure good of product. The INQ is calculated by dividing the amount of nutrient in 1 000kcal (4 200kJ) of food with the allowance of nutrient in 1 000kcal (4 200kJ) of food. The amount of nutrient is measured in grams and the allowance of nutrient is taken from the EAR, also measure in grams (Amuna *et al.* 2000, Zotor 2002). The aim of a multi-mix was to supply the specific consumer with a product, which can be added to the meal to boost the nutrient needs or provide the nutrients that are lacking. Challenges to finding suitable food vehicles and the right fortification compound, also depends on cultural hindrance, expense and sustainability (Amuna *et al.* 2000).

The focus of this study was to address the problem of malnutrition within an informal settlement in Gauteng, South Africa. A project was undertaken by the Centre of Food and Nutrition researchers to determine the situational and nutritional status of a randomly selected group within an informal settlement in the Vaal Triangle. The results indicated that there were chronic problems relating to poverty, malnutrition and food insecurity.

The Vaal Triangle is an industrial area situated approximately 70 kilometres south of Johannesburg. Forty eight per cent, out of 794 599 people residing in the area, are unemployed with 46 per cent of households living in poverty. The research centre currently participates in research projects to empower the community with knowledge and basic food sources (vegetable gardens), among others, to improve the nutritional status of the children, pregnant women and elderly.

This paper focused on the development of a multi-mix to address and reduce the problem of wasting, underweight and micronutrient deficiencies with the primary school children in the informal settlement, as reflected in Table 1 (Napier 2003). The nutrients to be targeted in the multi-mix were calcium, protein, zinc and energy. The primary objective was to supply at least one-third of the daily EAR for children aged six to 13 years with emphasis on the targeted nutrients. The secondary objective was to ensure the multi-mix was affordable, considering the budget restrictions, convenient, palatable, culturally acceptable and of high nutritional value.

METHODOLOGY

Criteria formulation:

Defining a multi-mix and understanding the criteria for the formulation was the first step towards the process of formulation and development of a multi-mix.

A literature study was undertaken to review the ingredients most commonly purchased and consumed (Table 2) within the community (Napier 2003). The nutritional requirements of the children were identified (IM 1997, 1998, 2002), which provided a basic skeleton for the formulation of the multi-mix. The role of the staple food within South Africa and the community was considered as the back-bone of the multi-mix due to the consumption levels and cost effectiveness of the ingredient.

The EAR of the targeted children, six to 13 years, was divided into two age groups: four to eight years and nine to 13 years. It was therefore decided to take the highest value from the both groups as the skeleton of the formulation.

The process continued with the identification of possible ingredients, keeping in mind the sources from which the multi-mix must be formulated (Figure 1).

The multi-mix was formulated considering the nutritional requirements of children, the nutrients lacking within the diets and the nutritional criteria of a multi-mix. The multi-mix consisted of maize, the staple ingredient of the community and children, sugar beans, consumed daily with samp, spinach and carrots, grown within the established vegetable gardens, pilchards in tomato sauce, an inexpensive source of protein, and oil. These ingredients were commonly consumed, cheap and locally available. The estimated nutritional value of the multi-mix was calculated with the assistance of a Dietary Manager® program, which was based on the Food Composition Tables of South Africa.

Preparation:

Throughout the process of preparation the highest standard of hygiene measures were taken to prevent any form of cross-contamination.
The steps taken throughout the process included the sanitising of all surfaces and equipment, before commencing. Safety gloves were worn with a mouth-mask and hat. A laboratory jacket was worn and all equipment was thoroughly washed throughout the process of preparation. The question of food standards and safety procedures needed to be adhered to at all times to ensure that no contamination occurs during the manufacturing or developing process (Amuna *et al.* 2000).

All the ingredients were dried separately, due to the various moisture contents, Under strict temperature controls of 65°C and pasteurised at 85°C for 15 minutes. According to Vierra (1996) the dryness is determined by sampling a piece, which needs to be dry and brittle. It should crumble when pressed between two fingers. All ingredients where cooled to room temperature before further processing took place, have a Moisture content of more than 14 per cent (Amuna *et al.* 2000). Once the ingredients were cooled down, the final multi-mix was weighed and ground into powder form. The weight was measured at the beginning and end of dehydration process to determine the ratio of fresh to dried ingredients. This was necessary as the Dietary Manager®, a software program, could only record ingredients in fresh form.

Chemical analysis:

A dry 100g portion was used for the chemical analysis by the Agricultural Research Council (ARC), an accredited laboratory, to determine the nutritional value of carbohydrates protein, fat, total energy, fibre, ash and moisture content as well as micro-nutrients such as zinc, copper, iron, calcium and various B-complex vitamins. The process of analysis is summarised in Table 5 (Oldewage-Theron & Amuna 2002)

Cost analysis:

A cost analysis was completed for the multi-mix whereby the weight of the dried ingredients was converted into fresh-form and the calculations based on the fresh weight and unit price of each ingredient.

Recipe development:

The multi-mix was incorporated into recipes. The recipes were chosen based on the importance of cultural acceptability and cost implications. The nutrients, which were lacking in the diets of the children, aged six to 13 years: protein, energy, calcium and zinc were also considered. The recipes were also based on ingredients, which were locally available and common within the households. With peanut butter, apples and onions being available, it presented an ideal recipe for biscuits and muffins, which could be consumed as a 'healthy' snack during the day. These recipes would also boost the levels of zinc, calcium, energy and protein in the diet.

Sensory evaluation:

The first sensory evaluation was held at the primary school, with 20 children aged between six and 13 years. It was decided to commence with one class to determine whether the choice of recipes was correct. Individuals were placed in rows of four, each row seating five. Each scholar was handed a glass of water, pencil and sensory evaluation form. It was discussed with them, with the assistance of a teacher, that no verbal interaction and physical contact was allowed to take place. Children rinsed their mouths with the water provided. The sensory evaluation forms were explained to the teacher whom interpreted all the information to the children. The questionnaires consisted of the hedonic face-scale, which allowed the children to best explain their emotions concerning the product evaluated. Each face had a rating of one out of four to four out of four. One, being very bad, whilst four, being very good.

The second and third sensory evaluation sessions where completed by professionals within the field. This was done for the purpose of standardizing the recipes with the least amount of ingredients, whilst still ensuring the characteristics of smell, feel, taste, texture and appearance were maintained and within acceptable standards.

A final sensory evaluation was completed at the school with 56 individuals. The evaluation form was shortened and simplified to make the evaluation process easier for the children. The children where required to evaluate the three recipes based on appearance, taste and smell. The results were indicated on the hedonic face scale. The final question was whether the each child would consume the product again. The results of liking and disliking were based primarily on the last question. The children were explained in detail how to complete the evaluation form and some children repeated the explanation to confirm understanding. Children were asked to provide honest answers and not to copy from others.

Shelf-life testing:

The multi-mix and final recipes where then sent away for micro-biological testing at room temperature as most households did not have any form of refrigeration, to determine the shelf-life period.

RESULTS AND DISCUSSION

Formulation and preparation:

The results of the standardized 100g portion size, had a slight variance to the original objective of providing one-third of the daily requirements of primary school children, for all the targeted nutrients. Energy remained below the 30 per cent requirement at 16 per cent, with calcium at 41,7 per cent, zinc at over 1000 per cent and protein above 30 per cent. It was decided to recalculate the portion size to 150g for four to eight year olds and 200g nine to 13 years of age. The resulted in all nutrients, including energy to be above the 50 per cent level.

Cost analysis:

The cost-effective criteria was achieved. With the inclusion of oil, the multi-mix was costed at a price of R1,50 per portion, which was within the spend per person, per day, for all three meals, within the community.

Chemical analysis:

The chemical analysis of the standard 100g portion, indicated a variation to the objective stated of achieving 30 per cent of the targeted nutrients calcium, protein, zinc and energy. The energy content obtained with the multi-mix was only 15 per cent, which was 1 493 kilojoules (kJ) of the required 2 871 kJ. When oil was added for preparation purposes, the energy content was elevated to 1 587 kJ, 16 per cent. It was therefore decided to ensure the final recipes consisted of high energy value ingredients. Table 3 provides the results of the chemical analysis. The recovery for the nutrients of target protein, energy, calcium and zinc were below 90 per cent, except for calcium at 104 per cent and zinc at 211 per cent. The protein and energy values were 89 and 77 per cent respectively. Although the theoretical INQ values were correct, the actual figures showed vitamin and mineral losses during the preparation process. Slight variations occurred to the expected results of vit. A and C, which are not resistant to heat with vit.amin A also diminishing when exposed to light. The INQ indicated calcium at 2,7 and zinc at 7,3. Protein totalled at 4,1. This shows that the quality of the nutrients were very good. The ED supplied by the multi-mix was 15,87 kJ/g while the theoretical was 16,71kJ/g. An ED between 3,6 – 4,5 kcal/g , that small quantities can be consumed daily yet still provide maximum nutrient benefit.

Sensory analysis:

The final recipes where standardised with 100g of multimix. They included peanut butter biscuit, a sweet muffin and savoury muffin. With the inclusion of basic ingredients, the nutritional value of the multi-mix improved and boosted the energy levels to between 20-21 per cent. The difference between the two muffins was the inclusion of either grated apple or sautéed onions.

The validity of the first sensory evaluation was questionable due to errors which occurred during the completion of the forms; the time of day which resulted in most children being hungry as they were on their way home; and the inability to distinguish between flavour and taste as well as the feel characteristics, which the children assumed as the feel on the fingers. The children were therefore requested to evaluate the recipes on characteristics of taste, smell and appearance in the final evaluation session. The children had a higher preference to sweet snack items. The results of the final evaluation session (evaluation no. 4) between 52 and 57 scholars indicated the peanut butter biscuit at 83,9 per cent liking the recipe whilst 16,1 per cent disliked the biscuit. The muffin with apple received the highest score due to the sweetness and flavour of the apple appearing in the muffin. The total number liking the muffin was 94,5 per cent whilst 5,5 per cent disliked the muffin with apple. The muffin with sautéed onion received the lowest rate with only 73,1 per cent of the children liking the product whilst 26,9 per cent preferred not to consume again. The average score for the biscuit was 89 per cent, muffin with apple was 88,7 per cent and muffin with onions was 83,4 per cent. The above-mentioned products where evaluated by the lecturers and the biscuit received 91,6 per cent overall whilst the muffins with apple and onions both received 90 per cent.

The multi-mix was analysed for shelf-life and results indicated a 28-day shelf-life at room temperature. The colony forming units per gram (Cfu/g) remained low throughout the trial. The results of the shelf-life testing for the recipes indicated the biscuit can be stored for a seven-day period at room temperature. Due to the high Cfu/g in the sweet and savoury muffin, these recipes can only be kept safely for a 24-hour period at room temperature.

CONCLUSION

The stated objectives were to develop a multi-mix that addressed one-third of nutritional requirements based on the selected nutrients, for children aged six to 13 years, and to ensure that the multi-mix consisted of ingredients that were culturally acceptable, commonly purchased and consumed, while being cost-effective. The formulation of the multi-mix has proven that various combinations of ingredients can provide substantial nutritional value for specific age groups. The context of this study encompassed the strategies of the Department of Health which included the improvement and strengthening of nutrition supplementation and the enhancement of the technical role of nutrition in food security interventions. This study can be beneficial, as part of an intervention, to assist in reducing malnutrition, and food insecurity, by providing good quality nutrient-rich mixes, which are affordable.

Through the sensory evaluation it can be observed that the majority of children enjoyed snack items during the day. Although children prefer a sweet product, savoury items do not deter them from responding positively. The colour of the multi-mix had no relevance to the evaluation, as the children were familiar with spinach and the green colour associated with it.

When considering the shelf-life of the multi-mix, according to ARC, may be stored for more than 28 days at 25°C. Less micro-organism growth occurs below 5°C. If refrigeration facilities became available, there is a possibility for longer storage periods. This implies that the food provider can prepare the multi-mix every second month, or quarterly.

The advantages to multi-mix formulation is a) that the multi-mix becomes culturally acceptable, as the criteria includes ensuring the use of ingredients, which are in excess and of high consumption; b) nutrient dense to focus on a specific nutrient deficiency or a group of nutrients deficient; c) convenient as the multi-mix can be prepared once a month due to the 28 day storage ability at room temperature; and d) adaptable into recipes, which allows for variety to the menu.

The shelf-life testing would also assist with future planning of implementing the multi-mix as part of an intervention programme by determining the amount of preparation required on a weekly or daily basis by the parents or food providers.

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Table1: Setlabotsja Primary School: prevalence of malnutrition in the primary school for 2002 and 2003 (Napier:2003)

N*=147		
Underweight (≤-2SD)	2002	2003
Boys	13,5%	9,3 %
Girls	12,0%	15,2%
Stunted (≤-2SD)	2002	2003
Boys	19,2%	31,2%
Girls	16,8%	30,3%
Wasted (≤-2SD)	2002	2003
Boys	25,7%	31,0%
Girls	10,8%	22,9%

*number

Table 2: Top 20 food items consumed, measured by questionnaires, in an informal settlement (Naper:2003).

Item	Average portion (g*) per day
Maize meal cooked, stiff	403,84
Tea, brewed	203,24
Maize meal cooked, soft	136,83
Milk, full fat/whole fresh	47,22
Bread/rolls brown	56,27
Mabella/sorghum cooked	78,92
Cold drink squash, diluted	52,8
Rice, white cooked	39,28
Coffee, brewed instant	80,50
Maize meal cooked, crumbly	87,26
Tea rooibos, brewed	221,44
Apple average, raw	27,59
Bread/rolls, white	29,1
Sugar, white granular	8,8
Samp and beans	42,22
Tomato and onion, stewed	17,83
Egg, fried in sun oil	24,70
Cold drink carbonated	66,18
Orange, raw, peeled	30,94
Macaroni, spaghetti cooked	39,74

*grams

Table 3: Methods for the chemical analyses of the multi-mixes to determine the nutrient content (Oldewage-Theron & Amuna:2002)

Nutrient	Method	Basic principle
Protein	Adapted Kjedahl (modified Berthelot reaction)	Acid is used to release nitrogen in the sample, which is then measured and used to derive protein value by using a conversion factor
Fat	Acid-hydrolysis	Acid is used to release fat in the sample, and ethers are then employed to remove the fat.
Ash	Direct	Organic matter is removed by heating the sample in a furnace at 550 ° C
Moisture	Drying	Water is evaporated by drying the sample in an oven at 105 ° C
Carbohydrate	Derived	100 % - (% protein + % fat + % ash + % moisture)
Energy	Derived	(Protein X 16.8 kJ) + (Carbohydrate X 16.8 kJ) + (Fat X 37.8 kJ)
Minerals (Ca & Fe)	Atomic absorbance spectroscopy (AAS)	Sample is digested in acid to release minerals. AAS atomises sample, then passes a beam of radiation through it – absorption is measured at wavelength corresponding to mineral of interest
Minerals (Cu, Mg, Zn)	Inductively coupled plasma mass spectroscopy (ICP – MS)	Sample is digested in acid to release minerals. ICP-MS ionises sample, then separates ions according to mass and counts the ions.
Vitamins (B's, A, C & folate)	High performance liquid chromatography (HPLC)	A procedure for the separation of non-polar solutes. Non polar solutes are chromatographed on a column having a non-polar liquid immobilized on an inert matrix. A more polar liquid that serves as the mobile phase is passed over the matrix, solute molecules are eluted in proportion to their solubility.
Vitamins (other)	Theoretical calculations	Standard food composition tables and Food Finder/Dietary Manager ®.

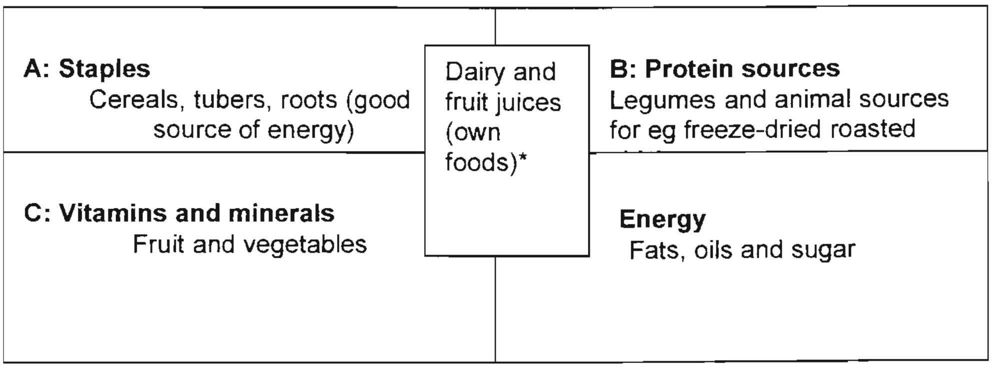

Figure 1: Adapted food square used as a guide for the formulation of the multi-mix (Cameron and Hofvander, 1989).

* Cameron and Hofvander (1989) formulated this food square for weanlings and used breast milk and formula milk.. The multimixes will thus be supplements to the available household meals.