DEVELOPMENT OF A NOVEL BREAKFAST FOOD PRODUCT FOR PRIMARY SCHOOL CHILDREN IN AN INFORMAL SETTLEMENT

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B-Tech Food Service Management

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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.

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The dissertation is the result of my own independent work, except where otherwise stated other sources are acknowledged by giving explicit references. A bibliography is appended. I also declare that I did not plagiarise any author's work.

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ABSTRACT

A baseline survey on the nutritional status of primary school children was conducted by means of Quantitative Food Frequency Questionnaire (QFFQ) and the 24-Hr recall questionnaires. The questionnaires were distributed by trained fieldworkers and completed by children attending the primary school in this community. The results of the QFFQ and the 24-Hr recall were used to identify nutrient deficiencies in the target group and to design a food product for a school feeding programme targeted to address specific nutritional needs. The aim of this study was to develop a nutritious novel food product that was affordable and appealing to children, rich in energy, protein and micronutrients. Five recipes were originally tested and evaluated. Recipes were theoretically analyzed by using the Dietary Manager program. The three most suitable recipes were chosen. Sensory analysis, by means of a paired preference test was done to determine which of the three products the subjects preferred. The final product developed was a maize meal and whole wheat "vetkoek". The Agricultural Research Council (ARC) laboratory in Irene bio-chemically analysed the vetkoek.

A second sensory analysis was conducted to evaluate the product for acceptability. A smiley face evaluation sheet was developed for the acceptance testing. The results showed that the majority (65 percent) of the consumers liked the product very much, 18 percent liked the product moderately, and 17 percent found it acceptable, 90 percent found it to be acceptable for inclusion in a school-feeding program. After the sensory evaluation was done a trained microbiologist at the ARC conducted the shelf life testing.

A recipe pamphlet was developed and printed in a format that is easily understood by illiterate people. The pamphlet was used by the community workers, who were responsible for preparing the vetkoek.

The results indicated that a vetkoek, meeting all the stated criteria can successfully be developed for a school programme

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GLOSSARY OF TERMS

AA	ascorbic acid
AAS	atomic absorbance spectroscopy
AI	adequate intake
AIDS	acquired immunodeficiency syndrome
AMDR	adequate macronutrient distribution range
ARC	Agricultural Research Council
a_w	water activity or water availability
BMI	body mass index
°C	degrees Celsius
Ca	calcium
CAADP	Comprehensive Africa Agricultural Development Programme
cm	centimetre
CSIR	Council for Scientific and Industrial Research
CVD	cardiovascular diseases
DHAA	dehydro ascorbic acid
DOH	Department of Health
DRI	dietary reference intakes
DSHEA	Dietary Supplement Health and Education Act
EAR	estimated average requirement
EDTA	ethylene diamine tetra-acetic acid
EER	estimated energy requirement
FAO	Food and Agricultural Organisation
FBDG	Food Based Dietary Guidelines
Fe	iron
FFTG	Food Fortification Task Group
FNIC	Food and Nutrition Information Centre
g	gram
GAIN	Global Alliance for Improved Nutrition
GFE	Global Food for Education

GMO	genetically modified organisms
Hb	haemoglobin
Hct	haematocrit
$HClO_4$	Perchloric acid
HIV	Human immunodeficiency virus
HNO_3	Concentrated nitric acid
HPLC	High-performance liquid chromatography
Hr	Hour
ICP-MS	Inductively coupled plasma mass spectroscopy
IDA	Iron deficiency anaemia
ID	Iron deficiency
IDD	Iodine deficiency disorders
ILSI	International Life Sciences Institute
INACG	International Iron Consultative Group
INEE	Interagency Network for Education in Emergencies
INP	Integrated Nutrition Programme
IQ	Intelligence Quotient
K	potassium
kg	kilogram
kJ	kilojoule
LPG	Liquefied Petroleum Gas
MCH	Maternal and Child Health
MCV	mean cell volume
MEC	Member of the Executive Council
mg	milligram
ml	millilitre
MRC	Medical Research Council
m^2	square metre
Na	sodium
NBD	National Burden of Disease
NCHS	National Centre for Health Statistics
NDHS	Nigeria Demographic and Health Survey

NEP	Nutrition Education Programme
NEPAD	New Partnership for Africa's Development
NFCS	National Food Consumption Survey
NGO	Non Governmental Organisation
NHANES	National Health and Nutrition Examination Survey
nm	nanometre
NSLP	National School Lunch Programme
PE	petroleum ether
PEM	protein energy malnutrition
pH	hydrogen ion concentration (relative acidity or alkalinity)
PSNP	Primary School Nutrition Programme
QFFQ	Quantitative Food Frequency Questionnaire
RBC	red blood cell count
RDA	Recommended Daily Allowance
RDP	Reconstruction and Development Programme
RE	Retinol Equivalents
RtHC	Road to Health Chart
SA	South Africa
SAVACG	South African Vitamin A Consultancy Group Survey
SD	standard deviations
SGB	student governing body
SFP	School Feeding Programme
SRBP	serum retinol binding protein
TBA	Traditional Birth Attendants
TB	tuberculosis
THUSA	Transition and Health during Urbanisation in Southern Africa
UL	upper intake level
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
US(A)	United States (of America)
USAID	The United States Agency for International Development

USD	United States Dollar
USDA	United States Department of Agriculture
USFDA	United States Food and Drug Administration
UV	ultra violet
VAD	Vitamin A deficiency
VIC	Vitamin Information Centre
VUT	Vaal University of Technology
WBC	white blood cell count
WFP	World Food Program
WHO	World Health Organisation
WITS	University of the Witwatersrand
Zn	Zinc

Chapter 1 Problem setting and overview of the study

1.1 Background study

Optimal nutrition is important for the normal development, health and well being of children. Severe malnutrition, as a result of complex socio-economic and biologic interactions, affects physical growth and performance, cognitive and social development, resistance to infection as well as reproductive performance in later adulthood. Any responsible society should aim to safeguard the health of its children through optimal nutrition (Vorster & Venter 1992:95). Malnutrition is one of the most neglected forms of human deprivation, particularly among children. Scientific evidence shows that, when compared with the risks faced by a well-nourished child, the risk of death from common childhood disease is doubled for a mildly malnourished child, tripled for a moderately malnourished child, and may be as high as eight times for a severely malnourished child (Maiti 2003:1). The malnutrition crisis is real and its persistence has profound and frightening implications for children, society and the future of humankind. Malnutrition is not a simple matter of whether a child can satisfy his or her appetite. A child who eats enough to satisfy immediate hunger can however still be malnourished. Malnutrition is a silent emergency; it is a crisis about death and disability of children on a vast scale (UNICEF 1998:1).

1.2 Malnutrition

According to the Food and Agricultural Organisation (FAO 2005:6), malnutrition or undesirable physical or disease conditions related to nutrition can be caused by eating too little, too much or an unbalanced diet that does not contain all the nutrients necessary for maintaining good nutritional status. Inadequate dietary intake, disease and infections, are causes of malnutrition (Kinabo & Msuya, 2002:65). Spowart (1998:13) concluded that malnutrition is an inclusive term that involves the lack, imbalance, or excess of one or more of 50 nutrients that are required by the body.

1.2.1 Factors contributing to malnutrition

The United Nations Children's Fund (UNICEF) conceptual framework (Fig 1.1) indicates the causes of malnutrition and was developed in 1990 as part of UNICEFs nutrition strategy. The framework shows that causes of malnutrition are multi-sectoral, taking into account food, health and caring practices. Causes are categorised as immediate, underlying and basic, whereby factors at one level influence other levels. The conceptual framework enables the analysis of the causes of malnutrition in any community, as it indicates the interrelationship between the various contributing factors. The framework also helps to clarify the objectives of actions selected for the implementation (DoH 2004/4:1; UNICEF 1990:22).

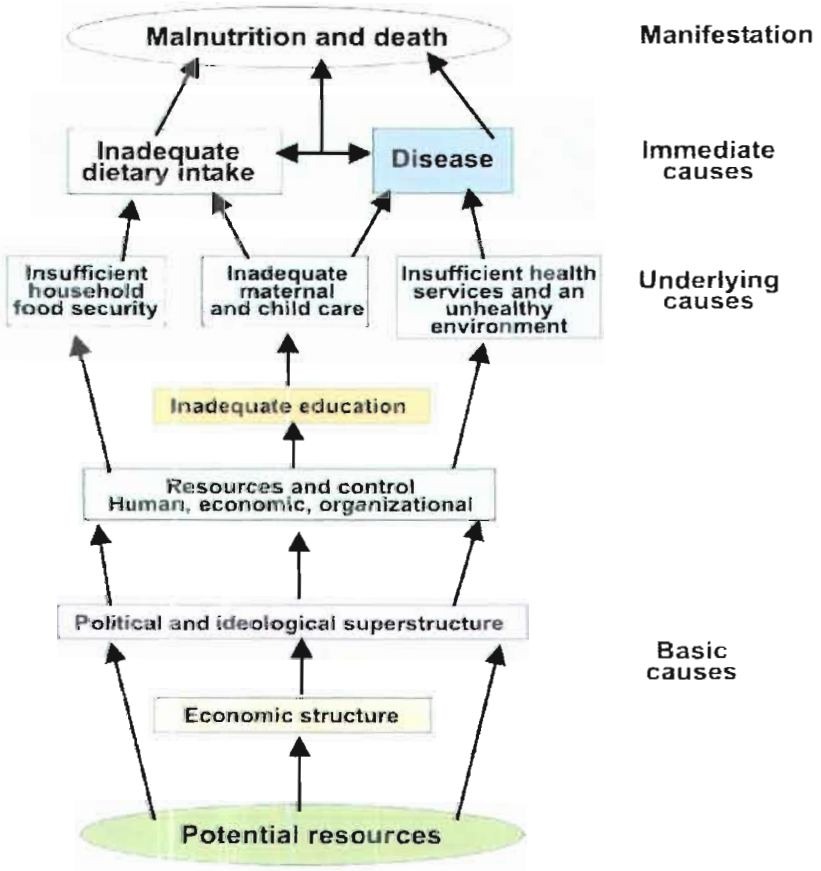

Figure 1.1 UNICEF framework of malnutrition (UNICEF 1990:22)

1.2.2 Malnutrition globally

Malnutrition, with its two components namely protein-energy malnutrition and micronutrient deficiencies, is a major health problem globally, and is the most important risk factor for illness and death (Muller & Krawinkel 2005:279). Table 1.1 shows the prevalence of malnutrition from 1995 to 2005 in different countries (UNS/SCN 2004:71-74).

Table 1.1 Prevalence of malnutrition in pre-school children globally (adapted from UNS/SCN 2004:71-74).

UN Region and sub-regions	**Stunted (%)**			**Underweight (%)**			**Wasted (%)**		
	1995	2000	2005	1995	2000	2005	1995	2000	2005
Eastern Africa	44.4	44.4	44.4	27.9	29.2	30.6	6.6	7.6	8.7
Middle Africa	40.0	37.8	35.8	26.9	26.1	25.3	7.0	9.1	11.9
Northern Africa	24.4	21.7	19.1	10.9	9.7	8.6	4.7	6.2	8.0
Southern Africa	25.0	24.6	24.3	13.9	13.7	13.6	3.7	4.9	6.6
Western Africa	33.8	32.9	32.0	27.5	27.1	26.8	10.5	10.3	10.2
Asia	**35.4**	**30.1**	**25.7**	**31.5**	**27.9**	**24.8**	**9.7**	**9.2**	**8.9**
Eastern Asia	21.5	14.8	10.0	13.2	9.3	6.5	2.7	2.2	1.8
South Central Asia	45.2	39.7	34.5	45.2	40.8	36.5	14.7	14.0	13.3
South-East Asia	36.8	32.1	27.7	31.2	27.4	23.9	9.2	8.9	8.7
Western Asia	21.7	18.7	16.1	12.1	11.3	10.6	4.4	4.2	3.9
Latin America	**15.9**	**13.7**	**11.8**	**7.3**	**6.1**	**5.0**	**1.6**	**1.6**	**1.5**
Caribbean	9.6	7.4	5.7	7.8	6.1	4.7	2.5	2.5	2.4
Central America	23.0	20.4	18.0	10.7	9.2	7.9	1.9	1.7	1.6
South America	13.3	11.3	9.6	5.7	4.6	3.7	1.4	1.4	1.4
All developing countries	**33.5**	**29.6**	**26.5**	**27.4**	**24.8**	**22.7**	**8.3**	**8.2**	**8.3**

1.2.3 Malnutrition in Africa

According to UNICEF (2001) an estimated 11 million under-five deaths occurred in 2000, most of them in sub-Saharan Africa and South Asia. The high levels of under-nutrition in children and women in South Asia and sub-Saharan Africa pose a major challenge for child survival and development and because the children have lowered resistance to infection, they are more likely to die from common childhood ailments like diarrhoeal diseases and respiratory infections. Those who survive will fall into a vicious cycle of recurring illness, their growth will falter and learning abilities will diminish.

1.3 Types of malnutrition

Malnutrition consists of both over- and under-nutrition (DoH 2004.4:3, Muller & Krawinkel 2005:279, De Hoop 2005:7). This study was conducted in a primary school and the literature will thus focus on the prevalence rates and consequences of malnutrition in children. In developing countries, deficiencies in iron, iodine, vitamin A and zinc are the main manifestations of malnutrition (Muller & Krawinkel 2005:279). The consequences of malnutrition may include growth stunting, anorexia, susceptibility to infections, behavioural changes and learning disabilities (Klugman 2002:2).

1.3.1 Over-nutrition

Over-nutrition occurs when too many kilojoules / calories or too much of a specific nutrient - protein, fat, or carbohydrate is consumed. Over nutrition presents major nutritional problems, manifesting as obesity and related diseases such as diabetes, atherosclerotic heart disease, hypertension and the metabolic syndrome (DoH 2004.4:3, Mahan & Escott-Stump 2004:409).

1.3.1.1 Obesity

Obesity is a disease of complex and multiple causes leading to an imbalance between energy intake and output and resulting in the accumulation of large amounts of body fat. (Martorell 2001:1). Obesity is measured as excessive weight for a given height, using the body mass index (BMI) which is calculated by dividing weight in kilograms (kg) by height squared metre (m^2). The WHO defines overweight as a BMI between 25.0 and 29.9 kg/m^2 and obesity as a BMI of 30.0 kg/m^2 or greater. Obesity in children under five years of age is defined as a BMI that is greater than two standard deviations above the mean, using the international reference population recommended by the World Health Orgaization (WHO) (Martorell 2001:1).

- Global prevalence

The increasing prevalence of obesity is a significant and alarming public health concern. The National Health and Nutrition Examination Survey (NHANES) conducted in the United States of America (USA) in 1999, reported that eleven percent of children (ages six to eleven) years were overweight, with a BMI greater than the 95^{th} percentile. The documented prevalence figure is two percent more than the prevalence in the 1988 to 1994 NHANES survey (Mahan & Escott-Stump 2004:275-276). In a study conducted by Martorell (2001:1) the prevalence of obesity in children was 2,6 percent in Pakistan, 5,2 percent in Malawi, and 3,1 percent in the United States (Kleinman 1997:19).

Table 1.2 Prevalence of overweight in pre-school children (0-5 years old) from 1995 to 2005 (adapted from UNS/SCN 2004:75).

UN Region and sub-regions	**1995 (%)**	**2000 (%)**	**2005 (%)**
Africa	**3.3**	**4.2**	**5.2**
Eastern Africa	2.7	2.9	3.1
Middle Africa	1.7	2.0	2.5
Northern Africa	7.7	11.7	17.4
Southern Africa	6.5	n/a	n/a
Western Africa	1.6	2.0	2.5
Asia	2.6	2.5	2.5
Eastern Asia	4.0	3.2	2.4
South-Central Asia	1.7	2.0	2.5
South-East Asia	2.2	2.4	2.6
Western Asia	3.6	4.2	3.9
Latin America and Caribbean	**4.4**	**4.3**	**4.3**
Caribbean	3.5	4.1	4.7
Central America	3.3	3.9	4.6
South America	4.9	4.5	4.2
All developing Countries	2.9	3.0	3.4

- Prevalence South Africa

The National Food Consumption Survey (NFCS), conducted in 1999 reported overweight or obesity in 17,1 percent of the sample (children aged one to nine years) at national level. The NFCS found that 7, 7 percent of children aged one to nine years old are overweight in the formal urban areas. The survey reports that 3, 5 percent of adolescent males and 17, 6 percent of adolescent females are overweight, while 2 percent adult males and 5, 9 percent adult females are obese (DoH 2004:3, Labadarios, Steyn, Mgijima, & Daldla. 2005:104).

- Consequences

Studies show that childhood obesity is a cause for concern because it is an important indicator of adult obesity: approximately one third of obese pre-school children, and one half of obese school age children become obese adults. Obesity affects children's health. The risk of developing hyperlipidemia; hypertension and abnormal glucose tolerance is higher among obese children (Martorell 2001:1). Consequences of obesity in childhood include psychosocial difficulties such as discrimination from others, a negative self-image, depression and decreased socialization. Factors contributing to excess energy intake for the paediatric population include the proliferation of eating and food establishments, eating linked to leisure activities, children making more food and eating decisions, larger portion sizes and inactivity (Mahan & Escott-Stump 2004:275-276, Martorell 2001:1).

1.3.1.2 Diseases of lifestyle

People worldwide are consuming more foods that are energy dense, high in sugar and / or saturated fats or excessively salty. Chronic diseases are the major cause of death worldwide (WHO & FAO 2003, Cannon 2001:1). Chronic diseases are non-infectious and tend to persist and worsen. Examples of debilitating chronic diseases include tooth decay, obesity, constipation and other gut disorders. Disabling chronic diseases include adult-onset diabetes, hyperlipidemia, hypertension angina, and osteoporosis, and deadly chronic diseases include stroke, heart disease and cancer (Cannon 2001:1). Evidence shows that many overweight children have one or more cardiovascular risk factors such as hyperlipidemia, hypertension or hyperinsulinemia. Another health consequence of overweight is the rapid increase in the incidence of type 2 diabetes in children and adolescents (Mahan & Escott-Stump 2004:275-276).

- Global prevalence

Non-communicable conditions including cardiovascular diseases (CVD), diabetes, obesity, cancer and respiratory diseases, account for 59 percent of the 57 million

deaths annually and 46 percent of the global burden of disease. Heart attacks and strokes kill about 12 million people every year. An estimated 3.9 million people die from hypertensive and other heart conditions. More that one billion adults are overweight and at least 300 million are clinically obese. Risk factors that cause the majority of the chronic disease burden include: high cholesterol, high blood pressure, obesity, smoking and alcohol. While an optimal diet is critical, daily moderate to intense physical activity is important for good health, helping lower blood pressure, reduce body fat and improve glucose metabolism (WHO & FAO 2003).

- Immediate and root causes of chronic diseases

Malnutrition: Poor nutrition is the immediate cause of a number of chronic diseases, including heart disease and some forms of cancer (Cannon 2001:1, Borra, Kelly, Shirreffs, Neville & Geiger 2003:721). A root cause of poor nutrition is certain types of food technology that transform perishable raw materials into products that are high in fat, sugar and salt. The process of hydrogenation, for example is a root cause of heart disease. When volatile oils are converted into hard stable fats with a long shelf life, hydrogenation increases the percentage of total fats and saturated fats and trans fatty acids in the human food supply (WHO & FAO 2003, Cannon 2001:2).

Tobacco: The use of tobacco is an important immediate cause of heart disease and of cancers of the lungs, mouth, throat, and, oesophagus. The root causes of these diseases are the political, social and industrial settings in which tobacco production is subsidized; cigarettes are sold cheaply, smoking is glamorised, and advertising and promotion to young people is sanctioned (WHO & FAO 2003, Cannon 2001:2).

Inactivity: Physical inactivity increases the risk of various chronic diseases. The root cause of human inactivity includes sedentary jobs, households organised around the television and computer games and the shift from participant to spectator sport. High crime rates (that make cycling and walking dangerous) and cities (that make life difficult without private automobiles) are other contributing factors to physical inactivity (WHO & FAO 2003, Cannon 2001:1).

Displacement: The typical consequences of urbanisation: pollution, sedentary occupations (Borra *et al.* 2003:721, Cannon 2001:2) and the pathogenic transformation of food supplies increase the risk of chronic diseases.

Poverty: Poverty is a root cause of poor diets. People who live at subsistence levels in rural areas, often have no choice but to eat local available food items that result in diets that are poor in nutrients. Poor people in urban areas often subsist on cheap fatty and sugary foods. Poverty and depression are other underlying reasons for smoking and alcohol abuse (Cannon 2001:2).

The following factors have a major impact in reducing the prevalence of chronic disease:

- A change in dietary habits, by eating more fruit and vegetables as well as nuts and whole grains,
- cutting the intake amount of fatty, salty, and sugary foods
- moving from saturated animal fats to unsaturated vegetable oil-based fats
- increasing physical activity
- maintaining normal body weight (within the Body Mass Index (BMI) range of 18,5 to 24,9)
- tobacco control (stop smoking).

Chronic diseases are becoming increasingly prevalent in many of the poorest developing countries, creating a double burden on top of the infectious diseases that continue to afflict these countries (WHO & FAO 2003, Cannon 2001:1).

1.3.2 Under-nutrition

Under-nutrition refers to disorders resulting from inadequate diet or from failure to absorb or assimilate dietary elements (Drake, Maier, Jukes & Patrikios 2002:2). The Food and Agricultural Organisation (FAO) defines under-nutrition as the lack of adequate energy, protein and micronutrients to meet the basic requirements for body

maintenance, growth and development. Nutrition deficiency occurs when the nutrient intake is not balanced with specific requirements for optimal health. Within the safe range of intake, homeostatic mechanisms of the body use nutrients equally effectively, with no detectable advantage being gained by a given level of intake. As nutritional deficiencies develop, adaptations are made to achieve a new steady state without any significant loss in physiologic function. As the intake of nutrients further varies from the accepted range, the organism adapts to the changing supply of nutrients by reducing its function or changing the size or status of the affected body components. An example of this adaptive function can be discerned in the period before iron deficiency anaemia develops: a gradual diminution in iron stores can be diagnosed on the basis of increased iron absorption, decreased serum ferritin levels or bone marrow evaluation. Nutritional deficiency is a result of inadequate ingestion, impaired digestion or absorption, dysfunctional metabolic processing or increased excretion of essential nutrients (WHO & FAO 2003).

Under-nutrition may result from a lack of access to food; (DoH 2003:15, Merck 2003), disorders that interfere with the intake, metabolism or absorption of nutrients or an increased need for kilojoules (calories). The most obvious signs of under-nutrition are loss of body fat (adipose tissue). When not enough kilojoules/calories are consumed, the body breaks down its own tissues and uses them for calories. The loss of fat is often first noticeable in the face; the cheeks are hollow, and the eyes sunken. If the deficiency of kilojoules (calories) is severe children can loose more that half their body weight. Bones protrude, and the skin becomes thin, dry, inelastic, pale and cold. The hair becomes dry and sparse, falling out easily. In children who are severely undernourished, behavioural development may be markedly slow and mental retardation may occur. The number of some types of white blood cells decreases and as a result the immune system is weakened, increasing the risk of infections. Heart and respiratory failure may develop if the deficiency of kilojoules (calories) continues for a long time (Merck 2003).

- Prevalence of under-nutrition in South Africa

Table 1.3 Prevalence of malnutrition in pre-school children in two informal settlements in South Africa (Dannhauser, Bester, Joubert, Badenhorst, Slabber, Badenhorst, Du Toit, Barnard, Botha, Nogabe 2000:303).

Stunted (%)		Underweight (%)		Wasted (%)	
A	B	A	B	A	B
29%	21.5%	19.8%	18.8%	6.5%	3.7%

A - Joe Slovo informal settlement near Bloemfontein South Africa

B – JB Mafora informal settlement near Bloemfontein South Africa

The prevalence of being underweight, stunted and wasted were similar in both areas as indicated in Table 1.3. In a similar study conducted by Faber, Jogessar and Benade (2001:401) in Kwa Zulu-Natal South Africa, results indicated that 50 percent of the subjects (children aged 2-5) had a low vitamin A status, 33 percent had depleted iron stores and 21 percent were stunted. The National Food Consumption Survey (NFCS) reported that the average dietary intake of energy, calcium, iron, zinc, selenium, vitamin A, vitamin D, vitamin C, vitamin E, riboflavin, niacin, and vitamin B6, for children was less than 67 percent and, in some instances, below 50 percent of the RDA. In pre-school children, nutrient deficiencies in iron, vitamin A, iodine, energy, protein, calcium, iron, zinc, and riboflavin were more prevalent (Klugman 2002:2-3).

More than three quarters of all child deaths are caused by neonatal disorders, more than half of these deaths occur because of the increased vulnerability of children who are undernourished and underweight. Children born to undernourished mothers are likely to be underweight at birth. Under nourishment may result in impaired growth and development, lowered resistance to infection, poor wound healing and poor clinical outcome with increased morbidity and mortality (Mahan & Escott-Stump

2004:409, Black, Hess & Papas 2005:2, FAO 2004a). The "Barker Hypothesis" suggests that low birth weight and stunting in early childhood heightens the risk of developing diabetes, heart disease and other diseases of lifestyle commonly associated with too much food and too little physical activity in adulthood (FAO 2004a).

1.3.2.1 Stunting

Stunting is defined by the WHO as "low height-for-age, or height for age more than 2 standard deviations (SD) below the median value of the reference (healthy) population" (Reinhard & Wijayaratne: 2000:10). According to WHO (1995:417) "height-for-age reflects achieved linear growth and its deficits indicate long-term, cumulative inadequacies of health or nutrition". Two related terms namely, "length" and "stature" are also used. Length refers to measurement in a recumbent position and is often used for children under two to three years of age, who cannot stand. Standing height measurement, often referred to as stature, is measured against a wall that does not have a baseboard, a right angle head board should rest on the highest part of the head. Bare feet should be placed with the heels together and in contact with the wall. The buttocks should also be in contact with the wall and the head adjusted so that the child looks straight ahead. "Shortness" is the descriptive definition of low height-for-age. "Stunting" is a frequently used term implying that shortness is pathological. It reflects a process of failure to reach linear growth potential as a result of sub-optimal health and/or nutritional conditions. A child indicated at -2SD on the reference median for height-for-age is considered stunted (Katzenellenbogen, Joubert & Karim 1999:244, Margetts & Nelson 2000:299).

- Prevalence of stunting in South Africa

The NFCS conducted in 1999 showed that 21, 6 percent of children between the ages of 1 and 9 years are stunted. The main problem is a diet low in energy, poor in protein quality and deficient in micronutrients. Every second child was found to have an intake of less than half the recommended level of energy, vitamin A and C, iron,

zinc and calcium (DoH 2000:3).

- Global prevalence

An estimated 33 percent of pre-school children under the age of five, in the developing world, are stunted. Eastern Africa shows the highest levels of stunting, with an average of 48 percent. In South Central Asia stunting is widespread and the estimated prevalence for the region is 44 percent (Pinstrup-Andersen & Babinard 2001:11; ACC/SCN 2000:2).

- Consequences of stunting

Stunting is an indicator for long-term nutritional deprivation (Reinhard & Wijayaratne 2000:10). Stunting (low height-for-age) is a physical indicator of chronic or long-term malnutrition and is often linked to poor mental development. Stunting is a cumulative process of poor growth that primarily occurs before the age of three years and is not easily reversed. Children, stunted at school age are likely to have been exposed to poor nutrition since early childhood and the degree of stunting tends to increase throughout the school age. Severe stunting in the first two years of life is strongly associated with lower test scores in school age children (age 8-11). Lower test scores are related to later enrolment, increased absenteeism and repetition of school years among stunted children (Drake *et al.* 2002:1-3, Vorster & Venter 1992:95).

In the fifth report on the world nutrition situation (UNS/SCN 2004:78) the following prevalence of wasting, stunting and underweight in pre-school children (0-5 years) was indicated:

Table 1.4 Prevalence of wasted, stunted and underweight pre-school children (0-5 years) (adapted from UNS/SCN 2004:76-79).

Country	Wasting (%)	Stunting (%)	Underweight (%)
South Africa	2.5	22.8	9.2
China	2.2	14.2	10.0
India	15.7	44.9	46.7
Japan	0.8	5.6	3.7
Mexico	2.0	17.7	7.5
Netherlands	0.7	0.8	0.7
Philippines	6.5	32.1	31.8
Qatar	1.5	8.1	5.5
Turkey	1.9	16.0	8.3
USA	0.7	2.0	1.4
Yugoslavia	3.7	5.1	1.9

1.3.2.2 Wasting

Wasting is defined by the WHO as low weight for height, a weight for height ratio that is more than 2 standard deviations below the median value for BMI-for-age and of the reference (healthy) population (Reinhard & Wijajaratne 2000:10, Margetts & Nelson 2000:299, Katzenellenbogen *et al.* 1999:244). Wasting is an indicator of acute malnutrition (Reinhard & Wijayaratne 2000:10). BMI-for-age reflects short-term deficits that can indicate a recent, severe shortage of food and nutritional adequacy. BMI-for-age reflects body weight relative to height and is calculated as (kg)/height (m^2) square (Flegal, Wei & Ogden 2002:761). It is important to note that BMI-for-age does not serve as a substitute for height-for-age or weight-for-age, since each index reflects a different combination of biological processes. Although common determinants are shared, they cannot be used interchangeably. The term "wasting", is widely used to describe a recent and severe process that has led to significant weight loss, usually as a consequence of acute starvation and/or severe

disease. "Overweight" is the preferred term for describing high BMI-for-age. Even though there is a strong correlation between high BMI-for-age and obesity as measured by adiposity, greater lean body mass can also contribute to BMI-for-age. On an individual basis, therefore, "fatness" or "obesity" should not be used to describe high BMI-for-age (WHO 1995:419).

- Prevalence

Two main types of malnutrition have been identified in Nigerian children: micronutrient malnutrition and protein-energy malnutrition. In the UNICEF survey conducted in 1992, the results indicated that the prevalence of wasting was 10.1 percent, stunting 52.3 percent and underweight 28.8 percent. Data from the Nigeria Demographic and Health Survey (NDHS) conducted in 1999 indicated that the prevalence of wasting has increased, while underweight and stunting have decreased compared with the 1990 NDHS. The major forms of micronutrient malnutrition constituting a public health problem in Nigeria include: iron deficiency, iodine deficiency and vitamin A deficiency disorders (Adelekan 2001:83-84).

1.3.2.3 Underweight

Underweight is defined by the WHO as low weight for age, weight for age more than 2 standard deviations (SD) below the median value of the reference (healthy) population (WHO 1995: 419, Reinhard & Wijayaratne 2000:10). Underweight can be indicated by low weight-for-age where the weight is indicated as <-2SD of the sex-specific reference data relative to age. A child could have a low weight-for-age if it is stunted, wasted or both (Katzenellenbogen *et al.* 1999:244, WHO 1995:419).

According to the WHO (1995:419), weight-for-age is still the most common measurement used to indicate the nutritional status of a child, it indicates a complete picture as it includes short term consequences as well as long term or chronic problems that can cause weight loss. Weight-for-age reflects body mass relative to chronological age. It is influenced by both the height of the child (height-for-age)

and his or her weight (weight-for-height); and its composite nature makes interpretation complex.

Underweight is commonly used for national and regional statistics (Reinhard & Wijayaratne 2000:10). Underweight (low weight-for-age) is an indicator of both chronic and acute under-nutrition. Underweight among school age children can be the result of prenatal under-nutrition, deficiencies of macro- and micro nutrients, infection and possibly, inadequate attention by caregivers (Drake *et al.* 2002:1-3, Vorster & Venter 1992:95). The proper descriptive term for high weight-for-age would be "heaviness". Because few children have high weight-for-age as a result of tallness, high weight-for-age often reflects overweight (WHO 1995:419).

- Prevalence of underweight

In 2000 an estimated 27 percent of pre-school children in developing countries were underweight (<-2 SD weight-for-age). South Central Asia was the worst affected region, with an average of 44 percent. In Western Africa 37 percent and Eastern Africa 36 percent of children were underweight (ACC/SCN 2000:2).

Table 1.5 Estimates of prevalence of underweight in children in 1990 and 2015 (adapted from de Onis, Blossner, Borghi, Frongillo and Morris 2004:2603)

Region	Prevalence (95% CI), %		Relative change (95% CI), %
	1990	2015	
Africa (entire region)	24.0 (23.5-24.5)	26.8 (26.1-27.5)	11.6 (7.9 to15.6)
Northern	9.5 (7.9-11.3)	4.2 (2.0-8.5)	-55.6 (-78.3 to -8.9)
Sub Saharan	26.8 (23.9-29.6)	29.2(26.5-32.5)	9.2 (-6.5 to 27.5)
Eastern	26.7 (22.0-32.0)	33.3 (27.6-39.6)	25.0 (-3.1 to 61.2)
Middle	27.8 (19.8-37.5)	23.6 (17.7-30.8)	-14.9 (-43.8 to 28.7)
Southern	14.0 (9.9-19.5)	13.3 (9.3-18.6)	-5.2 (-41.0 to 52.4)
Western	27.8 (23.6-32.4)	26.2(21.2-31.9)	-5.8 (-26.8 to 21.2)
Asia (entire region)	35.1 (31.7-38.5)	18.5 (14.6-22.4)	-47.2 (-58.1 to- 33.5)
Eastern	18.5 (17.6-19.4)	3.0 (2.8-3.3)	-83.6 (-84.9 to - 82.2)
South Central	49.6 942.4-56.8)	28.7 (22.0-36.5)	-42.2 (-56.8 to – 22.8)
South Eastern	35.2 930.8-40.0)	17.9 (13.8-22.9)	-49.1 (-61.6 to -32.5)
Western	12.9 (9.9-16.7)	9.2 (1.4-41.4)	-28.5 (-87.7 to 315.3)
Latin America (entire region)	8.7 (6.1-11.3)	3.4 (2.0-4.8)	-60.8 (-76.5 to 34.7)
Caribbean	10.0 (5.9-16.4)	2.8 (1.3-5.8)	-72.2 (-88.5 to -32.6)
Central	12.4 (7.5-19.9)	5.8 (2.9-11.3)	-53.5 (-79.7 to 6.7)
South	7.0 (4.5-10.8)	2.4 (11.4-4.2)	-65.0(-82.5 to -30.0)
Developing countries **	1.6 (0.8-3.0)	0.9 (0.2-4.3)	-41.0 (-92.1 to 342.8)
Entire world	26.5 (24.5-28.6	17.6 (15.4-19.8)	-33.7 (-42.8 to -23.1)

**Europe, Australia, Japan, Canada, and USA

1.3.2.4 Protein energy malnutrition

Protein energy malnutrition (PEM) is a deficiency syndrome caused by the inadequate intake of macronutrients, and results in weight loss and in severe forms of growth retardation (DoH 2004:1, Merck 2004:1, Kinabo & Msuya 2002:65). Clinically PEM has three forms: dry (thin, desiccated), wet (oedematous, swollen), and a combined form between the two extremes. The form of PEM depends on the balance of non protein and protein sources of energy. Each of the three forms can be graded as mild, moderate, or severe. Grade is determined by calculating weight as a percentage of expected weight for length using international standards (normal PEM, 90 to 110 percent; mild PEM, 85 to 90 percent; moderate PEM, 75 to 85 percent and severe PEM, less than 75 percent). The most severe clinical manifestations are kwashiorkor and marasmus (Merck 2004:1, Kinabo & Msuya 2002:65).

- Marasmus, the dry form of PEM, results from near starvation with deficiency of protein and non-protein nutrients. The marasmic child consumes very little food and is very thin from loss of muscle and body fat. Marasmus is the predominant form of PEM in most developing countries. Marasmic infants have hunger, gross weight loss, growth retardation, and wasting of body fat and muscle.
- Kwashiorkor, the wet form of PEM (an African word meaning "first child-second child") refers to the observation that the first child develops PEM when the second child is born and replaces the first child at the mother's breast. Food that is fed to the weaned child is of a poor nutritional quality, when compared with breast milk, and the child fails to thrive. The protein deficiency is usually more marked than the energy deficiency, and results in oedema; dermatitis; thinning, decolouration and reddening of the hair; enlarged fatty liver and retarded growth. Children with kwashiorkor tend to be older than those with marasmus and tend to develop the disease after they have been weaned. The combined form of PEM is called marasmic kwashiorkor. Children, with this form of PEM have some oedema and more body fat than those with marasmus (Merck 2004:1-2).

- Prevalence

PEM in young children is currently the most severe nutritional disorder in Asia, Africa and Latin America (DoH 2004:1). Studies conducted in Tanzania have shown that protein energy malnutrition exists among school age children. Children in the ten year age group appear to have been more adversely affected than children in other age groups and boys were more affected than girls. (Kinabo & Msuya 2002:64). The National Burden of Disease Study (NBD) conducted in 2000 reported that protein energy malnutrition was the cause of 30 percent of childhood deaths occurring in South Africa (Bradshaw, Bourne & Nannan 2003:3).

1.4 Micronutrient deficiencies.

Micronutrient deficiency is called "silent / hidden" malnutrition because it is not easily visible until the deficiency is severe (DoH 2003:11). The FAO (2004a:15) found that protein-energy malnutrition, vitamin A deficiency, iodine deficiency disorders (IDD) and nutritional anaemia mainly resulting from iron deficiency losses, are the most common serious nutritional problems in almost all countries of Asia, Africa, Latin America and the Near East. The major cause of micronutrient deficiencies is the lack of an adequate intake of bio-available minerals and vitamins from staple diets (Venkatesh Mannar & Sankar 2004:997). Nutritional anaemia, particularly deficiencies of iron, iodine and vitamin A is a major problem for school age children in low income countries. These deficiencies can negatively impact on growth, increase susceptibility to infection and also impair the mental development and learning ability of school children (FAO 2004a:15; Drake *et al.* 2002:4; Venkatesh Mannar & Sankar 2004:997).

1.4.1 Iron deficiency and anaemia

Iron deficiency anaemia is characterised by the production of small erythrocrates and a diminished level of circulating hemoglobin (Mahan & Escott-Stump 2004:839). Iron deficiency (ID) is the most common nutritional disorder in the world and is

estimated to affect more than 2 billion people, of whom 1.2 billion suffer from iron deficiency anaemia (IDA). It is estimated that 53 percent or 210 million school-age children suffer from IDA. The highest prevalence is reported in Asia (58.5 percent) followed by Africa (49.8 percent). In a survey of nearly 14,000 rural school children in Africa and Asia, the prevalence of IDA was more than 40 percent (Drake *et al.* 2002:4). In Nigeria, the prevalence of IDA is estimated at 20-25 percent in children and is worst in the south-west areas of the country, factors that contribute to this include the consumption of cereal based diets which are low in bio available iron (Adelekan 2001:86).

1.4.1.1 Implications of iron deficiency and anaemia on children's health

Iron deficiency anaemia can affect learning and studies revealed that children and adolescents with anaemia have problems with short-term memory (Mahan & Escott-Stump 2004:291). Impaired cognitive development and lower school performance of children due to IDA will lower adult productivity and earnings by 500 million United States dollars annually (Bowley 2005:24). Iron deficiency and anaemia affect more than 3, 5 billion people in the developing world. Anaemia during infancy, exacerbated by maternal under-nutrition, impairs cognitive development, reduces productivity and causes educational losses and also increases morbidity and maternal mortality (Pinstrup-Andersen & Babinard 2001:11, ACC/SCN 2000:2).

1.4.2 Iodine deficiency and iodine deficiency disorders

Iodine deficiency affects an estimated 60 million school children worldwide. Recent studies of IDD in school age children, carried out in Egypt, Swaziland and South Africa, have found prevalence rates from 35 percent to 70 percent; this indicates a severe health problem (Drake *et al.* 2002:5). In Nigeria, an estimated 4 million children are at risk of IDD (Adelekan 2001:86).

1.4.2.1 Implication of iodine deficiency and iodine deficiency disorders on children's health

In school children iodine deficiency is associated with poor cognition and is the most common preventable cause of mental retardation in the world (Mahan & Escott-Stump 2004:151).

1.4.3 Vitamin A deficiency

Definition: Primary deficiencies of vitamin A result from inadequate intakes of preformed vitamin A or provitamin A carotenoids. Secondary deficiencies can result from mal-absorption caused by insufficient fat, biliary or pancreatic insufficiency, also by impaired transport from abetalipoproteinemia, liver disease, protein energy malnutrition, or zinc deficiency (Mahan & Escott-Stump, 2004:81).

1.4.3.1 Implications of vitamin A deficiency on children's health

It is estimated that 85 million school age children are at risk of acute respiratory and other infections because they are deficient in vitamin A (Drake *et al.* 2002:6). Vitamin A deficiency is the most significant cause of blindness in the developing world. An estimated 250 million children are at risk. Between 250 000 and 500 000 cases of blindness from vitamin A deficiency occurs annually. In 1991 an estimated 14 million pre-school children, mostly from South Asia had clinical eye disease (xerophtalmia) caused by vitamin A deficiency (Mahan & Escott-Stump 2004:81). Nigeria is listed by the WHO as one of the countries with the highest risk of vitamin A deficiency, with an estimated 7 million pre-school children suffering from vitamin A deficiency (Adelekan 2001:86). Vitamin A deficiency increases the risk of death from diarrhoea, measles and malaria by 20 to 24 percent (FAO 2005:18). Although severe vitamin A deficiency, which causes blindness is declining, sub-clinical deficiency still affects up to 250 million pre-school children, school-age children, and pregnant women. Sub-clinical vitamin A deficiency contributes significantly to raised morbidity and mortality in populations that are at risk (ACC/SCN 2000:2).

1.4.4 Zinc deficiency

Symptoms of zinc deficiency include hypogeusia (decreased taste acuity), delayed wound healing, alopecia and diverse forms of skin lesions. Acquired zinc deficiency may occur as the result of mal-absorption, starvation or increased losses via urinary, pancreatic or other exocrine secretions. Acrodermatitis enteropathica, an outosomal recessive disease characterised by zinc mal-absorption, results in eczematoid skin lesions, alopecia, diarrhoea, bacterial and yeast infections and if left untreated can result in death. Zinc deficiency results in various immunologic defects. Severe deficiency is accompanied by thymic atrophy, lymphopenia, reduced lymphocyte proliferative respons to mitogens (a selective decrease in T4-helper cells), decreased cell activity and energy, and deficient thymic hormone activity (Mahan & Escott-Stump 2004:146).

1.4.4.1 Implications of zinc deficiency on children's health

Zinc is essential for growth; a deficiency results in growth failure, poor appetite, decreased taste acuity and poor wound healing (FAO 2005:18, Mahan & Escott-Stump 2004:267). For children whose diets lack zinc, the risk of dying from diarrhoea, pneumonia and malaria increases from 13 to 21 percent (FAO 2005:18).

The empirical research of this study was conducted at a Primary school for children aged six to thirteen years and for this reason the remainder of the literature in this chapter will focus on primary school children.

1.5 Malnutrition in primary school children globally

Evidence has shown that malnutrition has negative consequences for a child's long term overall development. Malnourished children have lowered resistance to infection; they are more likely to die from common childhood ailments like diarrhoea and respiratory infections. Three quarters of the children who died from causes related to malnutrition were only mildly or moderately undernourished. Poverty, low

levels of education and poor access to health services are major contributors to childhood malnutrition. Half of South Asia's children are malnourished. In Africa one in every three children is underweight and in several African countries the nutritional status of children is worsening. Malnourished children are much more likely to die as a result of a common childhood disease than those who are adequately nourished. Among children, malnutrition is especially prone to strike those who lack nutritionally adequate diets, who are not protected from illness and do not receive adequate care. Illness is frequently a consequence of malnutrition and malnutrition is also commonly the result of illness. Malnutrition is implicated in more than half of all child deaths worldwide (UNICEF 1998:7).

1.5.1 Malnutrition in primary school children in South Africa

South African (SA) studies have indicated that 14-19 percent of school children had nothing to eat before they went to school. White children, who had breakfast, mainly had cereals for breakfast, while black children most frequently consumed tea and coffee. In South Africa, where a high rate of stunting has been identified, it is important that children should have adequate energy and protein intake (Kruger, Dhansay, Labadarios, Kotiah & Kullman 2002:15).

The 1999 NFCS indicated that one out of five children (21.6 percent), aged one to nine years old in SA, are stunted at national level and 50 percent of the children had an energy intake less than two-thirds of their energy needs. Gauteng showed a prevalence of 20 percent. Nationally the prevalence of stunting decreased with age: from 25.5 percent in children aged one to three years, to 21 percent in those aged four to six years, to 13 percent in those aged seven to nine years old. A similar pattern emerged for the prevalence of underweight whilst the prevalence of wasting remained constant in all age groups at less than 4. In South Africa the mean intakes of calcium, iron, zinc, vitamins A, D, E, C, B6, riboflavin and niacin were very low compared with the dietary reference intakes (DRI). The five most commonly consumed foods nationally are: maize, sugar, tea, whole milk and brown bread (van Heerden & Schönfeldt 2004:533, VIC 2001:3).

Table 1.6 Mean nutrient intakes of children seven to nine years in Gauteng and SA (Labadarios *et al.* 1999:251).

Nutrient	RDA	Gauteng	SA
Vit E	7IU	4.1	5.1
Vit C	45mg	31	48
Phosphorus	500mg	604	678
Calcium	800mg	282	315
Zinc	10mg	5.1	5.8
Iron	10mg	5.8	6.9

1.6 Impact of malnutrition on children's education

At its most basic level, malnutrition is a consequence of disease and inadequate dietary intake. Malnourished children have lifetime disabilities, weakened immune systems and lack the capacity for learning. In young children, malnutrition dulls motivation and curiosity and reduces play and exploratory activities. These effects impair the mental and cognitive development, by reducing the amount of interaction children have with their environment and with those who provide care. Many children suffer from multiple types of malnutrition, and it is estimated that globally 226 million children are stunted. Stunting is associated with long-term reduction in dietary intake and poor quality diets. It is estimated that some 67 million children are wasted; the result of reduced dietary intake and illness and about 183 million children weigh less than they should for their age. In infancy and early childhood, iron deficiency anaemia can delay psychomotor development and impair cognitive development, lowering the intelligence quotient (IQ) by about nine points. Anaemic pre-scholars have been found to have difficulty in maintaining attention and discriminating between visual stimuli. Poor school achievement among primary school children has also been linked to iron deficiency. Malnourished children who live past childhood face diminished futures. They will become adults with lower physical and intellectual abilities, lower levels of productivity and higher levels of chronic illness and disability (UNICEF 1998:7). In one of the largest

anthropometrical studies of rural school children in low income countries (Ghana, Tanzania, Indonesia, Vietnam and India) it was found that the overall prevalence of stunting and underweight was high in all five countries, ranging from 48 to 56 percent for stunting and 34 to 62 percent for under weight. The boys in most of these countries were more stunted than the girls and in all countries boys were more underweight than girls (Drake *et al.* 2002:2).

Studies on the effect of under-nutrition on cognitive ability indicate that chronic under-nutrition is associated with lower achievement levels in school children. Malnutrition can take a variety of forms that often appear in combination and contribute to each other, such as protein-energy malnutrition, iodine deficiency disorders and deficiencies of iron and vitamin A (Drake *et al.* 2002:22, UNICEF 1998:7).

1.7 Methods of addressing malnutrition amongst children

Micronutrient deficiencies are a significant cause of malnutrition and are associated with ill health in the developing world. Solutions to control and prevent these deficiencies are available and affordable. Micronutrient malnutrition can be addressed by implementing programmes designed to educate people to diversify their diets or by providing nutrient supplements to vulnerable groups (in the form of tablets, capsules and syrup) through targeted distribution programmes (supplementation). Commonly eaten foods can be fortified with missing micronutrients (food fortification) (Venkatesh Mannar & Sankar 2004:997). According to Darnton-Hill (1998:91) the three main approaches used world-wide to address malnutrition deficiencies are supplementation, food fortification, and food diversification. One of the main focus areas of the Integrated Nutrition Programme (INP) in South Africa is micronutrient control. The INP has implemented the same strategies as mentioned by Darnton-Hill namely supplementation, food fortification, promotion of dietary diversification and related public health measurements, in order to address micronutrient deficiencies (Labadarios *et al.* 2005: 106).

1.7.1 Micronutrient supplementation

Micronutrient supplementation is the provision of micronutrients to increase a person's micronutrient intake in order to prevent, reduce or control a deficiency (DoH 2003:12, Bowley 2003a:2). Supplementation refers to the periodic administration of pharmacological preparations of nutrients as tablets, capsules, soft gels, gel caps, liquids and powders or by injection (FAO & WHO 2002:5). The term dietary supplement in the United States of America is defined in the Dietary Supplement Health and Education Act (DSHEA) of (1994:1) as a product taken by mouth that contains a dietary ingredient intended to supplement the diet. The dietary ingredients in these products may include: vitamins, minerals, herbs or other botanicals, amino acids, and substances such as enzymes, organ tissues, glandular, and metabolites. In order for an ingredient of a dietary supplement to be considered a dietary ingredient it must be one or a combination of the following substances; a vitamin, mineral, a herb or other botanical product, an amino acid, a dietary substance for human consumption to supplement the diet by increasing the total dietary intake (e.g. enzymes or tissues from organs or glands) or a concentrate, metabolite, constituent or extract. DSHEA places dietary supplements in a special category under the umbrella of food and not drugs and requires that every supplement be labelled a dietary supplement.

Nutritional supplementation should be restricted to vulnerable groups, which cannot meet their nutrient needs through food i.e. low-income socio economic groups. According to The United States Agency for International Development (USAID) supplements for the prevention of deficiencies are usually given on a time limited basis, during immunisation days and family planning contacts. Supplementation is rapidly becoming part of treatment plans for measles and pneumonia and is cost-effective for reaching isolated areas with a high prevalence of deficiencies. Vitamin A, iron and iodine are available in concentrated or synthetic form at a relatively low cost and can be administered either orally or by injection (USAID 1993:8). Vitamin A supplementation is a low cost reliable and effective way to combat vitamin A deficiency (VAD) and can be rapidly implemented as a programme strategy on a national scale. It should not necessarily be regarded as a short-term measure, as most

of the supplementation programmes implemented globally have a minimum life span of five to ten years. In many developing countries supplementation programmes have been running for decades. Supplementation can be integrated with existing programmes for example, with both routine and campaign-based immunisation programmes (VAGI 1997:3-6).

In developing countries, a priority intervention is the iron supplement distribution for women of reproductive age (USAID 1993:23). UNICEF supports the micronutrient supplementation, in the form of iron-folic acid and Vitamin A, during routine immunisation and acceleration campaigns, as well as through Maternal and Child Health (MCH) centres and Traditional Birth Attendants (TBA). An estimated one million children between the ages of six months and five years received two capsules of vitamin A in 2004 (UNICEF 2005). Although many iron supplementation trials have been proven to be effective in carefully controlled circumstances, few have proven to be effective when broadly applied. Low compliance and lack of adequate supply systems have been suggested as reasons for this limited success (Davidsson & Stoltzfus, 2000:13).

In South Africa, the vitamin A supplementation programme was implemented in September 2002, with the aim of diminishing vitamin A deficiency among the most vulnerable groups in the population through the distribution of vitamin A capsules (DoH 2004:12, Labadarios *et al.* 2005:106).

1.7.1.1 Advantages of supplementation

Some food supplementation schemes have been associated with higher birth weight, improved growth, decreased morbidity and improved cognitive development among infants and pre-school children (Pinstrup-Andersen 1991:5). Iron supplementation is recognised as the only option to control or prevent iron deficiency anaemia in pregnant women (FAO & WHO 2002:7).

1.7.1.2 Disadvantages of supplementation

One of the major deficiencies of food supplementation programmes is that they treat the symptoms of malnutrition, not the causes. These programmes are only effective as long as they are funded, however they do not lead to conditions in which they are no longer needed. The benefits of food supplementation programmes are limited; a reason for this is that the amount of food made available is small and after leakage to other household members only 10-25 percent reaches the target individuals (Pinstrup-Andersen 1991:5).

1.7.2 Food fortification

Food fortification is the addition of one or more essential nutrients to a food whether or not it is normally contained in the food. The aim of food fortification is to improve the quality of food for the consumers, with the purpose of preventing, reducing or controlling a deficiency of one or more nutrients (DoH 2003:12, Bowley 2003b:2).

Micronutrient interventions, and in particular fortification, have been identified by the World Bank as among the most cost effective off all health interventions Venkatesh Mannar and Sankar 2004:2). According to the FAO & WHO (2002:14), fortification refers to the addition of nutrients to a commonly eaten food to maintain or improve the quality of the diet. A single nutrient or group of micronutrients can be added to the food vehicle. Iron fortification of wheat flour and iodine fortification of salt are examples of fortification strategies with excellent results. There are a few essential conditions that must be met in any fortification programme. The fortification should be effective, bio-available, acceptable and affordable. The selected food vehicle should be easily accessible and a specified amount of it should be regularly consumed in the local diet. Detailed production instructions and monitoring procedures should be in place and enforced by law.

The food fortification concept was developed during the early part of the 20th century as a means of addressing micronutrient deficiencies that were prevalent in Europe and North America at the time. More than 80 years of experience in various

developed and developing countries indicate that fortification of commonly consumed foods offers an opportunity to reduce or even eliminate the prevalence of these deficiencies safely and cost-effectively (Labadarios, Steyn, Maunder, Macintyre, Swart, Gericke, Huskisson, Dannhauser, Vorster & Nesamvuni. 2000:883). Weighley, Mueller and Robinson (1997:29) describe fortification as the addition of nutrients at levels higher than those found or not present altogether in the original food. Fortification is the process of adding vitamins and or minerals to food in microgram or milligram quantities to increase the overall nutritional content (Venkatesh Mannar 1999:24). Examples of food that can be fortified include: flour, sugar, salt, margarine, cooking oil and sauces (Venkatesh Mannar & Sankar 2004:2). The Global Alliance for Improved Nutrition (GAIN) was established in 2003 as an alliance of donors, non governmental organisations (NGO), United Nation agencies, private sector companies, research institutions and civil societies. The purpose of GAIN is to reduce micronutrient deficiencies in developing countries through the implementation of national food fortification programmes. National fortification programmes have been established in 14 countries and are projected to deliver fortified food to 450 million people over three years. These programmes focus on providing iron, vitamin A and micronutrients to deficient populations by means of suitable food vehicles, with the emphasis on fortification of staple foods (Bowley 2005:19).

1.7.2.1 Fortification in South Africa

In South Africa, the Directorate Nutrition within the Department of Health (DoH) initiated mandatory food fortification by establishing a food fortification task group (FFTG). UNICEF supported the government in the implementation of food fortification regulations during 2004. This translates into regulation by government on compulsory fortification of maize flour and wheat flour with 2 minerals and 6 vitamins that have been identified to be the most deficient in the South African diet. Maize and wheat flour are currently fortified, and 200g of raw maize/wheaten flour will provide a person of ten years and older with the following: vitamin A (31 percent), thiamine (25 percent), niacin (25 percent), pyridoxine (25 percent), foliate

(50 percent), riboflavin (17 percent from maize and 20 percent from wheat flour), iron (25 percent from unsifted maize meal and 50 percent from maize meal) and zinc (20 percent). This is approximately 25 percent of the recommended daily allowance (RDA) for persons aged ten years and older. This process has been a key milestone in addressing nutritional needs of all South Africans (DoH 2004:11, Labadarios *et al.* 2005:106, Klugman 2002, de Hoop and Matji 2002:13).

Each country has its own government body that is charged with setting food regulations. The control of micronutrient deficiencies, particularly vitamin A deficiency, iodine deficiency disorders and iron deficiency is one of the focus areas of the INP of the DoH in South Africa. The DoH (SA) aims to control micronutrient deficiencies through a combination of multi-pronged strategies, of which food fortification is a cost-effective medium to long-term intervention (De Hoop 2000:1).

According to the NFCS conducted in 1999 more than eighty years of experience in developed and developing countries indicates that fortification of commonly consumed foods offers an opportunity to substantially reduce, or even eliminate the prevalence of vitamin and mineral deficiencies safely and cost effectively. The food fortification concept was developed in the early part of the century as a means of addressing mineral and vitamin deficiency diseases at the time prevalent in Europe and North America. To improve the nutritional status of populations, food fortification is only one of the many strategies necessary; however, teaching the population to eat correctly and increase their consumption of fruit and vegetables, is accepted as being the best long-term solution to micronutrient deficiencies and malnutrition in general. Food fortification is not only for the benefit of populations with a poor dietary intake, but also for the general population (Labadarios *et al.* 2000:913).

Table 1.7 indicates different African countries and the food product to which specific vitamins and minerals are added. South African wheat and maize fortification is indicated in red.

Table 1.7 National food fortification programmes in Africa (status September 2005) (Adapted from Bowley 2005:24 Darnton-Hill & Nalubola 2002:233)

Country	Programme *		**Vitamins and Minerals added**
Ghana	Wheat	V	A, B1, B2, B6, B12, folic acid, niacin, iron, zinc
	Edible oils	V	A
Guinea	Wheat	V	B1, B2, folic acid, niacin, iron
Lesotho	Wheat	V	A, B1, B2, B6, folic acid, niacin, iron, zinc
	Maize	V	A, B1, B2, B6, folic acid, niacin, iron, zinc
Malawi	Maize	V	A, B1, B2, B6, B12, folic acid, niacin, iron, zinc
	Sugar	V	A
Mali	Cottonseed oil	V	A
Morocco	Wheat	M	B1, B2, folic acid, niacin, iron
	Edible oils	V	A, D
Namibia	Maize	V	A, B1, B2, B6, folic acid, niacin, iron, zinc
Nigeria	Wheat	M	A, B1, B2, niacin, iron
	Maize	M	A
	Edible oils	M	A
	Sugar	M	A
South Africa	Wheat	M	A, B1, B2, B6, folic acid, niacin, iron, zinc
	Maize	M	A, B1, B2, B6, folic acid, niacin, iron, zinc
Sudan	Wheat	V	Folic acid, iron
Uganda	Maize	V	A, B1, B2, B6, folic acid, niacin, iron, zinc
Zambia	Wheat	V	B1, B2, niacin
	Maize	V	A, B1, B2, B6, folic acid, niacin, iron, zinc
	Sugar	M	A

* (M) = mandatory; (V) = voluntary

1.7.2.2 Requirements for a fortified food:

- Commonly consumed by the target population
- Constant consumption pattern with a low risk of excess consumption
- Good stability during storage
- Relatively low in cost
- Centrally processed with minimal stratification of the fortificant
- No interactions between the fortificant and the carrier food
- Contained in most meals, with the availability unrelated to socio-economic status
- Linked to energy intake (Bowley 2003a:2, FAO 1996:19).

1.7.2.3 Advantages of food fortification

The unique feature of food fortification as a health intervention is the fact that it is delivered outside the traditional health sector, directly to the consumer, through the food industry itself (Bowley 2005:20). Fortification of common foods with vitamins and minerals is one of the most sustainable strategies to deliver key micronutrients to large populations and can reduce micronutrient malnutrition (Venkatesh Mannar & Sankar 2004:997, UNICEF 2004). The exceptional cost effectiveness of food fortification, has been noted in reports by the World Bank, the Copenhagen Consensus Panel, the UN Millennium Project and the Commission for Africa (Venkatesh Mannar & Sankar 2004:997, UNICEF 2005, Van Ameringen 2005:20). Food fortification cannot reach all populations deficient in essential micronutrients due to limited access to commercially or centrally processed foods. This can be a result of geography, poverty or cultural preference, public health and welfare approaches to deliver supplements or dietary education. For the large and expanding population that regularly purchases and consume commercially processed foods, fortification can make a difference (MI 1999:7). At the population level, food fortification is the best option, when a suitable food vehicle can be identified (Davidsson & Stoltzfus 2000:13). Food fortification has been an effective nutrition intervention used for over eight decades in industrialised countries and has proven its effectiveness in

eliminating micronutrient deficiencies. Almost 25 percent of iron intakes in the US diet come from fortified sources, especially flour products. Food fortification is regarded as one of the safest ways to deliver necessary amounts of micronutrients to the majority of the population in an effective and safe manner (Venkatesh Mannar & Sankar 2004:1000).

Table 1.8 Food fortification: dosage and annual cost per person in the USA

Nutrient	Recommended daily allowance (RDA)	Annual cost per person (US$) 100% RDA
A	1000 mcg RE	0.253
D	400IU	0.051
E	10 mg TE	0.285
B^1	1.5 mg	0.032
B^2	1.7 mg	0.053
B6	2 mg	0.064
C	60 mg	0.558
Niacin	19 mg	0.067
Folate	200mcg	0.016
B^{12}	3 mcg	0.053
Iron	15 mg	0.04
TOTAL		1.47

1.7.2.4 Disadvantages of food fortification

Technical problems, such as installation and maintenance of new machinery and the stability of added micronutrient fortificants in the food, are factors that can constrain the development of successful fortification programmes. The major problems associated with food fortification include the identification of suitable vehicles that is made difficult by the absence of reliable information on the dietary habits of the target population. Other problems include the selection of an appropriate fortification compound, the determination of technologies to be used in the fortification process,

and the implementation of appropriate monitoring mechanisms to determine whether the goals of the programme are being met (FAO 1996:19).

1.7.3 Restoration (enrichment) of food

Restoration is a general term for the replacement of nutrients, lost during food processing, to levels similar to the original levels. (Bowley 2003a:2, FAO & WHO 2002:14, Weighley *et al.* 1997:28-29). For example when "whole wheat" flour is processed to "white" flour, nutrients are unintentionally removed and important nutrients are lost unless they are replaced. Enrichment is the addition of nutrients to achieve concentrations as specified by the standards of identity. An example is when vitamins and minerals are returned to some processed grain products (Weighley *et al.* 1997:28-29). Reasons for adding nutrients to food are: to restore losses due to processing, storage and handling, as a public health measure to correct a recognised dietary deficiency and to improve overall nutritional quality of food (Bowley 2003a: 2).

1.7.4 Food diversification

Food diversification aims to increase dietary availability, regular access and consumption of vitamin and mineral rich foods in at-risk micronutrient deficient groups, and involves the changes in dietary behaviour of the group (DoH:2003:11). Food modification is primarily a strategy to improve either the amount of food in the diet or its bio-availability (Venkatesh Mannar 1999:24). Producing or purchasing a greater variety of affordable foods than those usually consumed is considered to be the safest and most sustainable long-term measure in the control of most micronutrient deficiencies (USAID 1993:8). According to the WHO dietary diversification is important to improve the intake of critical nutrients. The vitamin A content of most staple diets can be significantly improved with the addition of a relatively small portion of plant foods rich in carotenoids. For example, a 50 gram (g) portion of cooked carrots added to a daily diet provides 500 milligram (mg) retinol equivalents, which is the recommended nutrient density for this vitamin. Fruit and vegetables such as carrot,

mango, papaya and melon contain large amounts of nutritionally active carotenoids. Green leafy vegetables such as ivy gourd have been successfully used in Thailand as a source of vitamin A and carotenoid-rich red palm oil is an excellent source of vitamin A used in other countries. When regular portions of these foods are included in an individual's diet, it can provide 100 percent or more of the daily requirement for retinal equivalents. Vitamin A is also present in animal food sources in a highly bio-available form. Good vitamin C sources are citrus fruit, guava, kiwi, cranberries, strawberries, papaya, mango, melon, cantaloupe, spinach, Swiss chard, tomato, asparagus and Brussels sprouts. All these foods, when added to a diet in regular portion sizes, will significantly improve the vitamin C density. Because ascorbic acid is heat labile, minimal cooking is recommended to maximise the bio-available nutrient.

Minerals such as iron and zinc are low in cereal and tuber-diets, but the addition of legumes can slightly improve the iron content of those diets. The bio-availability of this non-heme iron source is low and it is therefore not possible to meet the recommended levels of iron and zinc in staple diets, unless some meat, poultry or fish is included in the diet. By adding a small portion (50g) of meat, poultry or fish the total iron content will increase as well as the amount of bio-available iron. For zinc, the presence of a small portion (50g) of meat, poultry or fish will secure dietary sufficiency of most staple diets (FAO & WHO 2002:4). The rural poor make up an estimated 80 percent of the world's 800 million hungry people. They make daily use of soil and water for both farming and fishing, of forests for food, fuel and fodder and of the biodiversity of a wide range of wild and domesticated plants and animals (FAO & WHO 2002:24).

1.7.5 Strategies to accomplish food diversity in practice

- Community or home vegetable and fruit gardens are projects that can lead to increased production and consumption of micronutrient-rich foods, e.g legumes, green leafy vegetables and fruit at household level. The success of such projects requires a good knowledge and understanding of local conditions as well as the involvement of women in the community in general.

- Production of fish, poultry and small animals (rabbits, goats and guinea pigs). These are excellent sources of highly bio-available essential micronutrients such as vitamin A, iron and zinc. The production of animal foods at local level may permit communities to access foods that would otherwise not be available because of high costs. These types of projects also need support from local governments or non-governmental organisations to overcome cost constraints for the implementation of the programme.
- Implementation of large-scale commercial vegetable and fruit production, with the objective to provide micronutrient-rich foods at reasonable prices through effective and competitive markets, with lower consumer prices without reducing producer prices.
- Reduction of post-harvest losses of the nutritional value of micronutrient-rich foods, such as fruit and vegetables, with the improvement of storage and food-preservation facilities. At the household level, the promotion of effective cooking methods and practical ways of preserving foods may significantly increase the access to bio-available foods.
- Improvement of micronutrient levels in soil and plants, which will improve the composition of plant foods and enhance yields. Current agricultural practices can improve the micronutrient content of foods through correcting soil quality and pH (hydrogen ion concentration or the relative acidity or alkalinity) and increasing soil mineral content depleted by erosion and poor soil conservation. Long-term food based solutions to micronutrient deficiencies will require improvement of agricultural practices, seed quality and plant breeding (FAO 2004b:11, WHO & FAO 2002:4).

In 1998 the Department of Health in South Africa developed the existing nutrition programme into the INP for South Africa. The INP will focus on the following eight strategies:

- Contribution to household food security.
- Disease-specific nutritional support, treatment and counselling.
- Growth monitoring and promotion.

- Nutritional promotion, education and advocacy.
- Promotion, protection and support of breastfeeding.
- Micronutrient malnutrition control.
- Food service management.
- A nutritional intervention programme for the human immunodeficiency virus (HIV), the acquired immunodeficiency syndrome (AIDS), and tuberculosis (TB) (Labadarios *et al.* 2005:100).

1.7.5.1 Food security

- Food security is defined as access by all people at all times to sufficient food required for a healthy and active life. For a household to be food secure, it must have physical and economic access to an adequate and varied food supply. Each household must have the ability, knowledge and resources to produce or procure the food it needs. (UNICEF 1998:1, FAO 2004b:11). Food deprivation is measured based on the calculation of three key parameters for each country: the average amount of food available per person, the level of inequality in access to that food and the minimum number of calories required for an average person (FAO 2004b: 14-15).

Under-nutrition is caused by inadequate food intake, which can be caused by poverty and household food insecurity (DoH 2003:15).

To achieve food security government must ensure that the following is available:

- a nutritionally adequate and safe food supply at both national and household levels,
- a reasonable degree of stability in the supply of food throughout the year and
- access by each household to sufficient food to meet all their needs (FAO 2004b:11).

1.7.5.2 Food availability

To nourish a population adequately, there must be a sufficient quantity and variety of good-quality and safe food in the country. In most low-income food-deficit countries a fundamental strategy of food policy is to improve and increase food production. Developing countries should strive for integrated rural development, combining sustainable agricultural development and the promotion of off-farm economic activities and to expand agricultural efforts to increase and improve food production (FAO 2004b:12).

1.7.6 Nutrition education

Nutrition education relates to communication activities used to improve the nutritional status of the population, to prevent nutrition-related diseases and improve the quality of life for individuals (DoH 2003:11). As children grow, they acquire knowledge and assimilate concepts. The early years are ideal for providing nutrition information and promoting positive attitudes about all foods. Children's development level should be taken into consideration when nutrition education is conducted. Activities and information that focus on children's real world experiences and relationships with food are most likely to yield positive results (Mahan & Escott-Stump 2004:275). UNICEF (2005) has incorporated basic messages about health, hygiene and nutrition into the standard school curriculum, in order to increase understanding at a young age.

1.7.6.1 Purpose of nutrition education

South Africa's INP was developed from the recommendations of the Nutrition Committee appointed in 1994 by the Minister of Health to develop a nutrition strategy for the country. The INP aims at implementing programmes that are integrated, sustainable, people orientated, community-driven and are targeted at the most vulnerable groups of the population (DoH 2004:1). One of the focus areas is nutrition education, which aims to improve the nutritional status of the population, prevent nutrition-related diseases and improve the quality of life, including nutrition advocacy

to support and draw attention to a nutrition cause or issue to achieve desired results (de Hoop 2005:7-8, Labadarios *et al.* 2005:105). School nutrition programmes only improve the nutritional status of young children when the programme contains an appropriate nutrition education component (Babu 2001:24).

1.7.6.2 Advantages of nutrition education

Improved child nutrition, as a result of well-designed food and nutrition programmes and policies, can contribute to the enhancement of human capital, which is fundamental for increasing productivity of society for economic growth. Improving child nutrition should be seen as a national development priority and as an important economic strategy (Babu 2001:19).

1.7.6.3 Food based dietary guidelines as a strategy for nutrition education

According to the Food and Agricultural Organisation (FAO) Food Based Dietary Guidelines (FBDG) are instruments for the expression of food and nutrition policy and should be based directly on diet and disease relationships of particular relevance to the individual country. The South African FBDG was published during 2001 and was based on locally consumed foods. The aim is to address existing nutrient deficiencies and excesses, and the resulting nutrition related public health problems of a specific country or community. In order to successfully change eating behaviour, a number of specific characteristics for FBDG have been identified, based on the FAO and WHO recommendations. These include the following: Each guideline should have only one, easy, understandable, simple message. Guidelines should be formulated or illustrated in such a way that people from different cultures and literacy backgrounds will grasp their meaning; they should be user-friendly and easy to understand; they should be formulated in a positive way. No negative messages using words such as avoid, decrease, limit, cut out or eat less, should be used. The FBDG should not create guilt feelings about, or negative associations with, foods; they should be compatible with the different cultures and eating patterns of the target population. They should be based on affordable, available foods that are widely

consumed; they should also be sustainable; encourage environmentally friendly agriculture; lead to a selection of foods that is usually eaten together or in groupings that are compatible with existing dietary practices; they should address both over- and under-nutrition. Furthermore FBDG should help people to choose the most appropriate diet they can afford and encourage undernourished people to choose a more adequate diet and over-nourished people to choose a more sensible diet; they should emphasise the joy of eating; they should be formulated and communicated to the target population using marketing skills based on the knowledge, perceptions, attitudes and behaviours of the target population (DoH 2004:7).

The Department of Health has adopted the following official Food Based Dietary Guidelines for South Africans older than seven years:

- enjoy a variety of food,
- be active,
- drink lots of clean, safe water,
- make starchy foods the basis of most meals,
- eat plenty of vegetables and fruit every day,
- eat dry beans, split peas, lentils and soy regularly,
- chicken, fish, meat, milk or eggs can be eaten daily,
- eat fats sparingly,
- use salt sparingly,
- use food and drinks containing sugar sparingly and not between meals and
- if you drink alcohol, drink it sensibly.

The FBDG are qualitative statements that express dietary goals in terms of foods and food-availability rather than nutrients. The guidelines are based upon scientific knowledge available about the relationships between diet and disease, and the profile of morbidity and mortality in SA. The guidelines form the core of the Government's nutrition education message to motivate South Africans in recognising the important role of nutrition in the promotion of health and well-being (DoH 2004:7).

1.8 School feeding programmes

As early as 1790 a combined programme of teaching and feeding hungry children was begun in Munich, Germany, and in France a school lunch programme for needy children in about 464 places was established by Victor Duray in 1867. In Norway the Oslo Breakfast consisted of half a pint of milk, wholemeal bread, cheese, half an orange and half an apple; from September to March, one dose of cod-liver oil was included - this was provided by Christiana Oslo since 1897. Holland became the first country to adopt national legislation specifically to provide school lunches in 1900. In Switzerland lunches were provided to about eight percent of the primary school children by private societies. This was done to encourage school attendance by children who lived far from school and who were unable to go home for lunch. Dr Huber found that teachers supported the school feeding because of better attendance, improved attention and better scholastic work by the children. His findings and recommendations resulted in a national order being issued in 1903, making it obligatory for municipalities to provide food for children in need. In 1906 state funds were authorized for this purpose. In 1905, the Education Provision of Meals Act was passed in England, the aim being to secure suitable meals for school children. By 1914 up to 50 Italian cities were conducting some form of school feeding programme. Reducing hunger and malnutrition is essential to improve school attendance and children's learning capacities and performance, especially among rural people, who make up the vast majority of both the unschooled and the hungry (FAO 2005:15).

Hunger is a barrier to learning and school feeding programmes throughout the world have successfully attracted children to school by offering them food or a nourishing snack. The primary school objective of a school feeding programme is to provide meals or snacks to alleviate short-term hunger, enabling children to learn. A hungry child cannot concentrate or perform and is unlikely to stay in school. School feeding programmes have proven effective in encouraging enrolment, increasing attention spans and improving school attendance. School feeding programmes are powerful tools for alleviating day-to-day hunger pains. It is suggested that giving children a

daily breakfast at school may improve their scholastic achievement. When the time spent in school is increased, certain cognitive functions and attention to tasks are improved (Grantham-McGregor, Chang & Walker 1998:785).

Results of international studies indicate that breakfast makes a significant contribution to a child's nutrient intake for the day in such a way that one who misses breakfast is unlikely to make up the deficit of nutrients during the rest of the day (Kruger *et al.* 2002:15). A study done in SA by Labadarios (1997:91) indicated that approximately one out of five rural and urban black and urban coloured primary school children do not eat breakfast before going to school and feel hungry as a result. Breakfast should provide children with approximately one-third of their daily energy and other nutritional requirements. If the children have inadequate breakfast at home, they may suffer from periods of hunger. The alleviation of short term hunger may affect cognitive functions, such as memory and efficiency of information processing. Children's classroom behaviour, their attention and participation, may also improve and fidgeting may be reduced when they eat breakfast before going to school (Grantham-McGregor, *et al.* 1998:785). Efforts targeted primarily at relieving short-term hunger should focus on providing breakfast or a small snack shortly after children arrive at school (Jamison & Leslie 1990:206). Richter, Rose and Griessel (1997:93) reported that developing countries experienced many problems in trying to isolate the effects of school feeding from other socio-economic, cultural and educational factors. Food distribution programmes, including school feeding, are not always sufficiently well implemented to show beneficial effects. Problems *inter alia* supply, administration, storage and delivery may occur. However, school feeding programmes can have numerous benefits. Children from poor families or marginal communities, are frequently absent from school and this reduces the likelihood of them benefiting from educational activities.

The advantages of serving breakfast at school are:

- Parents are more eager to send their children to school.
- Children are more eager to go to school.

- Children are better able to concentrate and learn (Roche 2000: 3).

Richter *et al.* (1997:93) concluded that a school breakfast programme had a beneficial effect on the cognitive and behavioural performance of socially disadvantaged, undernourished children in their first two years of attending school.

1.8.1 Purpose of school feeding

The main purpose of School feeding programmes according to the WHO is:

- To alleviate short term hunger in malnourished school children. This helps increase students' concentration producing higher levels of cognitive function and learning
- To motivate parents to enrol their children in school and have them attend more regularly
- To reduce absenteeism and increase the duration of schooling, and performance. Drop-out rates and school year repetition diminish with school feeding (WFP 2005a).

According to the World Food Programme (WFP), the standard formula used to calculate the average serving size for pre-school and primary school meals for school feeding is:

- Pre-school children aged three to five years receive on average 6720 kilojoules (kJ) with 32 grams of protein
- Primary schoolchildren aged six to twelve years should receive 8400 kJ with 40 grams of protein (WFP 2005a).

The recommended level of protein is based on the average consumed in a local rural diet and assumes an 85 percent digestibility rating. When possible WFP uses a school breakfast or light midmorning snack to boost student energy levels and help students concentrate on their lessons (WFP 2005a)

All foods are made up of a combination of life sustaining macro- and micro-nutrients:

- Macronutrients: protein, carbohydrates and fats from the bulk of the diet and supply all the energy needed for the body. Both energy and protein are needed to support the maintenance and the growth of children.
- Micronutrients include all vitamins and minerals. Required in only tiny amounts, they are essential and needed for a wide range of bodily functions and processes (WFP 2005a).

Community involvement increases in schools, particularly where programmes depend on local assistance for preparing and serving meals to children. Interventions for micronutrient deficiencies include dietary diversification; many micronutrient deficiencies would disappear if enough food were available to all members of the population to allow them to eat sufficient food in a balanced diet (Maberley, Trowbridge, Yip, Sullivan & West 1994:288). Evidence indicates the negative consequences for children suffering from short-term hunger, particularly in children who do not have anything to eat before going to school. Children who are hungry are more likely to have difficulty concentrating and performing complex tasks. School feeding must take place within the context of broad, national school reform programmes. Communities must be involved and must take responsibility for school feeding programmes from the beginning. This greatly increases the likelihood of the programme's success and sustainability. School feeding programmes must be targeted towards the most underserved, food-insecure areas, with relatively low rates of school attendance (Drake *et al.* 2002:9-10).

1.8.2 School feeding globally

USAID/Haiti, has been experimenting with nutrient- rich snack biscuits made from surplus grains, which reduce the need for cooking and other preparations at the school and also provide micronutrients (Drake *et al.* 2002:9). The school feeding effort in Kenya has confirmed that food is an effective incentive to successfully attract children to school. According to the United Nations Educational, Scientific

and Cultural Organisation (UNESCO), almost 18 percent of school children in Kenya suffer from chronic stunting, with a further 34 percent showing mild to moderate growth retardation. Nutritional deprivation was found to be much more prevalent in arid and semi-arid land areas. It is not uncommon for only one meal to be prepared daily and for children to go to school without eating breakfast (WFP 2005a).

The Ecuadorian government provides $25 million each year to deliver breakfasts and lunches to 1.5 million school children in 15,000 schools through the School Feeding Program (SFP). Ecuador is a low-income, food-deficit South American country that includes the Galapagos Islands. The SFP is an intervention aimed at children between the ages of five and 14. With food as an additional incentive for attending school, attendance rates are significantly higher, with lower dropout rates. Once in school, a well-nourished child has a greater capacity for learning with longer attention span, better concentration and higher retention.

In Cameroon, a low-income food deficit country, the ration that is distributed amongst school children is 714 kilocalories, 18 grams of protein and 21 grams of fat, this represents 30 to 35 percent of the energy intake recommended for school children according to UNESCO norms. The ration is completed by fresh condiments and vegetables, supplied by the local community, through school management committees or parents' associations and is served in the morning and in the afternoon. Enrolment levels of girls targeted in the Cameroon school feeding programme have increased over the last three years by 16 percent and nearly 50 percent since the beginning of WFP school feeding. In Kenya biscuits and porridge have been used in school feeding programmes. As part of the school feeding programme a nutritious drink and high energy biscuit are given in the morning with porridge added at lunch time. All food is fortified with vitamins and minerals so that the two meals provide approximately two thirds of the daily micronutrient requirements for children (Hertz 1995).

1.8.3 School feeding in South Africa

In 1994 President Nelson Mandela introduced school feeding on a national scale in SA, as a lead project of the Reconstruction and Development Programme (RDP). The primary aim of the Primary School Nutrition Programme (PSNP) was to contribute to the improvement of active capacity of primary school children by provision of a nutritious snack to alleviate temporary hunger (Labadarios 1997:91, DoH 2004:14). The scope of the school feeding programme is: "The provision of an early snack, meeting 30 percent of the energy requirements of 3.8 million children (50 percent of primary school children) in areas targeted on the basis of the poverty criteria". The aims of providing an early-morning snack are primarily to contribute to pupils' active learning capacity, school attendance and punctuality, and to alleviate short-term hunger (Labadarios 1997:91).

The PSNP in SA reached around 5 million primary school children in geographic areas with high levels of poverty (Roche 2000:3). The vision of the PSNP is to have a self-sustained school nutrition programme which is not dependant on funds from the government. The remaining 80 percent of the child's daily nutritional needs is still the responsibility of the parents. To ensure that hunger is effectively alleviated, the snack should be substantial, and contain foods that take longer to digest. Table 1.9 describes the aim and objectives of the PSNP (DoH 2001:3).

Table 1.9 Aim and objectives of the PSNP in South Africa (DoH 2001:3)

Aim	Objectives
To alleviate temporary hunger	• To determine the hungry school children per grade younger than 14 years • To feed children 100 percent of the feeding days • Feeding children daily before 10:00 • To increase the concentration span of the children being fed by 1 percentage

The programme aims at providing 25 percent (i.e. snack) of the child's daily feeding needs and not a full meal. The snack provided at school ensures that children are less hungry while having to learn and therefore concentration and learning capacity are increased. To ensure that hunger is effectively alleviated, the snack should be substantial, containing food that takes longer to digest (DoH 2001:4). Since the establishment of the PSNP up to end of March 2002, approximately 15 000 schools have participated in the school feeding component of the PSNP. An average of 5 million school children have benefited annually since its inception (Labadarios *et al.* 2005:103).

1.8.3.1 Products used in school feeding in South Africa

The following items are included in the menu for children making use of the PSNP: fortified biscuits, brown bread, margarine, jam, peanut butter, vitamin C enriched drink, full cream milk, fish, maize meal, soy mince, orange/guava juice, vegetable oil, dried legumes and sugar (DoH 2001:3). In a study conducted by the Council for Scientific and Industrial Research (CSIR) and the University of Stellenbosch a novel nutrition product was developed. The aim was to use fish waste products in school feeding schemes as a means of improving neurological capacity in young children. The research has resulted in the production of a fish flour that is stable at room temperature, and suitable for incorporation into food or health capsules. A 10g portion of the flour provides RDA values of approximately 11 percent protein and 70 percent for calcium. The fish flour was primarily selected as a fortification product to be used in school feeding schemes for undernourished children (Timme 2003).

The Medical Research Council (MRC) launched a carotene-nutritional biscuit in 2000. The biscuit was developed by Dr. S. Benadé of the MRC. Dr. Benadé decided on the idea of a fortified biscuit because a cookie is seen as a snack rather than a meal. One of the ingredients in the biscuit is non-hydrogenated red palm oil which contains no trans-fatty acids and is naturally rich in vitamins A and E. The biscuit has been subjected to four years of scientific tests and the result of the research proved that children eating the fortified biscuits showed substantial health

improvements. Three biscuits per child per day will address the three main micronutrient deficiencies. Results showed that within 12 months, vitamin A deficiency was reduced from 40 percent to 12 percent and anaemia was reduced from 27 percent to 13 percent. One year after implementation of the biscuit, lower absenteeism rates and improved school performance were reported (Stein 2001).

1.8.4 Benefits of school feeding programmes

Jamaican studies showed that providing breakfast to students at school improved certain cognitive functions, particularly in undernourished children (Grantham-McGregor *et al.* 1998:785). The Global Food for Education (GFE) programme has demonstrated how much can be accomplished through school feeding programmes. In Pakistan, where girls often marry young and stay at home, enrolment by girls in GFE schools increased by 32 percent because of the school meals and the tins of cooking oil provided as an education incentive to the parents. In the Lebanon GFE project, teachers reported that children have more energy, concentrate better and learn faster since school meals were introduced, while more parents learn the value of education, especially for their daughters.

Nearly seven million children in 38 countries have been receiving school meals under the United States Department of Agriculture (USDA) initiative (USDA 2003:1). The provision of school meals reduces the parents' cost of sending children to school. It is therefore possible that children would enrol earlier, school attendance would be more frequent, and they will be less likely to drop out if meals are provided (Grantham-McGregor *et al.* 1998:785). School meals that are quantitatively and qualitatively adequate to significantly reduce protein-energy malnutrition or micronutrient deficiencies are expensive. Even nutritionally less adequate school feeding programmes have shown significant positive effects on children's school attendance (Jamison & Leslie 1990:206). National and international studies (Table 1.10) show that by improving the nutritional status of toddlers and school children, learning, behaviour and growth are beneficially affected. Well-fed children are stronger, brighter and more co-operative (Roche 2000:2; Kruger *et al.* 2002:8-9).

Table 1.10 Research studies conducted in school feeding programmes (adapted from Roche 2000:2; Kruger *et al.* 2002:6).

SOUTH AFRICAN STUDIES:			
Study	**Study population**	**Intervention**	**Results**
Richter *et al.* (1997).	55 undernourished rural South African children aged 7-14 years (test group); 53 well nourished urban children 7-10 years (control).	Test group receive a school breakfast of fortified cereals with milk and banana for 6 months.	The breakfast had a significant beneficial effect on cognitive and behavioural performance.
Van Stuijvenberg *et al.*(1999).	115 South African children aged 6-11 years (test group); 113 children in control group.	Cookies fortified with 60% RDA of beta-carotene, iodine and iron, and a drink with 90mg vitamin C, on school days for a one year period (test group); placebo snacks (control).	Improvement in short term memory and attention in test group and fewer illness-related absences from school.
INTERNATIONAL STUDIES:			
Study	**Study population**	**Intervention**	**Results**
Benton and Robberts (1988).	90 Welsh school children aged 12-13 years.	Vitamin/mineral supplements for eight months (30 children) placebo and no treatment (30 children each).	Increase in non-verbal intelligence in supplemented group.
Powell *et al.*(1998).	407 undernourished 407 well nourished Jamaican school children.	Breakfast, every day for one year period (test group); one- quarter orange (controls).	Breakfast improved nutritional status and school attendance.

Table 1.10 (Continued) Research studies conducted in school feeding programmes (Roche 2000:2; Kruger *et al.* 2002:6).

INTERNATIONAL STUDIES:			
Study	**Study population**	**Intervention**	**Results**
Cromer *et al.* (1990).	Well-nourished USA children, grade 9 aged 14-16 years.	Low-energy breakfast, showed high levels of beta-OH-butyrate.	No significant differences in cognitive function.
Schoenthaler *et al.*(1999).	615 USA school children.	Vitamin / Mineral supplements with 50, 100 or 200% RDA for 13 weeks compared with placebo.	Improvement in non-verbal intelligence by children on 100% RDA supplements.
Sandstead *et al.* (1998).	740 Chinese school children aged 6-9 years from urban, low-income families.	Supplements with 20 mg. Zinc, micro- nutrients or both, six days per week for 10 weeks.	Micronutrient supplementation with zinc improved neuro-psychological performance and growth significantly.
Jacoby and López de Romaná (1998).	500 000 school children in Peruvian Andes aged 5-10 years.	School Breakfast with 60% RDA of vitamins and minerals, and 100% iron daily for six months.	Anaemia prevalence fell from 66% to 14%. School attendance improved significantly. Improvement in vocabulary test.
Chandler *et al* (1995).	Jamaican school-children.	School Breakfast for Undernourished children.	Undernourished children's verbal fluency improved significantly

1.8.5 School feeding strategies

According to the Interagency Network for Education in Emergencies (INEE) the following strategies must be kept in mind regarding school feeding: Ensure high health standards during preparation and storage of the food. Steps must be taken to ensure that illness is not spread through school feeding programmes due to poor storage and preparation (INEE 2004).

1.8.5.1 Problems in school feeding programmes

Costs of school feeding will generally be high, but will depend substantially on the mechanisms for food preparation and delivery. An important consideration is the extent to which the rest of the family benefits from the programme, children taking food home to give to younger brothers and sisters (Jamison & Leslie 1990:209). The following problems regarding the operational process of school feeding programmes include the following:

- Irregular supplies
- Food lost through spoilage, black market or theft
- Disruption of teaching for the preparation of school meals
- Burdensome reporting and the monitoring of the programme
- Burden on the school staff
- Logistical difficulties of transporting large quantities of food with poor transportation and communication systems.

With the PSNP in South Africa the following problems were identified: a lack of resources, for example deliveries, equipment and computers. Table 1.11 indicates the problems experienced by the schools in the North West Province:

Table 1.11 Delivery problems experienced by schools (Wentzel-Viljoen 2003:140)

Problem	**Percentage of Schools (n=156)**
Non-deliveries	57.3
Irregular deliveries	71.5
Early deliveries	32.5
Late deliveries	59.9
Incomplete food packages delivered	16.7
Incorrect quantities delivered	22.0
Food not delivered at school premises	13.2
Contractors/sub-contractors interfere with school activities	9.3
Expired food delivered	24.5

1.8.5.2 Cost of school feeding programmes

The average cost per student of the development SFP of the World Food Programme in 2000 was $0.19 per day, or $34 for a 180 day school year (USDA 2003). In Ecuador, where meals are provided to the children 160 days a year by the WFP, the annual average cost is about $24 per child. In South Africa, the cost for the government in 1999/2000 to feed one learner per year was an average of R79 over the three-year period. This cost per learner includes food, transport of the food to the school, administration and helper costs, but excludes any staff costs (Wentzel-Viljoen 2003:347). In South Africa 3.9 billion rand was made available for the financial periods of 1994/1995 and 2001/2002 (Labadarios *et al.* 2005:103).

1.8.5.3 Guidelines for school feeding

The INEE has the following requirements when preparing a product for school feeding:

- Is there sufficient water for cooking and cleaning?
- Is there a place for the food handlers to wash their hands?

- Is fuel available?
- Are the ingredients available to cook the food and make it palatable? (for example salt)
- Is the food cooked thoroughly? Where possible choose easy cooked commodities especially for the mornings.
- Is cooked food eaten immediately?
- Are cooked foods carefully stored?
- Are locally produced vegetables safe? (When crops are grown on land with waste water).
- Is contact between raw food and cooked foods avoided?
- Are kitchen surfaces, utensils and cooking pots clean?
- Does the school have sufficient cleaning material for cleaning pots?
- Are foods protected from insects, rodents and animals? (INEE 2004).

Vorster and Venter (1992:96) recommended that when planning a school feeding programme the role of socio-economic factors in the nutritional status of the target group must be evaluated. This will influence the design of the programme, the implementation thereof, and the response of children to the programme. It is suggested that a holistic or integrated approach should be selected, with maximum integration of nutritional intervention with other community development activities. Community participation in both design and implementation of the programme should be encouraged

1.8.5.4 Aims of a school feeding programme

In South Africa the PSNP was introduced in 1994 with the main focus areas being school feeding, nutrition education and health promotion.

The aims of nutrition interventions in primary schools are the following:

1. To contribute to the improvement of education quality and general health by:
   - Enhancing active learning capacity
   - Alleviating short-term hunger
   - Improving school attendance
   - Improving punctuality
   - Addressing micronutrient deficiencies
   - Controlling parasite infestations
2. To improve nutritional knowledge, perceptions, attitudes and behaviour amongst primary school children, their parents and teachers.
3. To enhance broader development initiatives (WFP 2005a:2).

1.9 Motivation for this study

Although many strategies are implemented to address malnutrition, it continues to be a problem amongst children, as stated in the preceding literature. This study was undertaken in the Vaal Triangle. The niche area in the department of hospitality and tourism is "Addressing food insecurity in an urban area", due to the fact that there is a huge malnutrition problem in South Africa. The results of the study undertaken by Oldewage-Theron, Dicks, Napier and Rutengwe (2005:13) indicate the prevalence of poverty in this community in the Vaal Triangle. The Vaal Triangle is an industrial area situated approximately 70 km south of Gauteng and has a population of 794 599. McIlrath and Slabbert (2003:24) found that 48 percent are unemployed and 46 percent of households live in poverty. A situation analysis of the dwellers in an informal settlement of 1 260 households in the Vaal Triangle was done. The results showed that 90 percent of the respondents live in corrugated iron shacks. Overcrowding is common; 32 percent live in one-or two-room shacks, 44 live in three-to four-room shacks and 24 percent live in shacks with more than four rooms. The average size of the household was 4,9 percent. Thirty-one percent of the households consisted of six or more members, 19 percent of five members, 22 percent of four members and 28 percent of three or less than three members. The

unemployed rate in this area was 94 percent for the respondents and 80 percent for the partners. Two-thirds of the caregivers (69 percent) have an income below R500 per month. The main health problems that were observed were chronic coughing (44 percent) and headaches (54 percent). The causes of these were not established. Diets were poor and consisted mainly of refined carbohydrates. Eight out of ten households indicated that they eat more than one meal per day; 56 percent eat twice daily and 23 percent three times a day. The top twenty food items consumed were (Table 1.12): stiff and soft maize meal porridge, brewed rooibos and leaf tea, coffee, mabela, white bread, crumbly maize porridge, carbonated cold drink and mageau. The daily intakes (mean and standard deviation of various nutrients) were: 4550 ± 1993 kJ energy, 20 ± 9g protein, 21 ± 21g fat and 182 ± 78 g carbohydrates. The results indicate that this is a poverty-stricken community with chronic household food insecurity and compromised nutrition (Oldewage-Theron *et al.* 2005:13-25).

Table 1.12 Twenty food items most frequently consumed (Oldewage-Theron *et al.* 2005:23).

Food item	Mean daily intake (grams per person)	Number of respondents consuming items daily
Maize meal porridge (stiff)	345	409
Maize meal porridge (soft)	124	202
Tea, rooibos (brewed)	80	35
Tea, (brewed)	79	335
Coffee, (brewed)	76	38
Maltabella	74	177
Bread, white	73	38
Maize meal porridge (crumbly)	63	72
Cold drink (carbonated)	52	52
Mageu (fermented maize drink)	51	88
Soya beans	51	19
Potato (boiled with skin)	47	47
Stewed chicken with vegetables	45	25
Potato (boiled without skin)	31	28
Cold drink (squash)	31	264
Oats	30	12
Soup (powder)	29	19
Samp	28	98
Spinach (buttered)	23	126
Cabbage (with potato and onion)	21	138

Furthermore the nutritional status of primary school children in an informal settlement was assessed by dietary and anthropometrical methods, and biochemical blood analysis. The anthropometrical data obtained, when compared with the National Centre for Health Statistics (NCHS) standards, indicated that 18 percent of the children were stunted or chronically malnourished and that 25 percent of the children fell under the 5th percentile for weight-for-age. Twelve percent of the

children fell under the 5th percentile for BMI-for-age and, therefore, suffered from acute malnutrition. These results compare well to the data of children between seven and twelve years in Gauteng (Reitsma, Vorster, Venter, Labadarios, de Ridder & Louw 1994:12), documenting that 12 percent of the children were below the 5th percentile of height-for-age, 18 percent of the children below the 5th percentile of weight-for-age and 6 percent below the 5th percentile of weight-for-height. In this study the anthropometry is supported by the low energy intake. Zinc and ferritin levels were lower than the normal range for children in this age group. Comparing the biochemical and dietary intake results, it can be seen that the energy intake is lower and protein higher than the dietary reference intake per day (DRI). The high protein intake could be utilised as energy and not as much for growth purposes. The low zinc and ferritin confirms the low intake of green vegetables, fish and whole grain products, as reflected by the food most commonly consumed by the children during the day, this included maize meal, brown bread, tea, fresh milk, mabella, samp and beans, squash or carbonated cold drinks and cooked white rice. These findings confirmed that poverty and household food insecurity were the major problems in this community.

This project therefore concentrated on the development of a novel food product for implementation in the school feeding project in this poor community. The nutritious novel food was developed with the objective to address nutrient deficiencies identified in the baseline study, in order to improve the nutritional status of previously disadvantaged primary school children in the Vaal Triangle. Dr Molefi Sefualro, the member of the executive council (MEC) for Health, noted that feeding schemes should be based on everyday foods. He remarked that the majority of children were brought up on ordinary foods and staples known to certain communities or regions, and if basic foods can be prepared by community based organisations or project groups, opportunities will be created for the development of local economies. Women in particular will benefit from such a new approach to the feeding scheme (SA Gov 2000).

This product initiated the involvement of the local communities and the non

governmental organisations (NGO) in the Vaal Triangle for the upliftment of the community by assisting in gathering information, developing a cost-effective, nutritious novel food product, easy enough to be prepared by the parents and caregivers. The primary school, situated in this informal settlement, was selected, for this study and the intervention (Napier 2003) as permission from the Department of Education and the student governing bodies (SGB) had previously been obtained.

Food-based approaches to enhance nutrition include the increase of nutrition availability, accessibility, and intake of nutrient–rich foods, also to increase the bio-availability of nutrients from these foods through improved home processing techniques, better selection of dietary combinations and breeding methods. Studies done in Ethiopia found that home gardening combined with nutrition education increased the knowledge, attitude, and practices related to intake of vitamin A and prevention of night blindness. In Kenya, the introduction of new varieties of beta carotene rich sweet potatoes with the appropriate nutrition education increased the consumption of vitamin A rich foods. This indicates that well-designed food-based interventions that combine community involvement, production and nutrition education can have significant improvement in the nutritional status of the beneficiaries (Babu 2001:24).

1.10 Objectives of the study

As a result of the poor living conditions in the Vaal Triangle community, a baseline survey was undertaken in an informal settlement to determine the nutritional status of children in the identified school. The nutritional status of primary school children in this informal settlement was assessed by dietary and anthropometrical methods, and biochemical blood analysis.

The objective of this study was the development of a novel food product to be used in an intervention study as part of the school feeding programme for primary school children, aged six to thirteen years in an attempt to improve the nutritional status and address food malnutrition in primary school children.

The specific aim of this project was to develop a product, based on the following criteria:

- Balanced nutritional value: rich in energy
  rich in proteins and micronutrients, specifically those where deficiencies are present
  moderate in fat and sugar
- Practical: easy to prepare
  easy to store with a long shelf-life
  minimal waste
- Acceptable to children: attractive appearance
  taste acceptable
- Affordable: local raw materials (Roche 2000:4)

Before the development of a novel food, information is needed regarding the existing specific nutrient deficiencies, as well as the dietary intake and food consumption patterns of the children. Results from the baseline study conducted in the area were used as criteria for the development of the product.

1.11 Outline of the dissertation

In chapter one the problem and its setting is discussed. Chapter 2 will follow with the literature synthesis on product development. In chapter 3 the methodology employed for this study is described. Chapter 4 follows with the results of the empirical study and the conclusions and recommendations are discussed in Chapter 5.

1.12 Conceptual framework

The conceptual framework Figure 1.2 indicates the three different phases of the study. Phase one was the baseline survey and the researcher was assisted by C. Napier and Prof. W. Oldewage-Theron. Phases two and three were the sole responsibility of the researcher.

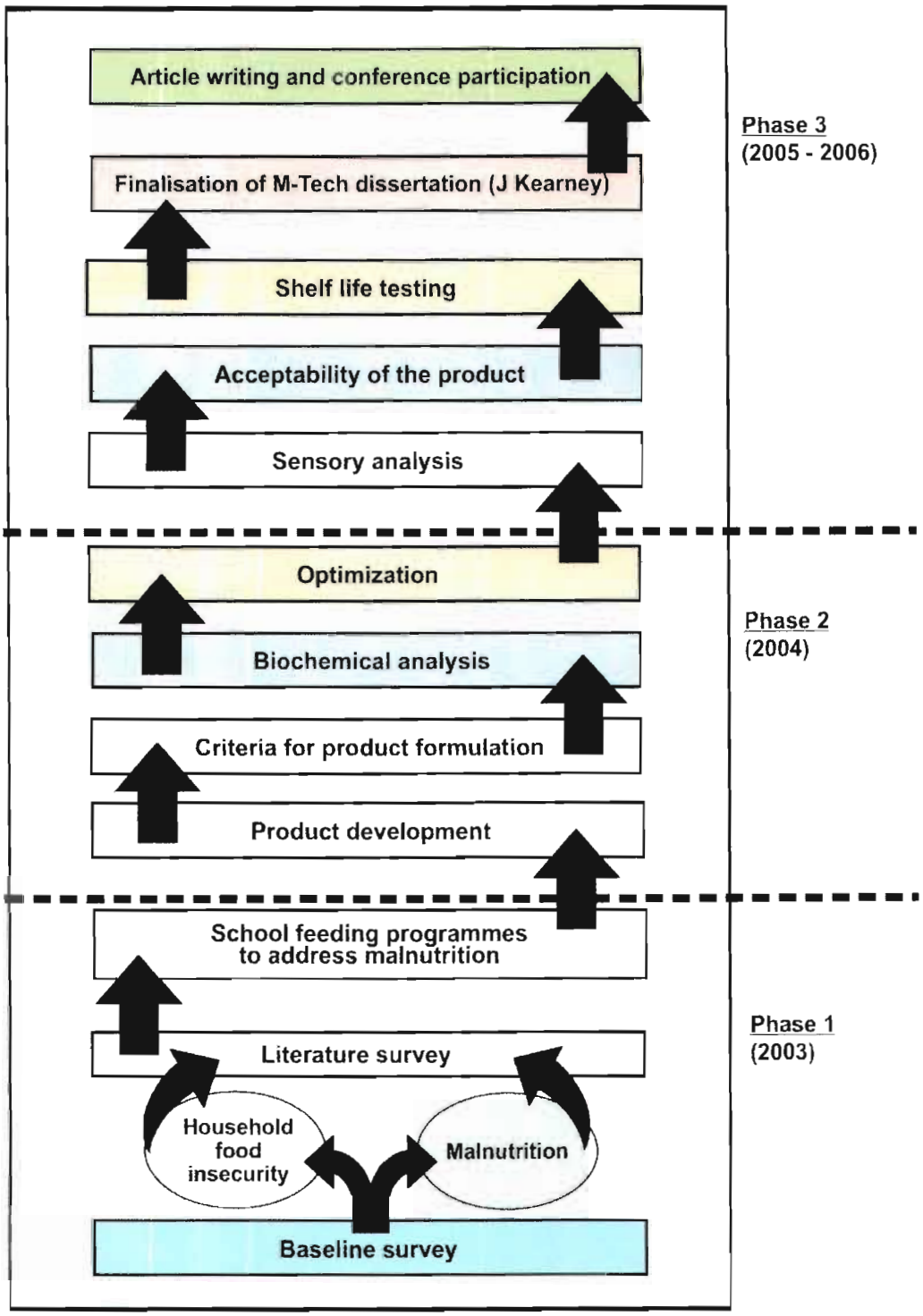

Figure 1.2 Conceptual framework

Chapter 2 Literature synthesis: Conceptualisation

2.1 Introduction

Malnutrition, both-over and under-nutrition, continues to be a problem amongst children globally and in South Africa, despite many strategies that have been implemented to address this problem. Hunger is a barrier to learning and school feeding programmes throughout the world aim to alleviate short-term hunger in school children and thus enable them to learn (Grantham-McGregor *et al.* 1998:785). The purpose of this study was to develop an affordable and acceptable novel food product to not only alleviate hunger, but also address the specific micronutrient deficiencies found to be present among primary school children in an informal settlement in the Vaal Triangle. In this chapter, the nutritional needs of primary school children will first be discussed, after which special attention will be given to the processes and steps to be followed in developing a novel food product. The literature review provides the foundation for the empirical study undertaken and discussed in chapter 3.

2.2 Nutritional needs of primary school children

Young children are often at risk of being malnourished. They have very high energy and nutrient requirements for their body size, in comparison to the requirements of adults. Proper care and feeding is essential for their normal growth, development and activity. Children should be encouraged to eat enough of a variety of energy and protein-rich foods and fruit and also vegetables for growth and body maintenance (FAO 1998:14).

2.3 Dietary recommendations for children

According to the FAO (1998:14) children face an increased risk of being malnourished due to their very high energy and nutrient needs in comparison to

adults. Children should be encouraged to eat enough of a variety of energy and protein-rich foods and fruit and vegetables for growth and body maintenance. Children need to maintain their diet of energy-rich and protein-rich foods throughout their growing years until adulthood. Brown, Creed-Kanashiro and Dewey (1995:336) indicate that the quality of the diet (micronutrient content and bio-availability; proportion of energy from animal products) may be an important determinant of energy intake and growth. This creates a dilemma in some countries where high-quality foods may not be accessible to those children with the greatest need, either because these foods are not available locally or because their cost is prohibitive.

According to the FAO (1998:10) vitamins can be added to foods to replace nutrients that have been lost in processing or to enhance the total nutrient content. Foods with added vitamins and minerals are called fortified foods, for example, iodine is frequently added to salt to produce iodized salt. In many countries bread, flour and other cereal products are fortified with B vitamins and iron. Vitamins A and D are often added to processed milk, dairy products and to some vegetable oil products.

Nutrition and health professionals use DRI as guidelines in the dietary assessment of groups and individuals. The term "Dietary Reference Intake" refers to a set of four nutrient-based reference values that represent the approach, adopted by the Food and Nutrition Board, to provide quantitative estimates of nutrient intakes for use in assessing and planning diets. Where adequate information is available, each nutrient has either an Estimated Average Requirement (EAR) and a Recommended Daily Allowance (RDA), or an Adequate Intake (AI). When the EAR for a nutrient cannot be determined, then an AI is set for the nutrient. In addition, many nutrients have a Tolerable Upper Intake Level (UL) (Murphy & Poos 2002:843).

Each DRI is defined as follows:

- Estimated Average Requirement (EAR): a nutrient intake estimated to meet the requirement of half the healthy individuals in a particular life-stage and gender group.
- Recommended Dietary Allowance (RDA): the average daily dietary intake

level sufficient to meet the nutrient requirements of nearly all (97- 98 percent) healthy individuals, in a particular life-stage and gender group.

- Adequate Intake (AI): a recommended intake level, based on observed or experimentally determined approximations or estimates of nutrient intake, by a group (or groups) of healthy people that is assumed to be adequate - used when a RDA cannot be determined.
- Tolerable Upper Intake Level (UL): the highest average daily nutrient intake level, likely to pose no risk of adverse health effects for almost all individuals in the general population. As intake increases above the UL, the risk of adverse effects increases (Murphy & Poos 2002:844).

The RDA is an intake level that exceeds the requirements of 97-98 percent of all individuals when the requirements of the group have a normal distribution. The RDA should therefore not be used as a cut-off point for assessing the nutrient intakes of groups, because it could seriously overestimate the proportion of the group at risk of inadequacy. Estimated Average Requirement is the appropriate DRI to use when assessing the adequacy of group intakes as can be seen in table 2.1 (Murphy & Poos 2002:845-846).

Table 2.1 Uses for dietary intakes for healthy individuals and groups (Trumbo, Yates, Schlicker & Poos 2001:301).

Type of use	**For the individual**	**For a group**
Assessment	EAR: use to examine the probability that usual intake is inadequate.	EAR: use to estimate the prevalence of inadequate intakes within a group.
	RDA: usual intake at or above this level has a low probability of inadequacy.	RDA: do not use to assess intakes of groups.
	AI: usual intake at or above this level has a low probability of inadequacy.	AI: mean usual intake at or above this level implies a low prevalence of inadequate intakes.
	UL: usual intake above this level has a potential risk of adverse affects.	UL: use to estimate the percentage of the population potentially at risk of adverse effects from excessive nutrient intake.

2.3.1 Macro-nutrient requirements

The FAO (1998:5) suggests that people, especially children, should try and eat a variety of foods throughout the day to meet nutritional needs. Food provides energy to grow and fulfill basic body functions (breathing, thinking, temperature control, blood circulation and digestion). Food also supplies the body with the materials to build and maintain the body and promote resistance to disease. These different functions are made possible by the nutrients contained in foods. Nutrients in food needed for optimal nutrition include: carbohydrates, protein, fat, iron, vitamin A, B vitamins, vitamin C, vitamin D, calcium, phosphorus, iodine, zinc and water.

2.3.2 Energy requirements

Children cannot eat the same amount of food in one meal as adults. They consume a lot of energy throughout the day, they should therefore sustain energy requirements by eating small meals and snacks spread over the day (FAO 1998:14). The Estimated Energy Requirement (EER) for boys aged three to eight years is 7316kj and for girls of the same age the EER is 6896kj. Boys aged nine to 13 years old require 9572kj and for girls of the same age the EER is 8698kj (Stanfield 1997:6-7, Evers 2002:1).

2.3.2.1 Carbohydrates

According to the Food and Nutrition Information Centre (FNIC) carbohydrates include sugars, starches and dietary fibre and are the major source of food energy. Foods rich in carbohydrates include rice, maize, wheat and other cereals, all types of root crops such as potatoes, legumes such as peas and beans, as well as many fruits and vegetables, and sugars (FAO 1998:5, Stanfield 1997:53, FNIC 2002:1). It is suggested that the maximum intake of added sugars be limited to providing no more than 25 percent of energy. The EAR requirements for children of the age four to 13 years are 100g of carbohydrates per day (FNIC 2002).

2.3.2.2 Protein

Proteins are needed to build and maintain muscle, blood, organs, skin, bones and other tissues of the body. Proteins can also be used to provide energy. Eating more protein than is needed can be wasteful; excess protein will be converted to glucose and used as energy, or stored in the body as fat. According to the FAO (1998:6) protein is especially important for growing children. Meat, poultry, fish, eggs, milk, cheese and yogurt are sources of protein that provide all nine indispensable amino acids in adequate amounts and for this reason are considered complete proteins. Proteins from plants, legumes, grains, nut, seeds and vegetables tend to be deficient in one or more of the indispensable amino acids and are called incomplete proteins. Normal tissue growth in infancy and childhood requires more amino acids than those

needed for tissue maintenance. In the absence of adequate dietary protein, growth is slowed down or even stopped (FNIC 2002, Stanfield 1997:75, Moore 1993:3).

Protein serves as the major structural component of all cells in the body and functions as enzymes, transport carriers, and certain hormones. During digestion and absorption, dietary proteins are broken down to amino acids, which become the building blocks of structural and functional compounds. Nine of the amino acids must be provided in the diet; these are termed indispensable amino acids. The body can manufacture the other amino acids needed to synthesize specific structures from the indispensable amino acids. The total protein needs for children between four and eight years of age according to the EAR are 15g/day and 27g/day for children nine to 13 years of age (FNIC 2002, Stanfield 1996:6-7, Evers 2002:2).

2.3.2.3 Fat

Fats and oils provide more than twice the amount of food energy as carbohydrates and proteins (FAO 1998:7). Added fat and oil is a good way to increase the energy intake of young children. When found in foods it is a source of n-6 and n-3 polyunsaturated fatty acids. Its presence in the diet increases absorption of fat-soluble vitamins and precursors such as vitamin A and pro-vitamin A carotenoids (FNIC 2002). This is important since children are often not able to eat enough bulky foods to meet their energy needs. Young children should receive between thirty to forty percent of their total daily energy intake from fat. Fat is also an important source of the fat-soluble vitamins. Dietary fat includes butter, margarine, vegetable oils, whole milk, visible fat on meat and poultry products, invisible fat in fish, shellfish, some plant products such as seeds and nuts and bakery products (FNIC 2002).

2.3.2.4 Fibre

Fibre in the diet improves laxatation and reduces the risk of coronary heart disease it also assists in maintaining normal blood glucose levels. Dietary fibre is naturally

present in grains, such as oats, wheat, or unrefined rice. The AI levels for total fibre needs for children between four and eight years of age is 25g per day, boys aged nine to 13 years require 31g per day and girls 26g per day (FNIC 2002, Evers 2002:3, Stanfield 1997:6-7).

2.3.3 Micro-nutrient requirements

Vitamins and minerals are called micronutrients and smaller amounts are needed than protein, fat and carbohydrates. Vitamins and minerals assist with all the body functions and form part of the body tissues (FAO 1998:9).

2.3.3.1 Vitamin A

Vitamin A deficiency (VAD) is a major public health concern and the most vulnerable are pre-school children and pregnant women in low-income countries (WHO 2000). The function of Vitamin A is building and maintaining healthy tissues, particularly eyes, skin, bones and tissues of the respiratory and digestive tracts. It is also important for the effective functioning of the immune system. According to the FAO (1998:9), VAD can lead to poor night vision, severe eye lesions and in severe cases permanent blindness, in children. VAD is the leading cause of preventable severe visual impairment and blindness. This occurs mainly in undernourished children, especially those with measles and other infections that could lead to increased illness and death.

Vitamin A is found naturally in foods of animal origin, notably breast milk, liver, eggs and dairy products. Dark coloured fruit and vegetables contain pigments, called carotenoids, which can be converted to vitamin A (Stanfield 1997:95). According to the EAR for children between four and six years of age require 275µg retinol equivalents (RE) and children aged nine to 13 years require 445µg RE of vitamin A per day (Stanfield 1997:6-7, Institute of Medicine (IOM) 2004).

2.3.3.2 B vitamins

These vitamins are called the vitamin B complex. The B vitamins assist with converting carbohydrates, fat and protein into energy and assist with building and repairing body tissues. Deficiencies of these vitamins can lead to serious effects including muscular weakness, paralysis, mental confusion, nervous system disorders, digestive problems, cracked and scaly skin, severe anaemia and heart failure (FAO 1998:9). Folate deficiency is a common cause of anaemia among women and young children. Food sources rich in B vitamins are dark green vegetables, nuts, beans, cereals, peas, meat, fish and eggs (Stanfield 1997:89, Moore 1993:367). Children need a certain amount of B vitamins to ensure proper functioning of the body; table 2.2 shows the EAR for the B vitamins for children aged four to 13 years.

Table 2.2 Estimated daily requirement of B vitamins for children (IOM 2004)

Water soluble vitamins	**Children 4-8 years**	**Children 9-13 years**
Biotin (µg)	12 AI	20 AI
Folate (µg)	160 EAR	250 EAR
Niacin (mg RE)	6 EAR	9 EAR
Pantothenic acid (mg)	3.0 AI	4.0 AI
Riboflavin (mg)	0.5 EAR	0.8 EAR
Thiamin (mg)	0.5 EAR	0.7 EAR
Vitamin B-6 (mg)	0.5 EAR	0.8 EAR
Vitamin B-12 (µg)	1.0 EAR	1.5 EAR

2.3.3.3 Vitamin C

Vitamin C is needed to increase absorption of dietary iron, to make collagen (connective tissue) which binds the body's cells together and to serve as an antioxidant. According to the FAO (1998:9) and Stanfield (1997:84), prolonged vitamin C deficiency can lead to scurvy, failure to thrive in children and low resistance to infection. The symptoms of scurvy are bleeding gums and sore, swollen

joints and can lead to death. Vitamin C assists in bone and teeth formation. Most fruits especially citrus and guava and many vegetables, including potatoes, are good sources of vitamin C. According to the FAO (1998:9) eating fresh fruit and vegetables is important for both adults and children. Children between four and eight years of age require 22mg of vitamin C per day and children nine to 13 years require 39mg per day (Stanfield 1997:6-7, IOM 2004).

2.3.3.4 Vitamin D

Vitamin D is important in maintaining blood calcium and phosphorus levels for normal bone calcification. Vitamin D is found in fish, liver oils, eggs and milk, it is also produced by the body when the skin is exposed to sunlight (Stanfield 1997:93, Moore 1993:57). According to the FAO (1998:9), a lack of vitamin D can lead to rickets, a disease which causes soft and deformed bones in young children. For children between six and 13 years, an adequate intake of 5µg of vitamin D per day is recommended (Ensminger, Ensminger, Konlande & Robinson 1994: 398, IOM 2004).

2.3.3.5 Iron

Iron deficiency is the world's most widespread nutritional disorder, affecting both developed and developing countries. Iron is a major component of red blood cells and iron deficiency is the main cause of anaemia in children (WHO 2000). According to the FAO (1998:9) and WHO (2000), iron deficiency is most prevalent in children and woman of childbearing age. Iron deficiency leads to low work capacity, learning difficulties, poor growth and development, increased morbidity and maternal mortality at childbirth. In infants and young children, functional consequences include impaired psychomotor development, coordination and scholastic achievement and decreased physical activity levels (WHO 2000). A child aged between four and eight years requires 4.1mg of iron per day and a child aged between nine and 13 requires 5.9mg (Ensminger *et al.* 1994: 398, IOM 2004).

The major sources of iron include meat, fish, poultry, liver and other organs. Other sources are legumes, dark green leafy vegetables and dried fruits. Vitamin C should be included with foods containing iron to assist with absorption (Stanfield 1997:106).

2.3.3.6 Calcium and phosphorus

Calcium and phosphorus are important for body maintenance and healthy bones and teeth. Milk and dairy products are sources of calcium and phosphorus (FAO 1998:9). Calcium is required for the complex process of blood coagulation. Together with other materials it regulates the passage of materials in and out of cells, controls the transmission of nerve messages and brings about the normal contraction of muscles, including the heart. Calcium absorption is regulated according to the body's requirements for maintenance and growth. A four to eight year old child who is growing rapidly absorbs a greater proportion of the calcium in his/her diet than an adult who simply needs to maintain the level of calcium in the bones and soft tissue. An adult requires 800mg of calcium per day; for a child between nine and 13 years 1300mg is recommended as an adequate intake. Dairy products are a good source of calcium, and together with fruit and vegetables contribute a fair amount of the calcium intake of children (Moore 1993:369, Stanfield 1997:101, Ensminger *et al.* 1994: 398, IOM 2004).

Phosphorus is essential for building bones and teeth and numerous other functions in the body. If the diet of a child supplies enough calcium and protein, it will provide enough phosphorus. Milk, meat, poultry, egg yolks, legumes and nuts are rich sources of phosphorus (Stanfield 1997: 101-102). Children aged between four and eight years require 405mg of Phosphorus per day and the EAR recommends 1055 mg for children aged nine to 13 years (Ensminger *et al.* 1994:398, IOM 2004).

2.3.3.7 Iodine

According to the FAO (1998:9) and Stanfield (1997:107), iodine is important for proper growth and development. Children aged between four and eight years require

65µg per day and 73µg is recommended for children between nine and 13 years (Ensminger *et al.* 1994:398, IOM 2004). The lack of iodine can cause goitre (swollen thyroid gland) and mental retardation. Iodine is found in seafood and foods grown in iodine-rich soils as well as in iodised salt. Iron deficiency disorders (IDD) constitute the single greatest cause of preventable brain damage in the foetus and infant, and of retarded psychomotor development in young children. It remains a major threat to the health and development of populations globally, particularly among pre-school children and pregnant women in low-income countries. IDD results in goitre, stillbirth and miscarriages, but the most devastating toll is mental retardation and deaf-mutism. While cretinism is the most extreme manifestation, of considerably greater significance are the more subtle degrees of mental impairment that can lead to poor school performance, reduced intellectual ability and impaired work capacity (WHO 2000).

2.3.3.8 Zinc

Zinc deficiency causes growth retardation or failure, diarrhoea, immune deficiencies, skin and eye lesions, delayed sexual maturation, night blindness and behavioural changes. Zinc supplementation of malnourished infants and growth-retarded young children has resulted in improved growth (WHO 2000). Sources of zinc include animal and plant foods that are good sources of protein: organ meats, muscle meats, poultry, whole-grain breads and cereals, legumes, peanuts and peanut butter. Children aged between four and eight years require 4mg of zinc per day and for children aged between nine and 13 years 7mg is the recommended EAR (Ensminger *et al.* 1994:398, IOM 2004). Children that eat a normal diet that is adequate in protein are not likely to lack zinc (Stanfield 1997:107, Moore 1993:370).

2.3.3.9 Magnesium

Magnesium is a key nutrient in the body and plays a very important role in the processes that generate energy in the body. It is one of the nutrients that tend to be insufficient in the body and there is evidence that children and adolescents do not get

enough magnesium from their diet. Magnesium is important for normal nerve and muscle function and a shortage may contribute to cardiovascular disorders and high blood pressure. Magnesium is found naturally in foods such as leafy vegetables, fish, meat, beans, nuts and seeds. For children aged between four to eight years, the EAR for magnesium is indicated as 110mg/day and for children nine to 13 years 200mg per day is recommended (Briffa 2004:60,166, IOM 2004).

2.3.4 Water

Water has many functions in the body including the formation of cells and body fluids, chemical reactions and urine secretion to carry waste from the body. It is essential to maintain an adequate intake of clean water to replace the water lost by the body, especially in hot weather and during physical activity. Children may also become dehydrated when they have diarrhoea, vomiting and fever (FAO 1998:9). Water requirements depend on many factors, including the amount of solids in the diet, air humidity, environmental temperature, type of clothing worn, respiratory rate and the state of health. The body obtains water from food, beverages and the metabolic breakdown of food for use by the body. Next to oxygen, water is the most important nutrient for the body (Stanfield 1997:111).

2.4 Food consumption patterns and food consumed by children

Longitudinal studies on nutrition and growth in children indicate a number of associations between certain body features and the quality and composition of the daily diet. As children grow older, they do not remain stable in their food choices. Between the ages two and ten years, the content of their diet can vary greatly. Evidence shows that a very high protein intake at the age of two is accompanied by accelerated growth and an increase in body adipose tissue at ages eight to ten years. A nationwide study on eating patterns was undertaken in Italy with a large sample (=35072) in a population of school-age children (7-11years). Analysis of the results revealed that the average diet of Italian school children is marked by a very high intake of animal protein and fat and a lower intake of carbohydrates than is

recommended, an excess intake of sugar was also noted. Analysis of the results by gender indicated that the caloric intake was higher in boys and that the protein intake was higher in girls. This indicates that the eating habits of Italian school children do not coincide with national dietary recommendations.

The diets of USA teenagers are characterised by a low number of food choices and a high percentage of calories from sugar and fat. Sweet drinks, pizzas, french fries, bread, milk and yoghurt are among the food preferred. Fruit and vegetables are foods least preferred. In the USA efforts are being made to provide nutritional education for children, with emphasis on the need to replace fat and sugar in the diet by fruit, vegetables and grains (Kleinman 1997:13-14). School aged children's food choices and dietary habits are influenced by personal and environmental factors. The socio-cultural influence on food choices include indirect effects (availability) and direct effects (peers, parents and teachers effect on food choices). Indirect personal effects include norms, beliefs, knowledge and the attributes of the consumer. Body image is one of the most important factors in school age children's food choice. A culture's ideal body shape affects both how much and what is eaten and this focus on body shape has special implications for females. Knowledge and beliefs about food, such as which foods are good for you, are another indirect personal effect that influences food choice. Social pressure, role models and self-esteem are direct effects and choices of peers and teachers can influence the choices made by children (Bordi, Park, Watkins, Caldwell & DeVitis 2002:2)

2.5 Functional versus novel foods

Ashwell (2002:5, 16) and Roberfroid (2002:133-134) define a food as functional when the food has satisfactorily demonstrated a positive effect in one or more target functions of the body (beyond adequate nutritional effects), in a way that is relevant to either improved state of health and well-being and / or when the risk of disease is reduced. Functional foods are defined as those foods that are accompanied by a performance benefit statement or a health claim (O'Donnel 2003, IFIC 2000). In an industry survey conducted by Prepared Foods, functional foods were defined by 63

on the known formulation for similar products or recipes from cookbooks and should include fixed and variable costs.

According to Steward-Knox and Mitchell (2003:59-62), the following aspects should be considered when designing a new product:

- use of the product (for example as a snack or main meal)
- method of preparation
- minimum or maximum nutrient content
- expected shelf life
- type of storage
- target group
- cost

After development of the product, it should be tested by the target group; their responses and opinions are collected and recorded as data. The data is evaluated to determine if the product fulfils the purpose for which it was designed, does the product meet the needs of the target group, whether the product is easy to prepare and store, and if it is affordable and safe for consumption. To ensure quality control, set recipes and quantities of ingredients must be used for each product (Steward-Knox and Mitchell 2003:59-62, Rudder, Ainsworth & Holgate 2001: 658).

2.6.1 Steps in product development

New product development processes are characterised by eight major steps:

- Idea generation
- Idea screening
- Concept development and testing
- Marketing strategy development
- Business analysis
- Product development
- Test marketing

- Commercialisation

Idea generation generally includes methods such as brainstorming sessions amongst personnel, gathering of information from various sources such as customers, competitors and trade journals. Idea screening is a tool used to identify good ideas and eliminate poor ideas. Concept development and testing involves taking the promising idea to a more concrete level and parameters for the product are defined. The marketing strategy development stage allows for a detailed strategy to be developed and address the target market, the planned product positioning, sale and market share. During the business analysis stage factors such as review of sales, costs and profit projections are undertaken. Product development involves the production of a physical product. Test marketing is deemed suitable for products that have passed through the previous stages. Commercialisation is seen as the stage in which the new product is launched (Rudder *et al.* 2001:659).

Products launched by manufacturers could be aligned with one of the six categories below:

1. New to the world products (10 percent)
2. New product lines (20 percent)
3. Additions to existing product lines (26 percent)
4. Improvements to existing products (26 percent)
5. Repositioning of existing products (7 percent)
6. Cost reduction: new products that provide similar performance at lower cost (11 percent) (Rudder *et al.* 2001:663).

2.7. Sensory evaluation

Sensory evaluation is the science of judging and evaluating the quality of a food by the use of the senses, i.e. taste, smell, sight, touch and hearing. Sensory testing has been developed into a precise, formal, structured methodology that is continually being updated to refine existing techniques. The developed methods serve economic interests and can establish the worth or acceptance of a commodity. Sensory

evaluation is used as a practical application in product development by aiding in product matching, improvements and grading. Research is another area where sensory evaluation is frequently used. Evaluation of a product may be needed to determine the effects of an experiment on its subjects. Finally, quality control and marketing is another application of sensory testing (Meilgaard, Vance Civille & Carr 1991:2).

Sensory evaluation is divided into two methods, subjective and objective testing. Subjective tests involve objective panelists, while objective testing employs the use of lab instruments with no involvement of the senses. Both tests are essential in sensory evaluation and necessary in a variety of conditions (Meilgaard, Vance Civille & Carr 1991:2). According to Steward-Knox and Mitchell (2003: 59-62) and Heymann (1995:2), sensory analysis is the scientific discipline used to evoke, measure, analyse and interpret reactions to characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing.

In the development of a functional food the method of consumer sensory evaluation was used. The goal was to study the subjects' responses and emotional reactions to the product. In the sensory analysis it was determined whether consumers liked the product and found it acceptable. All subjects who participated in the evaluation had to be part of the target consumer group. The primary function of sensory testing is to conduct valid reliable tests that provide data on which sound decisions can be made. Subjects used as the measuring instruments in sensory evaluation prove to be variable over time, variable amongst them selves and extremely prone to bias. To account adequately for these variations it is necessary for the measurements to be repeated and to have enough subjects (20-50) so that the findings are representative. Subjects should not be interchanged half way through a project. After the selection of the subjects they must be trained to fully understand the task at hand (Meilgaard *et al.* 1999:2). Knowledge of the test's objective, the type of information required and the selection of a scale for use in a particular test are some of the tasks to be conducted before a sensory test can be implemented. The words used for questions must be familiar, easily understood and unambiguous to the subjects. Words used

must have specific and useful meaning, must be readily related to the product and task, and must make sense to the subject in the context of the test. The task and scale must be easy to use to prevent subject frustration and increased measurement error. Ideally, the scale is a "null" instrument that does not influence the test outcome. Unbalanced scales can easily bias results because they decrease the expected probability for responses in categories that are under represented. The scale measures characteristics and attitude, for example preference scales should measure preference and quality scales should measure quality. Statistical analysis of responses is critical in determining whether results are due to change or some treatment variables (Stone & Sidel 1993:68-69).

2.7.1 Use of the hedonic scale in sensory evaluation

One of the subjective tests is the Hedonic scale method. This rating scale measures the level of the liking of foods, or any other product where an affective tone is necessary (O'Mahony:1986:12). These scales are primarily intended for use with children and those with limited reading and/or comprehension skills. Face scales are types of quality scales. Face scales can be described as a series of line drawings of facial expressions ordered in a sequence from a smile to a frown or a very unhappy face. The facial expression may be accompanied by a descriptive phrase and may have five, seven or nine categories. An appropriate orientation is needed, so that the children understand the meaning of the different facial expressions and what their task will be (Stone & Sidel 1993:68). This test relies on peoples' ability to communicate their feelings of like or dislike. Hedonic testing is popular because it may be used with untrained people as well as with experienced panel members. A minimum amount of verbal ability is necessary for reliable results (O'Mahony 1986:12).

In Hedonic testing, samples are presented in succession and the subject is asked to decide how much he likes or dislikes the product and to mark the scales accordingly. The main benefit of this test is its relative simplicity. The instructions to the panellist are restricted to procedures and no attempt is made at direct response. The subject is

however allowed to make his / her own inferences about the meaning of the scale categories and determine how to apply them to the samples. A separate scale is provided for each sample in a test session. The scales may be grouped together on a page, or be on separate pages. The Hedonic scale is anchored verbally with nine different categories ranging from like extremely to dislike extremely. These phrases are placed on a line-graphic scale either horizontally or vertically. Many different forms of the scale may be used with success, however variations in the scale form is likely to cause marked changes in the distribution of responses and ultimately in statistical parameters such as means and variances. Hedonic ratings are converted to scores and treated by rank analysis or analysis of variance. The ratings labels obtained on a hedonic scale may be affected by many factors other than the quality of the test samples. Characteristics of the subjects, the test situation, attitudes or expectations of the subjects can all have a profound affect on results. A researcher needs to be cautious about making inferences on the basis of comparison of average ratings obtained in different experiments. Many other tests, besides hedonic scales are used in the sensory evaluation of a food product. Determining the type of research that is being done, and the type of evaluation that is needed is crucial in order to obtain accurate results from a sensory project (Stone & Sidel 1993:68).

Table 2.3 Example of a sensory analysis smiley face scale

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot
□	□	□	□	□
Please mark the box under the figure which best describes how you feel about this product.				

2.8 Shelf life measurements

Shelf life is defined as the time during which the food product will remain safe and certain to retain desired sensory, chemical, physical and microbiological characteristics when stored under recommended conditions (Kilcast & Subramaniam 2000:2-4) Establishing the microbiological shelf life of the product is important. Many factors must be considered when designing a microbiological shelf life study, among these are: temperature, water content, time, types of micro-organisms, and presence of preservatives suitability of analysis, sampling, storage temperature and replication (Curiale 1998, Kilcast & Subramaniam 2000:2-4).

Shelf life studies should be designed specially for a particular product because of the number of variables that must be considered. Storage temperature usually determines the length of microbial shelf life of perishable foods. As the temperature increases, the microbial growth rate increases. At temperatures near freezing, organisms either grow very slowly or not at all. As the temperature increases beyond the optimum, the growth rate begins to slow. At some maximum temperatures, growth stops and higher temperatures begin to kill the cells. Each species of organism has a different minimum, optimum and maximum growth temperature range. When the storage temperature of a product changes; it is most likely that the shelf life, as well as the types of spoilage flora will change. Due to the important relationship between growth rate and storage temperature, the most useful shelf life information is obtained when the product is kept at its intended storage temperature.

Refrigerated products must be stored in the refrigerator and room temperature products should be stored at ambient conditions. Small changes in storage temperature may have a significant effect on the shelf life of the product. A few degrees may determine the difference between good shelf life and premature spoilage. Refrigerator and room temperatures may differ and to produce a meaningful study, temperatures must be known. This is most easily accomplished if the study temperatures are fixed and not varied.

Water level determines the characteristics of many foods. Some foods are expected to be dry, some appear moist and others contain water. Water is essential for microbial growth and if the amount of water changes, a food's susceptibility to spoilage may change. If a dry product that is resistant to spoilage becomes damp, it will likely spoil. Food packaging plays an essential role in the control of moisture, and has a significant effect on shelf life. There is an exchange of moisture between the atmosphere and food, this exchange continues until the food reaches equilibrium with the atmosphere (Curiale 1998).

Shelf life represents the useful storage life of food. At the end of the shelf life, the food develops characteristics - changes in taste, aroma, texture or appearance that are deemed unacceptable or undesirable. The underlying cause for the change may be microbiological, chemical or physical. Microbiological spoilage is exemplified by the above attributes. Examples of chemical and physical deterioration include rancidity and freezer burn. Food is a chemically complex matrix and predicting whether and how fast micro organisms will grow in any given food is difficult. Most foods contain sufficient nutrients to support microbial growth (USFDA 2001).

2.8.1 Duration of shelf life tests

A study's duration should at least match the target shelf life for the food being considered. A study may be designed to exceed the shelf life goal if expectations are met and the point of spoilage needs to be determined (Curiale 1998). It is also desirable to re-test the product significantly beyond its entire shelf life because sub-lethal injury may occur in some products. This can lead to a long lag period, where it may not be possible to culture inoculums, but over time, a small number of injured cells recover and grow in the product. The frequency of testing is governed by the duration of the microbiological challenge study. It is desirable to have a minimum data of five to seven points over the shelf life in order to have good indication of the inoculum's behaviour. If the shelf life is measured in days, the frequency of testing should be at least daily. If the shelf life is measured in weeks or months, the test frequency is no less than once a week. All studies will start with "zero time" testing,

(analysis of the product right after inoculation). It may be desirable to test more frequently early in the challenge study and then reduce the frequency of the testing to longer intervals (Kilcast & Subramaniam 2000: 3, USFDA 2001).

2.8.2 Selection of challenge organisms

Table 2.4 depicts certain pathogens that may be used in challenge studies for various types of foods. Knowledge of the food formulation and the history of the food is essential when selecting the appropriate challenge pathogens. Multiple specific strains of the target pathogens should be included in the challenge study. It is typical to challenge a food formulation with a "cocktail" or mixture of multiple strains in order to account potential strain variation. It is important to incubate and prepare the challenge suspension under standardised conditions (USFDA 2001).

Table 2.4 Pathogens used in challenge studies for various food products (adapted from USFDA 2001, 11, Vestergaard 2001:209).

Food type	**Type of organism**
Salad dressing	*Salmonellae, Staphylococcus aureus*
Bakery items (fillings, icings, non-fruit pies)	*Salmonellae, Staphylococcus aureus*
Sauces and Salsas stored at ambient temperature	*Salmonellae, Staphylococcus aureus*
Dairy products	*Salmonellae, Staphylococcus aureus, Clostridium botulinum*, enterohemorrhagic *Eschericia coli, Listeria monocytogenes*
Confectionary products	*Salmonellae*
Formula with new preservatives	*Salmonellae, Staphylococcus aureus, Clostridium botulinum*, enterohemorrhagic *Eschericia coli, Listeria monocytogene*

2.8.3 Sensible sampling

How often a food is analysed for micro organisms during the shelf life study must be decided with care in order to detect significant microbiological events. It is desirable to have at least two samples for analysis each time. In cases where higher levels of certainty are needed, a larger number of replicates should be used or the study should be replicated (Curiale 1998, USFDA 2001).

2.8.4 Spoilage susceptibility

Micro organisms possess specific growth requirements for temperature, moisture, acidity, nutrients and time. For micro organisms to grow, cultural conditions must be within a certain range. If minimum conditions are not satisfied, growth will not occur. In general, organisms grow at temperatures between 0° and 55°C, at pH values between two and 10 and at water-activity levels greater than 0.6. These delimited ranges are not absolute, and the boundaries between them are not usually sharply defined. Optimal growth generally occurs in the middle region of the various ranges and slows as the boundaries are approached. Assessing a food item in terms of its microbial growth requirements, makes it possible to determine its potential for spoilage. The taste, odour and appearance of a food are the ultimate criteria used by consumers to judge food's acceptability.

Organoleptic evaluation of food can be used as a direct method for determining shelf life. The food is prepared and periodically examined for changes in appearance, aroma, texture and taste until it becomes unacceptable. The organoleptic quality of food changes its micro-flora: bacteria, yeast and mould grow and metabolise available nutrients. The sensory changes are initially subtle, but they eventually make the food unacceptable. High numbers of micro-organisms are normal in certain foods, but indicate deterioration in other foods. Therefore, it is desirable to know, even in the absence of objectionable organoleptic changes, the microbiological state of food as it nears the end of shelf life.

For the delivery of a product with maximum quality, the shelf life of a product should be determined by organoleptic and microbiological examination. Several factors encourage, prevent or limit the growth of micro organisms in food; the most important are water activity or water availability (a_w), Hydrogen ion concentration (pH), and temperature (USFDA 2001, Curiale 1998).

2.8.4.1 Water activity or water availability

Water molecules are loosely orientated in pure liquid water and can easily rearrange. When other substances are added to water, water molecules orient themselves to the surface of the solute and the properties of the solution change dramatically. The microbial cell must compete with solute molecules for free water molecules. Bacteria are poor competitors, with the exception of *Staphylococcus aureus*, whereas moulds are excellent competitors.

A solution of pure water has an a_w (water activity) of 1.00 and the addition of a solute decrease the a_w to less than 1.00, a_w varies very little with temperature over the range of temperatures that support microbial growth. The a_w of a solution may dramatically affect the ability of heat to kill a bacterium at a given temperature. For example, a population of *Salmonella typhimurium* is reduced tenfold in 18 minutes at 60° C, if the a_w of the suspending medium is 0.995. If the a_w is lowered to 0.94, it takes 4.3 minutes at 60° C to cause the same tenfold reduction. An a_w value stated for a bacterium is generally the minimum a_w which supports growth. Growth is minimal at the minimum a_w and increases as a_w increases. At a_w values below the minimum for growth, bacteria do not necessarily die, the bacteria may remain dormant but infectious.

Most importantly, a_w is only one factor, and other factors must also be considered because it is the interplay between factors that determines if the bacteria will grow or not. In food a_w may change over time and may vary considerably between similar foods from different sources (USFDA 2001). The a_w of a food or food ingredient is more closely related to quality in terms of shelf life stability as affected by chemical,

enzymatic, and microbiological changes and compatibility with other foods, formulation and packaging requirements than the moisture content of the food itself. The a_w directly, or indirectly, affects the texture, appearance, aroma, taste, freeze-thaw stability and the microbiological, chemical and other characteristics of food (Weaver & Daniel 2003:43).

2.8.4.2 Hydrogen ion concentration (relative acidity or alkalinity)

The pH (Hydrogen ion concentration) range of a micro organism is defined by a minimum value (at the acidic end of the scale) and a maximum value (at the alkaline end of the scale). There is a pH optimum for each micro organism at which growth is maximal. Moving away from the pH optimum in either direction slows microbial growth. Shifts in pH of a food may reflect microbial activity over time. A food may start with a pH which precludes bacterial growth, but as a result of the metabolism of other microbes (yeasts or moulds), pH shifts may occur and allow bacterial growth (USFDA 2001).

2.8.4.3 Temperature

Temperature values for microbial growth have a minimum and a maximum range, with an optimum temperature for maximal growth. The rate of growth at extremes of temperature determines the classification of an organism (e.g. psychrotroph, thermothrop). The optimum growth temperature determines its classification as a thermophile, mesophile, or psychophile (USFDA 2001).

2.8.4.4 Interplay of factors affecting microbial growth in foods.

The interplay of the abovementioned factors plays an important role and determines whether a micro organism will grow in a given food. Predictions about whether or not a particular micro organism will grow in a food can only be made through experimentation (USFDA 2001).

2.8.4.5 Typical growth cycle of a population of micro organisms

The growth cycle consists of four phases. The beginning of the cycle is the "lag phase". Increases in cell numbers are not observed during this time and the food appears to be microbiologically stable. In the second phase, called the "growth phase" the cells begin to multiply. The product begins to change and is considered unstable. At some point along the microbial growth curve, the food usually will spoil. Therefore, for shelf life, the significant points concerning the microbial growth cycle are; the duration of the lag phase, the growth rate and the microbial count at the end of the growth phase. The end of shelf life 10 million bacteria or 100,000 yeast per gram usually occurs near the end of the "growth phase". To identify the different transition points along the growth path, the food is sampled periodically to quantify the number of organisms present.

An excessive period between samplings increases the risk of under- or over-estimating shelf life. The more analyses completed, the more accurate the shelf life determination will be. In the "stationary phase", neither the rate of growth nor the number of cells continues to increase. Growth stops at a density usually not exceeding 1,010 bacterial cells or 106 yeast cells per gram. The final phase of the cycle is called "the death phase" since cell viability decreases. Replication of the shelf life study will enhance the accuracy of the prediction. Periodic determinations of shelf life help to provide assurance that the product remains consistent over time with respect to spoilage rate. Accurate prediction of shelf life necessitates a carefully planned and executed series of experimental studies (Curiale 1998).

2.8.5 Methodical approach.

Microbial growth in foods for estimation of shelf life is most commonly monitored using agar plating procedures. The procedures are quantitative for the number of viable organisms present at the time of analysis. Because of differences in growth requirements among different types of micro organisms that may be found in food, no single procedure is available to enumerate all micro organisms. A simple

procedure is the aerobic plate count, which detects organisms that form colonies on plate count agar, usually incubated at 35°C for 48 hours. The plating procedure must be selected on the basis of the type or types of organisms anticipated or known to be present in the food (Curiale 1998).

2.8.6 Inoculum level

The inoculum level used in microbiological challenge study depends on whether the objective of the study is to determine product stability, shelf life or to reduce microbial numbers. Typically, an inoculum level of between 10^2-10^3 cells/g of product is used to ascertain the microbiological stability of a formulation. Higher inoculum levels may be appropriate for other products. Depending on the product formulation, some of the inoculum may die off initially before adapting to the environment. If an inoculum level that is too low is used, the incorrect assumption that the product is stable, when it is not, could be made (USFDA 2001).

2.8.6.1 Inoculum preparation and method of inoculation

The preparation of the inoculum to be used in microbiological challenge testing is an important part of the process. Appropriate procedures and containment facilities should be used when carrying out challenge tests with pathogens. The method of inoculation is extremely important when conducting a microbiological challenge study. Every effort must be made not to change the critical parameters of the product formulation undergoing challenge (USFDA 2001).

Table 2.5 Methods for chemical analyses of products to determine the nutrient content (Oldewage-Theron & Amuna 2002)

Nutrient	Method	Basic Principle
Protein	Total Kjedahl digestion method Modified Berthelot reaction	Acid is used to release nitrogen from the sample, which is then measured and used to derive protein value by using a conversion factor.
Fat	Acid - hydrolysis	Hydrochloric acid is used to digest the sample of fat and ether is added to dissolve 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 and 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 and Zn)	Inductively coupled plasma mass spectroscopy (ICP-MS)	Sample is digested in acid to release minerals. ICP - MS ionizes 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 non polar liquid immobilized on an inert matrix. A more polar liquid that serves as a mobile phase is passed over the matrix, solute molecules are eluted in proportion to their solubility
Vitamins (other)	Theoretical calculations	SA food composition tables and Food Finder/Dietary Manager®.

2.8.7 Data interpretation

After completion of the microbiological challenge, the data should be analysed, to see how the pathogens behaved over time. Trend analysis and graphical plotting of the data will indicate whether the challenge organisms died, remained stable or increased in numbers over time. In the case of toxin-producing pathogens, there should not be any trace of toxin detected over the designed challenge period. When the quantitative inoculum data for each time point is combined together with the acquired data on the background, micro flora and relevant physic-chemical parameters, gives a powerful representation of the microbiological stability of the formulation under evaluation is acquired. Based on this data, a reasonable shelf life can be established. Microbiological challenge studies can provide critical information on the microbiological safety and stability of a food formulation. Challenge studies can be valuable in determining whether a food product requires temperature control throughout its shelf life or if the product can tolerate storage at room temperature for a part of its shelf life (USFDA 2001).

2.9 Conclusion

The first two chapters have provided the theoretical background to this project. It can be concluded from the literature that malnutrition continues to be a concern in school aged children globally and in SA. Many strategies such as fortification, supplementation, food diversification and the Nutrition Education Programme (NEP) are undertaken to address the various forms of malnutrition. School feeding programmes are an important strategy to address malnutrition amongst primary school children. The benefits include reducing malnutrition as well as improving school attendance and cognitive performance. School feeding also forms part of the South African Integrated Nutrition Programme. The aim of this study was to develop a food product that would be cost effective, culturally acceptable and easy to prepare and to address the specific nutrient deficiencies found in this low-income community. The following chapters will describe the methods, results and recommendations of the process followed.

Chapter 3 Methodology

3.1 Introduction

This project was a team effort. The principal investigator, C. Napier, was responsible for the ethics approval and initial planning of the project. The researcher's responsibilities were the following.

1. Co-investigating a baseline situation analysis with C. Napier, in conjunction with the baseline survey
2. Conducting a breakfast survey
3. Development of the product
4. Sensory analysis of the product
5. Shelf life testing of the product (with the assistance of the ARC)
6. Designing a recipe pamphlet

This project concentrated on the development of a novel food product for school feeding. The nutritious novel food was developed with the objective of addressing nutrient deficiencies identified in the baseline study, in order to improve the nutritional status of previously disadvantaged primary school children in the Vaal Triangle, who were not receiving breakfast.

This product initiated the involvement of local communities and the non governmental organisations in the Vaal Triangle for the upliftment of the community. A primary school, situated in an informal settlement, was chosen for the intervention. Permission from the Department of Education (Annexure 1) and the School Governing Body (SGB) had previously been obtained. Negotiations with the school took place for their participation and approval from the SGB and the school principal was obtained. Ethical clearance was also obtained (Annexure 2). Children aged six to 13 years old were randomly selected for participation. Information sessions with the parents were held and consent for participation was obtained. Formal training sessions were provided for the community workers to prepare the

product. Measuring instruments were developed and tested and the fieldworkers were trained accordingly.

3.2 The three phases of the project

This project was undertaken in three phases, namely a baseline survey, product development and acceptance and shelf life testing. Each phase will be described separately.

3.2.1 Phase1: Baseline survey

The nutritional status of a random sample of 80 male and female primary school children, aged six to 13 years (representing 15 percent of the total school population) was assessed. The school is situated in a semi-urban area in Gauteng, South Africa and is only attended by children from the informal settlement under investigation. The school was identified when a strategic roundtable participatory planning workshop with all stakeholders was held in May 2002. The stakeholders included local government councillors for the region, a department of health representative and a department of education representative. The stakeholders all identified Eatonside as a community seen as "the poorest of the poor". The pilot study was conducted during 2002, the year before this study took place.

3.2.1.1 Objectives

Adequate information was needed on the existing nutritional status and dietary intake of primary school children, specifically those living in an informal settlement, as well as the food consumption patterns of these children.

3.2.1.2 Ethics

All the children obtained written parental consent to participate in the study (Annexure 3). The study was approved by the ethics committee of the University of

the Witwatersrand (WITS) Medical Ethics Committee for research on human beings (Annexure 2) and data was collected in May 2003.

3.2.2 Sampling strategy

3.2.2.1 Sample selection

The nutritional status of a random sample of primary school children in a public school, in an informal settlement in Gauteng, South Africa was assessed. The school is situated in a semi-urban area and is only attended by children from this informal settlement.

The first contact was made by a visit to the department of Education to obtain permission to do a study in a government school (Annexure 1). In this project the focus was on children aged six to thirteen years, in a primary school in an informal settlement.

The sample was stratified as follows:

1 children of age six to thirteen years
2 male and female
3 geographical area – residing in the informal settlement
4 attending the primary school

3.2.2.2 Sampling procedure

A random sample, representative of the community was chosen. The selection criteria for the above included the following:

1. Households with children in primary schools
2. Resident in the informal settlement
3. At least one person in that household should be literate.

In this project the following were excluded:

1 Children under the age of six and above the age of 13
2 Children in Sasolburg, Meyerton and other Vanderbijlpark and Vereeniging Municipal areas.

The parents of all the children meeting the inclusion criteria, in the school (n=519) were asked to participate, of whom 80 agreed. A total of 80 children (n=15 percent of total school population) were thus included in the sample population of the pilot study.

3.2.3 Fieldworker training

Food and Beverage management third year students and B Tech students were trained to act as fieldworkers by a registered dietician. These students were all Sotho speaking women. Training for the initial implementation of the activities and refresher courses throughout the project were included. Trained fieldworkers completed questionnaires in an interview situation and gathered information for the pilot study, from the sample population. Field workers were responsible for distributing and completing the questionnaires, weighing and measuring the children and issuing the snacks. The field workers received detailed instructions regarding anthropometric measurements and administering the qualitative food frequency questionnaire. Emphasis was placed on ensuring that the field workers were aware of the objectives and importance of the project.

3.2.4 Questionnaires

Three different questionnaires were used in this study. The questionnaires were kept simple and easy to read, as this is an illiterate community. The study conducted by Oldewage-Theron *et al.* (2005:17) in this community indicated that education levels were low and only 28 percent of the respondents attended high school or college. All the questionnaires were completed by the parents with the assistance of trained fieldworkers.

3.2.4.1 The socio-demographic questionnaire

The socio-demographic questionnaire (Annexure 4) included questions to determine: household density, number of children in the family, age of child, gender of the children, parents living at home, parents' education, parents' occupation, income level of the household, geographical area and money available for school snacks.

3.2.4.2 Quantitative food frequency questionnaire

The dietary intake and food consumption patterns were determined by a quantitative frequency food questionnaire (QFFQ) (Annexure 5) as test measurement and a 24-hour recall as reference measurement. The validated QFFQ that was used in the Transition and Health during Urbanisation in Southern Africa (THUSA) study (Macintyre 1998:200) was used in this study to obtain qualitative, descriptive information about usual food consumption patterns. The questionnaire consisted of two components namely a list of the foods and a set of frequency-of-use response categories. An extensive list of simply defined foods was included with the aim of estimating total food intake, and thus dietary diversity. The QFFQ was designed to include additional snacks and breakfast foods, to determine the need of a lunch box snack/meal for children attending the primary school. The QFFQ provides a retrospective review of intake frequency, i.e. food per day, per week or per month. For ease of evaluation, the food frequency questionnaire organises food into groups that have common nutrients. All the QFFQs were completed for the subjects by the fieldworkers, during an interview situation with the mother or caregiver. Food models were used simultaneously to determine portion sizes and to explain the food item to subjects.

3.2.4.3 24-Hour recall

Nutrient intake data depends to a large extent on methods used to obtain information on dietary habits and intakes. The 24-hour recall (Annexure 6) method tends to measure lower intakes, than diet history and food frequency questionnaires (Vorster,

Oosthuizen, Jerling, Veldman & Burger 1997:3). The 24-hour recall asks the person to list specific foods and the amount of foods they consumed in the last 24 hours, for use by the information processing professional. Problems that can be experienced in using this method include:

- Inability to accurately recall the kinds and amounts of food eaten
- over reporting low food intake
- under reporting high food intakes

Using a QFFQ and the 24-hour recall method in combination provides a more accurate estimation of food intake (Mahan and Escott-Stump 2004:366).

3.2.4.4 Breakfast consumption questionnaire

Breakfast consumption questionnaires (Annexure 7) were drawn up to determine the number of children who ate breakfast before going to school, and what specific food items were consumed.

3.2.5 Reproducibility

All the questionnaires, except the QFFQ and the 24 Hr recall, were tested on ten randomly selected female caregiver volunteers from the informal settlement for reproducibility. The purpose and content of each of the questionnaires was explained by the fieldworkers and then completed by the subjects. Repeat interviews took place for four consecutive weeks after the first interview. The subjects were randomly assigned to the field workers and were not necessarily interviewed by the same fieldworkers. This was conducted in order to eliminate observer bias. All of the completed questionnaires were statistically analysed to detect variables for individual subjects. No consistent pattern of variables was reported.

3.2.6 Measuring instruments

3.2.6.1 Anthropometric measurements

Two of the fieldworkers were responsible for measuring weight and height and recording these results. Body weight, in light clothing with shoes removed was determined to the nearest 0,1 kg and height to the nearest 0,5cm using a vertical length scale.

The height measurements were conducted as follows:

- The subject had to remove his/her shoes.
- The subject was positioned as follows:
  - facing the fieldworker
  - shoulders relaxed, with shoulder blades, buttocks and heels touching the measuring board
  - arms relaxed at the sides
  - legs straight and knees together, feet flat and heels touching
- The subject had to look straight ahead before the headpiece was slid down on the head. It just touched the crown of the head.
- The fieldworker recorded the reading in mm on the anthropometric measurement space provided on the demographic questionnaire.
- The procedure was repeated. The two readings should not vary by more than 5 mm.
- If the two readings varied by more than 5mm, the procedure was repeated until the two readings were within 5mm of each other.
- An average of the two readings within 5mm was recorded (SAVACG 1995:103).

The weight measurements were conducted using a digital Phillips scale as follows:

- The scale was placed on an even uncarpeted area with the spirit level indication in the middle.
- The scale was switched on and waited until the zero indicator (0.0) appeared as

well as the stable indicator (° in the top left-hand corner of the display panel).

- The subjects were weighed in light clothes, without shoes, after emptying their bladders.
- The subjects were placed on the scale. They had to stand upright in the middle of the platform, facing the fieldworker and looking straight ahead. Their feet had to be flat and slightly apart. They had to stand still until the measurement was recorded.
- The subject had to step down from the scale and wait for the zero reading to appear on the digital display.
- The procedure was then repeated. The readings had to be within 100g of each other.
- If the two readings were not within 100g of each other, the procedure was repeated until the two readings were within 100g of each other.
- An average of the two measurements was recorded (SAVACG 1995:100-101).

Photo 1 One of the subjects being weighed

3.2.6.2 Biochemical measurements

The subjects were required to fast overnight (12 hours). Venous blood samples were collected using a 21-guage scalp vein infusion set. All the blood samples were drawn with minimal stasis and between 07H00 and 10H00 to avoid effects of diurnal variation. Venous blood samples were drawn by a qualified nursing sister from *the vena cephalica* of seated subjects (after a 5-6 hour fast) using a Vacutainer needle with minimal use of tourniquets. Vacutainer blood collecting tubes were labelled in advance with the subject's trial number as well as the date.

Blood samples were collected as follows:

- 5ml Blood in ethylene diamine tetra-acetic acid (EDTA) tubes (purple lid) for full blood counts, total protein, albumin, vitamin B12 and folate.
- 10 ml Blood in silicone-coated tubes for preparation of serum for the analysis of serum retinol, vitamin E and zinc. The tube was immediately protected against UV light (after collection), by covering the tube with aluminium foil.

Photo 2 Registered nursing sister drawing blood from van of the subjects

All the blood samples were collected and handled by a haematologist under controlled, standardised conditions. One of the most important attributes of the project was the importance placed on the quality of the data. A monitoring haematologist visited the blood collection point to check and calibrate the equipment in use and to supervise the data collection. Detailed monitoring checklists were maintained to verify whether appropriate techniques were being employed for each point of the data collection. The laboratories involved in the analysis of the full blood count used standard techniques according to existing routine procedures.

3.3 Data analysis

3.3.1 Demographic questionnaires

After completing the fieldwork, questionnaires were sorted and checked for completeness, accuracy and usability by the researcher, 80 questionnaires were usable. The data on the completed questionnaires was captured on Excel spreadsheets by the researcher. The demographic questionnaires were analysed with the assistance of a statistician for descriptive statistics. Tables were drawn up with the percentages of the different variables included on the questionnaire. Standardised methods were used.

Data were presented in terms of frequencies and percentages for the following categories:

- age,
- gender,
- number of children per household,
- household income,
- regional dimensions and
- occupation of the breadwinner.

Photo 3 Trained fieldworkers completing questionnaires

3.3.2 Dietary intake

A 24-hour recall, a breakfast pattern questionnaire and QFFQ, previously validated in the THUSA study were obtained from each child together with the parent / caregiver during personal interviews. Food models were used to assist in the quantification of portion sizes. Data was captured and analysed by a qualified dietician using the Food Finder® version 3.0 computer software program. The QFFQs were analysed and the nutrient intake and foods consumed were established. The data from the QFFQs were captured and related in tables and graphs for interpretation. The statistical analysis was conducted by an independent statistical analyst to determine the adequacy of the nutrient intake and prevalence of deficiencies that could be concluded from the QFFQs. The minimum, median and maximum intake with standard deviation of the children were analysed and compared to 100 percent of the DRIs. From the data, a top 15 list of foods most frequently consumed was drawn up. The association of nutrient intake and nutritional status was compared at <67 percent of the RDAs.

3.3.3 Breakfast consumption

The questionnaires were captured on Excel spreadsheets and statistically analysed for descriptive statistics to determine the breakfast consumption patterns of the school children. From the data a list of the top 20 food items most frequently consumed for breakfast food was completed.

3.3.4 Anthropometric measurements

The National Centre for Health Statistics (NCHS) growth charts were used to make a statistical comparison of the anthropometric indicators. As recommended by the WHO, the nutritional status of the children in the survey was compared with an international reference population defined by the NCHS. Height and weight measurements were classified according to these percentiles, which are generally used as an intentional reference population. For this study, age was calculated in years from the date of birth to the actual date that each child participated in the survey (Flegal, Wei & Ogden 2002:761).

The anthropometric measurements were captured on an Excel spreadsheet and sent to a statistician for analysis. Scatter plots were drawn on the NCHS growth charts. The indices included the following; BMI-for-age, weight-for-age and height-for-age indicated on the 5^{th}, 50^{th} and 95^{th} percentile of the NCHS median (Flegal *et al.* 2002: 761).

3.3.5 Biochemical measurements

Blood was separated (centrifuged at 1.500 Xg for 20 minutes) within 2 hours of collection by a heamatologist. Separated plasma and serum were Eli quoted in marked Eppendorf test tubes. Two qualified medical technologists continuously audited the separating procedure. Serum for the analysis of ferritin, total protein, albumin, vitamin B12 and folate was stored at -10° C until analysis. Serum for retinol, vitamin E and zinc analysis was covered with aluminium foil and stored at -

10 °C until it was couriered to the Nutritional Intervention Research Unit of the Medical Research Council (MRC) in Cape Town. The EDTA tubes were directly placed on a sample tube mixer for immediate analysis. After analysis, the haematologist captured the data on an Excel spreadsheet, thereafter it was analysed using SPSS for means and SDs.

A total of 80 blood samples were drawn for the determination of serum vitamin A, haemoglobin, haematocrit (Hct), zinc, iron, ferritin, transferrin and total iron binding capacity. The following samples were collected from each subject:

- 5 ml EDTA (whole blood) for full blood counts and measurement of haematological markers: Hct, mean cell volume (MCV), red blood cell count (RBC), haemoglobin (Hb) and white blood cell count (WBC);
- 20 ml blood in silicone-coated tubes for preparation serum for the analysis of retinol, iron, ferritin and transferrin;
- 4, 5 ml venous blood in a tube containing 0, 5 ml sodium citrate (0, 11 mol/L) for the preparation of plasma to measure fibrinogen levels.

3.4 Phase 2: Development of the product

3.4.1 Criteria for the development of the product

The product that was developed was based on the following criteria: affordable to the community, prepared with available foods that are widely consumed, a sustainable product that can address under-nutrition. The main ingredients were based on the staple food items, most commonly, used in the community as indicated in the baseline survey (Napier. 2003). The product that was developed was a maize "vetkoek" (small cake made from deep-fried unsweetened dough, a typical South African snack).

The development of the nutritious novel food product was based on the following criteria:

- Balanced nutritional value - rich in energy zinc and iron. (The vetkoek was developed to meet an average of 25 percent of DRIs for energy, iron, zinc, calcium and vitamin A for children six to 13 years of age).
- Easy to prepare (18.9 percent illiterate mothers, only 17 percent of the households had access to electrical stoves and 8.8 percent had access to coal, 75.6 percent of the households had access to paraffin stoves).
- Minimal waste (ingredients must be available in the households).
- Acceptable to children (62 percent of children had bread and tea for breakfast, ingredients form part of food items most commonly consumed, vetkoek is a product that is well known by children in the Eatonside Area).
- Cost effective (<R 2.00 per person per day).

Photo 4 Ingredients used in the product were part of the top 15 food items consumed.

3.4.2 Different recipes identified

Five different vetkoek recipes were identified as possible products. A cost analysis was performed for each recipe to determine the three most cost effective recipes, with locally available ingredients. Each recipe was nutritionally analysed and the three most suitable were chosen.

3.4.3 Preparation and preliminary sensory testing

3.4.3.1 Formulation of the product (theoretical)

Five different vetkoek recipes were initially chosen. The Dietary Manager program, based on the SA food consumption tables, was used to evaluate the five recipes for nutritional content. The nutritional content of each recipe was compared to the DRI of children aged between six and 13. Different ingredients from the top 20 consumed foods (as indicated in the baseline survey) were added and after inclusion of ingredients the recipe was theoretically analysed by the Dietary Manager Program to determine the influence of single ingredients on the nutritional value of the recipe. A cost analysis was performed for each recipe to determine the recipe meeting the criteria of < R2.00 per portion.

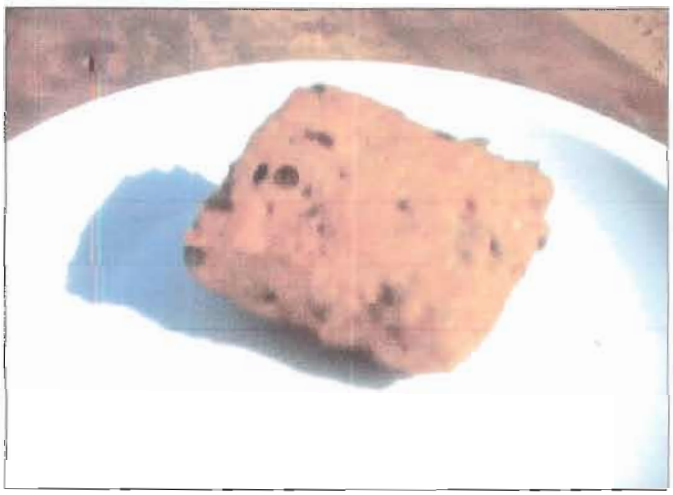

Photo 5 Vetkoek portion of 120 g

3.4.4 Biochemical analyses

The three recipes with nutrition values meeting the criteria closest to 25 percent of DRIs (for energy, iron, zinc, calcium, and vitamin A) for children six to 13 years of

age were selected for nutritional value and cost for the empirical study. The three different recipes were prepared and a preference testing was conducted. The most popular product was chosen and the prepared product was sent to the Agricultural Research centre in Pretoria, for actual analysis (Annexure 8). The results from the ARC indicated a shortfall in energy - 429 kJ, Ca- 156.4 mg and vit A - 40 RE. From the theoretical calculations on the Dietary Manager Program the shortages could be addressed by adding 20g of milk powder. The final adjustments were made to reach an average of 25 percent of DRIs for energy, iron, zinc, calcium, and vitamin A for children six to 13 years of age. The recipe was then finalised and the product was couriered to the ARC for a second nutritional analysis (Annexure 9).

The biochemical analysis was conducted by the ARC, and the following methods were used.

3.4.4.1 Dry matter / total solids

The dry matter content is the residue (expressed in percent by weight) that remains after the drying process described. Dry matter is the sample without water. The moisture within a sample is evaporated by use of heat. Weight loss is used to calculate dry matter content. This method is suitable for the determination of dry matter in plant tissue samples and food products (Swart 2004).

3.4.4.2 Determination of total Vitamin C as dehydro ascorbic acid

The method specifies a high performance liquid chromatographic technique for the determination of vitamin C. Mass fraction of the vitamin determined by the method specified. The vitamin concentration was expressed as mg/100 g. Extraction of vitamin C was done by using acetic acid and *meta*-phosphoric acid. Oxidation of ascorbic acid changed to dehydro ascorbic acid (DHAA). Derivatization of DHAA was done and determination with High-Performance Liquid Chromatography (HPLC) was done to conclude the fluorescence detection (Swart 2004).

Calcium, iron and zinc by atomic absorption: The digest solution was analysed with flame atomic absorbance spectroscopy (AAS) for iron and zinc using an Air-Acetylene Flame with wavelengths of 248.3 nanometre and 213.9 nanometre for iron and zinc respectively. An aliquot of the solution were diluted for determination of calcium by AAS in a Nitrous Oxide-Acetylene Flame, using a wavelength of 422.7 nanometre for calcium (Swart 2004).

3.4.5.2 Carotene

The test material was alkaline saponified and the unsaponifiable matter was extracted with ether. An aliquot of the ether extract was evaporated and dissolved in hexane. The analysis was performed on a HPLC with a silica column and hexane as the mobile phase. The carotene was detected with an Ultra Violet (UV) detector at 453 nm. Regression analysis was performed and the carotene calculated (Swart 2004).

3.4.5.3 Metabolisable energy by gas production

The two-phase procedure followed involved 72 hour fermentation by rumen micro-organisms in a buffer solution, followed by a 48 hour pepsin digestion after acidification. Cumulative gas production was measured during the fermentation period. The reduction in organic matter content was ascribed to digestion of the sample. Rate of gas production was used to determine fermentation rate. The results obtained include *in vitro* organic matter digestibility, fermentation time and metabolisable energy (Swart 2004).

3.5 Optimisation

The three recipes with nutrition values meeting the criteria closest to 25 percent of DRIs (for energy, iron, zinc, calcium, and vitamin A) for children six to 13 years of age were selected for nutritional value and cost for the empirical study. The three different recipes were prepared and a preference testing was conducted. The general appearance, taste and overall acceptability of the three products were evaluated. The

most popular vetkoek was chosen and the prepared product was sent to the Agricultural Research centre in Pretoria, for actual analysis (Annexure 8). The results from the ARC indicated the following shortfall; energy - 429 kJ, Ca- 156.4 mg and vit A - 40 RE. The recipe was adjusted to reach an average of 25 percent of DRIs for energy, iron, zinc, calcium, and vitamin A for children six to 13 years of age. The recipe was theoretically analysed by using the Dietary Manager Computer program, based on the South African food composition tables. From the theoretical calculations on Dietary Manager the shortages could be addressed by adding 20g of milk powder. The recipe was adjusted and sent to the ARC for a second nutritional analysis (Annexure 9). A third nutritional analysis was done to ensure that the final recipe fulfilled the set requirements (Annexure 10).

3.6 Shelf life analysis of the nutritional vetkoek

The researcher had to contract the shelf life studies out, as this was not her field of expertise. Shelf life studies were carried out under a range of controlled test conditions. Microbiological tests were conducted to evaluate the growth of harmful bacteria and micro organisms after specified time periods, to determine shelf life. During shelf life testing, the food was periodically examined for changes in appearance, aroma, texture and taste until it became unacceptable. The sensory changes were initially subtle, but they eventually made the food unacceptable. High numbers of micro organisms are normal in certain foods, but indicate deterioration in other foods. The shelf life analysis was done by an accredited laboratory: the ARC (Annexure11). The prepared vetkoek was couriered to the laboratory immediately after preparation for the shelf life testing. The vetkoek was delivered to the laboratory in a cool box without any cooling blocks. The vetkoek was packed in a foil tray with a cardboard lid. One tray was kept at 4° C and the other tray at room temperature (± 25° C). The vetkoek was plated out on day 0 (day of arrival), day 2, 4 and day 7.

3.6.1 Microbiological analysis

A 10g sample was aseptically removed from the inside of the vetkoek. The sample was homogenized in a Stomacher 400 (DHK Pty Ltd) with 90 ml of diluted buffered peptone water. The sample was plated out for a total aerobic plate count on Tryptone soy agar and incubated at 25°C for 72 hours and for yeast and moulds on Rose Bengal agar and incubated at 25°C for 72 hours.

3.7 Phase 3: Sensory evaluation

A paired preference testing was conducted to determine the most popular of the three products. In the second sensory evaluation an acceptance test was performed to determine how well the product was liked by consumers. A hedonic scale was used to indicate the degrees of dislike and like.

3.7.1 Paired preference testing

In the first sensory evaluation, a paired preference test (Annexure 12) was performed. The preference test forces a choice of one item over another. A sensory panel of 60 children, aged six to 13 years was composed by random selection from the primary school in order to evaluate the three types of vetkoek. Two sessions were held in two different class rooms, with 30 children in each class room. The sensory panel was seated in three rows of ten children; the children were not allowed to communicate with each other during the sensory evaluation session. An example of the sensory evaluation form was drawn on the black board in the class and a lecture in the children's own language was given before the sensory evaluation took place. Sensory evaluation forms and pencils were handed out to all the children. For serving, each vetkoek was placed on a white paper plate and numbered A, B and C. The children evaluated sample A first, then sample C and finally sample B, the sensory evaluation form indicated this order (Annexure 12). A glass of water was given to the children between tasting, to clear their taste buds and mouth before they tried the next sample. Personal assistance was offered to the children during

evaluation.

3.7.2 Acceptance testing

In the second sensory evaluation, an acceptance test (Annexure 13) was performed and the objective was to test the acceptability of the product. A hedonic scale was used, which is a suitable method for measuring children's responses to products. This test was relatively simple and the aim was to determine whether the children liked or disliked the vetkoek. The target group consisted of 30 children aged six to 13 years, currently attending the primary school in Eatonside. An example of the sensory evaluation form was drawn on the black board in the class and explained to the children's in their own language, and in English, to make sure that they understood exactly what was expected from them. Sensory evaluation forms and pencils were handed out to all the children.

For serving, the vetkoek was placed on a white paper plate and a glass of water was given to the children after tasting. As a reward for helping with the assessment the children got fruit and a sweet, they were also allowed to keep the pencils.

3.8 Developing the recipe pamphlet

A recipe pamphlet (Annexure 14), containing different vetkoek recipes was developed and printed for illiterate people. The pamphlet was used to train the mothers and caregivers who were responsible for preparing the vetkoek, for the school children. The recipe pamphlet contains the recipe for the vetkoek and another similar recipe that can be prepared with available ingredients in the households, according to the baseline study conducted. The same recipe pamphlet will be used in future in basic training of caregivers in this and other communities.

3.9 Intervention study

The intervention study, undertaken by C. Napier, used the developed vetkoek as part of a school feeding programme and the impact on the nutritional status of the sample was measured. The researcher did not take part in this extended study but assisted with the preparation for the intervention study. This included the provision of infrastructure and training for the five volunteer caregivers, who prepared the vetkoek on a daily basis for the subjects participating in the study.

3.9.1 Infrastructure provision

A production kitchen had to be erected on the school premises. A wooden hut measuring 4x4 m^2 with a veranda and corrugated iron roof was erected. Insulation panels were installed and the walls and ceiling were painted white. The kitchen had one door and one window opening to the outside that could be used as a serving hatch. A security door was installed to provide safety. A square cement slab was laid in front of the kitchen to keep children from standing in the mud in rainy seasons and to keep dust out of the kitchen. Water and electricity was installed from the adjacent building. A double basin stainless steel sink was installed. Shelves were mounted against the wall for storing the ingredients, small utensils and small equipment. The kitchen was equipped with a serving trolley, stainless steel table, a deep fat fryer, electronic scale, storage containers for ingredients and all the small utensils required to prepare the product. Cleaning equipment such as floor mops, brooms, brushes dish cloths and buckets were provided, as well as the following cleaning materials: dishwashing liquid, disinfectant and all purpose cleaning material.

An existing gas stove was installed in compliance with the "SABS 0157" and the "Vessels Under Pressure Act". A separate storage area was constructed outside the wooden kitchen for the safe storage of the gas bottles used for the gas stove.

A portioning frame was designed and constructed from stainless steel for use by the community workers to portion each batch of vetkoek into 20 x 120g portions. The

frame was 2cm high, 40cm long and 25cm wide. When the dough was prepared, the ladies were trained to roll it out to the same size as the portioning frame, the frame was then placed on the dough and pressed down which resulted in 20 vetkoek portions of 120g each.

3.9.2 Training of the volunteer community workers

The school principal identified caregivers in the community and training was provided on personal hygiene, basic kitchen hygiene and safety, basic food preparation, cooking methods and the use of electrical equipment. Training also included the preparation of the vetkoek recipe. These trained community workers were responsible for the preparation and portioning of the vetkoek on a daily basis. Initial training was presented in the student-training restaurant at the Vaal University of Technology (VUT) and all demonstrations were conducted in the kitchen. Video sessions on personal and kitchen hygiene were presented in the Goldfields library at VUT. Subsequent training was provided in the wooden kitchen that was built on the school premises. Training on hygiene and safety was given on a continued basis to maintain the standards and to ensure that a good quality product was prepared daily. The community workers were also responsible for the distribution of the vetkoek during school break in the morning and afternoon. The community workers had a list of children who participated and marked their names off when they received the vetkoek to ensure that the children received only one 120g vetkoek each.

After the initial training, visits to the school were conducted every day for the first two weeks, and weekly visits were conducted. During these visits quality, portion and stock control was conducted. These visits were done randomly and no appointments were made beforehand.

Photo 6 Trained community workers.

3.9.3 Provision of supplies

A local supplier that was able to deliver the ingredients to the school in the informal settlement was identified. The supplier was able to deliver spinach and fruit on a daily basis, and the dry ingredients on a weekly basis. A standard order was compiled and was given to the supplier every Friday for delivery on the following Monday. Ingredients delivered were checked according to the standard order provided by the researcher. Invoices were kept in a file in the kitchen and the researcher collected all invoices during visits to the school. Trained community workers with the assistance of teachers were responsible for receiving delivered goods.

Part of the researcher's student grant from the NRF was used for building the kitchen and payment of the supplies used in this study. The finance department of the VUT processed the invoices for payment.

3.10 Conclusion

The nutritional status of primary school children in an informal settlement was assessed by dietary, anthropometric and biochemical methods. The nutritional status of the children had to be established, and specific nutritional deficiencies had to be identified before the development of the product could commence.

Chapter 4 Results and Findings

4.1 Introduction

In this chapter the results will be provided for each phase of the project as described in the previous chapters.

4.2 Phase1: Results of the baseline study

4.2.1 Questionnaires: reproducibility results

The reliability and reproducibility of the questionnaires were tested by having 10 caregivers (from the informal settlement) complete the socio-demographic and breakfast pattern questionnaires each week for a period of four weeks. The answers were compared and based on the results, the questionnaires were accepted to be reliable and reproducible as a high correlation was found ($r = 0.523$, $p \leq 0.05$).

4.2.2 Socio demographic results

The demographic results are depicted in Tables 4.1, 4.2, and 4.3. The socio-demographic data reflected that 89 percent of the respondents stayed in a zinc shack with 44 percent having three to four rooms per house. One hundred percent had access to clean, safe, running water outside their houses and the bucket system toilet facilities were used by 97.3 percent of the respondents. Waste removal took place at only 6.2 percent of the houses. Gravel road was existent at 78.9 percent of houses. Ninety four percent of the children walked to school, 48 percent of the caregivers indicated that their children were fully immunized. More than half of the respondents (56.2%) indicated that they experienced problems with mice, rats and cockroaches.

Table 4.1 Demographic data.

Type of house	Number N=80	Percentage %
Clay	3	3.7
Zinc/shack	72	90
Clay & zinc/shack	1	1.3
Brick	4	5
Number of rooms		**Percentage**
< 2 rooms	25	31.2
3-4 rooms	35	43.8
> 4 rooms	20	25

All the respondents participating in this study resided in an informal settlement, which is not situated close to shopping complexes and shops. High unemployment (93%), the majority of household monthly income of less than R500 per month (68.7%) and most households (40 %) spending less than R50 on food per week, indicated that availability of food was not the primary problem but rather the availability of resources to acquire the food (Table 4.2). Taking into consideration that the average household size was 4, 9 people, it was calculated that less than R2, 90 per person per day was spent on food. This amount was equivalent to a half loaf of bread or half a litre of milk that would be bought locally

Table 4.2 Household data

Total household income	**Number =80**	**Percentage %**
< R500	55	68.7
R 501- R 1000	18	22.5
R 1001-R 1500	3	3.7
R1501- R2000	2	2.5
R 2001- R2500	1	1.3
Frequency of food shopping		**%**
Every day	7	8.75
Once a week	17	21.25
Once a month	43	53.75
Place of food shopping		**%**
Spaza shop	46	57.5
Street vendor	1	1.25
Supermarket	15	18.75
Other	4	5.0
Weekly food expenditure		**%**
R0 – R50	32	40
R51-R100	18	22.5
R101-R150	4	5.0
R151-R200	2	2.5
R201-R250	2	2.5
R251-300	1	1.25

The baseline survey indicated that 93 percent of the adult respondents were unemployed, 50 percent of the caregivers were in possession of a primary school qualification and 18.9 percent had no qualifications.

The results further indicated that 17.5 percent of the respondents consumed only one meal per day and 57.5 percent consumed two meals per day. A large portion (77.5 %) of the meals, were consumed at home (Table 4.3).

Table 4.3 Meal consumption patterns and children per household

Number of meals per day	**Respondents**	**Percentage**
0	1	1.24
1	14	17.5
2	46	57.5
3	18	22.5
>3	1	1.25
Place where children consume food		**Percentage**
Home	62	77.5
Friends	2	2.5
School	5	6.25
Home and school	8	10
Home and buy	1	1.25
Home and family	1	1.25
Family	1	1.25
Number of children per household		**Percentage**
0	24	30.0
1	28	35.0
2	16	20.0
3	8	10.0
4	2	2.5
5	1	1.25
6	1	1.25
Number of school children per household		**Percentage**
0	6	7.5
1	26	32.5
2	24	30.0
3	12	15.0
4	6	7.5
>5	6	7.75

4.2.3 Results: anthropometric measurements

4.2.3.1 Nutritional status of the children

Eighty three percent of the children were under the 5th percentile (28 percent under the 5th percentile) for height-for-age, while 85 percent were under the 50th percentile of weight-for-age (28 percent boys and 21.7 percent girls under the 5th percentile). The results of the baseline survey showed that a large percentage of children in this sample were malnourished (Table 4.4). Stunting and underweight were the main problems, indicating a chronic food shortage in this community as 28.1 percent of boys and 28.3 percent of the girls in this sample were stunted and 28.1 percent and 21.7 percent of the boys and girls respectively were underweight. The prevalence of wasting was 9.1 percent in boys' and 15.2 percent in girls (indicated in red in Table 4.4).

Table 4.4 Percentile distribution for weight-for-age, height-for-age and BMI-for-age of children six to 13 years of age; growth percentiles of the NCHS.

Percentiles	**Percentage of children**					
	Height-for-age Stunting		**Weight-for-age Underweight**		**BMI-for-age Wasting**	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Below 5th percentile Severely malnourished	28.1	28.3	28.1	21.7	9.1	15.2
On 5th percentile	3.1	2.2	3.1	2.2	0	0
Between 5th and 50th percentile	50	54.4	53.1	65.2	59.4	60.9
On 50th percentile	0	0	3.1	0	3.1	2.2
Between 50th and 95th percentile	15.6	10.9	9.4	8.7	28.1	19.6
Above 95th percentile	3.2	4.2	3.2	2.2	0.3	2.1

4.2.3.2 Food consumption patterns in the community

The top 15 food items (Table 4.5) most commonly consumed by the children indicate that the diet is mostly carbohydrate based, although carbohydrates are perceived as an energy providing food. It was also observed that the carbohydrates commonly consumed were maize meal, bread and sorghum which are not very nutrient dense and do not contribute greatly to the overall nutritional status of the children.

Table 4.5 Top 15 food items consumed with average portion size

Item N=80	**Average portion (g)**
Maize meal, cooked stiff porridge	403.84
Tea, brewed	203.24
Maize meal, cooked soft porridge	136.83
Milk, full fat / whole fresh	47.22
Bread / rolls brown / vetkoek brown	56.27
Mabella / sorghum cooked	78.92
Cold drink squash, diluted	52.58
Rice, white cooked	39.28
Coffee, brewed instant	80.5
Maize meal cooked, crumbly porridge	87.26
Tea, rooibos, brewed	221.44
Apple average, raw	27.59
Bread / rolls / vetkoek, white	29.41
Sugar, white granulated	8.8
Samp and beans	42.22

The results indicate that the top 10 food items most frequently bought by the households in the sample correspond with the top 15 food items consumed by children as indicated in Table 4.6.

Table 4.6 Top ten food items bought

Top 10 food items bought regularly (monthly)Food item	**Percentage**
Maize meal	96.1
Tea	89.3
Sugar	88.2
Oil	87
Fresh vegetables	72.7
Chicken	64.9
Fresh milk	61.7
Eggs	61
Fresh fruit	45
Butter/margarine	44.4

4.2.3.3 Breakfast consumption patterns

The results showed that 13.2 percent of the children did not eat any breakfast before going to school and of those who had breakfast, 86.8 percent had bread and tea for breakfast as reflected in Figure 4.1

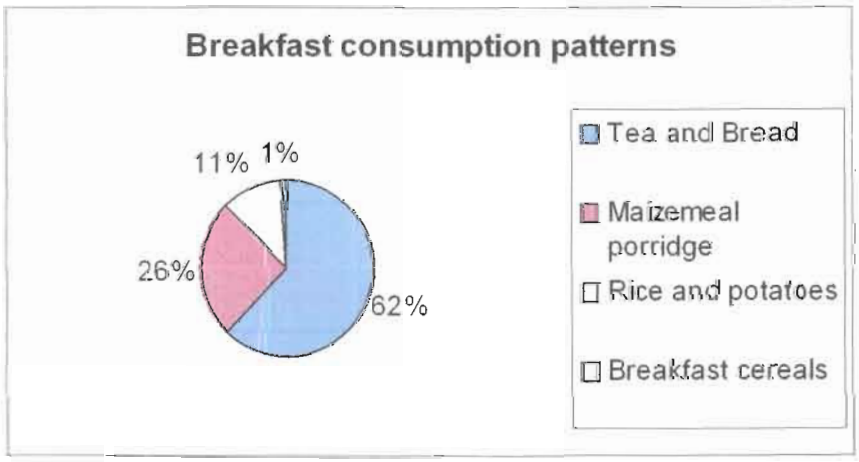

Figure 4.1 Breakfast consumption patterns of school children

4.2.3.4 Dietary intake of the children

Dietary analysis (Table 4.7) of the nutrient intake indicated that the mean daily energy intake of all the children was below the RDAs for children between aged seven to 10 years. (The RDAs for children in the age group seven to 10 years is: 6930-13869 kJ, and for boys between 11-12 years 8400-15540 kJ; and girls between 11-12 years 6300-12600 kJ respectively). Comparison of the total protein intake with the RDAs showed that the children consumed more than 100 percent of the recommended amount of protein. Calcium consumption was very low (17 %) for boys and girls.

Table 4.7 Mean dietary intake compared with RDAs and DRIs.

Component	Intake	RDA boys	RDA girls	% RDA boys	% RDA girls	DRI boys	DRI girls	% DRI boys	% DRI girls
Energy KJ	5990	8368							
Total protein (g)	39.6	34	34	116	116	0.95	0.95	42	42
CA (mg)	219.9	*1300	*1300	17	17	** 2500	** 2500	9	9
Fe (mg)	5.8	5.9	8.0	98	73	5.7	8.0	101	73
Mg (g)	212.4	200	240	106	89	200	240	106	89
P (mg)	623	1055	1055	59	59	1250	1250	50	50
Zn (mg)	4.9	7.0	8.0	70	60	7.0	8.0	70	60
Cr (µg/day)	22.4	*25	*21	89	106				
Se (µg/day)	17.8	35	40	51	45	35	40	51	45
I (mg/day)	17.8	73	120	24	15	73	120	24	15
Vit A (RE)(µg/day)	460	7445	600	103	77	420	600	109	77
Thiamin (mg)	0.77	0.7	0.9	110	86	0.7	0.9	110	86
Riboflavin (mg)	0.8	10.8	0.9	100	89	0.8	0.9	100	89
Niacin (mg)	7.47	9.0	12	83	62	9.0	12	83	62
Vitamin B6 (mg)	0.6	0.8	1.0	75	60	0.8	1.0	75	60
Folate (µg/day)	131.5	250	300	53	44	250	300	53	44
Vitamin B12 (µg/day)	2.17	1.5	1.8	145	120	1.5	1.8	145	120
Pantothenate (mg)	2.5	*4.0	*4.0	63	63				
Biotin (µg/day)	19.9	*20	*20	100	100				
Vitamin C (mg)	27.7	39	45	71	62	39	45	71	62
Vitamin D (µg/day)	2.4	*5.0	*5.0	48	48	**50	**50	48	48
Vitamin E (mg)	8	9.0	11	89	72	9.0	11	89	72

* AI Adequate intake

**UL Upper limit

4.3 Biochemical measurements

Zinc and ferritin levels were lower than the normal range for children in this age group. Comparing the biochemical and dietary intake results, it can be seen that the energy intake is lower and protein intake higher than the DRIs per day. The high protein intake could be utilised as energy and not as much for growth purposes. The low zinc and ferritin confirms the low intake of green vegetables, fish and whole grain products as reflected by the top 20.

According to Boyle (2003:451) laboratory methods to establish nutritional status can be used to identify individuals at risk of a nutrient deficiency, since tissue stores of nutrient gradually become depleted over time. Laboratory methods are used to detect sub-clinical deficiencies.

Table 4.8 Mean and standard deviation of biochemical variables of primary school children (n=80).

Code	Normal range	Mean	SD	Status
Vitamin A	< 20 (µg/dl)	25.1	6.2	Normal
Vitamin E	4.4-13.8 (mg/l)	10.7	1.8	Normal
Zinc	70-150 µg/dl	58.5	9.7	Low
c-reactive proteien	0-10mg/l	10	5.1	Normal
Total Proteien	60-82g/l	71.9	5.7	Normal
Albumin	37-52g/l	39	2.5	Normal
Ferritin	20-375ug/l	24.5	14.1	Normal
Vitamin B12	118-716pmol/l	295.5	92.1	Normal
Serum folate	3.4-38.3 pmol/l	17	7.3	Normal
Red blood cell count	4.0-5.4x106/ul	4.5	0.4	Normal
Haemoglobin	12.0-14.0g/dl	12.9	1.1	Normal
Haematocrit	36.0-44.0%	37.8	3.4	Normal
Mean cell volume	77-91fl	84	4.4	Normal
White cell count	4.5-13.5 (108/ul)	7	2.5	Normal

Table 4.8 indicates that the zinc status is lower than the normal range for children in this age group. The ferritin falls low in the normal range for children of this age with 24.5ug/l. The white cell count indicated normal levels and thus no infections were found in this sample at the time of blood collection, confirming that the malnutrition present was not due to infections but dietary intake.

4.4 Phase 2: Results of the product development

Different recipes were evaluated and a specific product, suitable for children, easy to prepare with ingredients readily available was the ideal. Five different vetkoek recipes were chosen, prepared and tested. A vetkoek was chosen as it forms part of the top 15 food items consumed, as indicated in the breakfast survey. All ingredients for this recipe are readily available and no stove is required. Basic vetkoek recipes were chosen and adjusted and three different types of maize meal and whole-wheat vetkoek were developed

A - Maize vetkoek

B - Maize and wholewheat vetkoek

C - Wholewheat vetkoek

After evaluation the recipes were adapted in order to identify a suitable product. Different ingredients were added to the vetkoek to test the influence on the taste, texture, and cooking process. From the original five recipes the three most suitable recipes were chosen.

The Dietary Manager Program, based on the SA food composition tables, was used to evaluate the nutritional value of the recipes. The different recipes were adjusted to be maize based (staple) and different ingredients were added to contribute to the nutrient content. The most popular recipe was chosen and the following shortfall was identified:

- Energy - 429 kJ
- Ca- 156.4 mg

- Vit A - 40 retinol equivalents (RE)

By adding 20g of milk powder the shortages could be addressed. Spinach was added to improve the iron content, pilchard fish was added for zinc, calcium and protein. The product was fried in vegetable oil to enhance the energy value of the vetkoek. These adjustments to the final recipe were made in order to address 25 percent of the DRIs for children aged six to nine years (Wentzel- Viljoen 2003:365).

The final vetkoek contains the following ingredients: maize meal, whole wheat, yeast, spinach, and milk powder, egg, sugar, salt and pilchard fish. The vetkoek is fried in vegetable oil. The different recipes were prepared and tested in the cooking laboratories of the Hospitality and Tourism department of the Vaal University of Technology. Recipes for the maize meal and whole wheat vetkoek were theoretically analysed by using the Dietary Manager Computer program, based on the South African food composition tables.

4.4.1 Criteria

The criteria for the development of the product were the following:

- The vetkoek should consist of at least 25 percent of the DRIs for children aged six to 13 years old
- To address the nutrient deficiencies, as indicated in the baseline, study namely zinc, iron and low energy intake
- The product should be easy to prepare
- Accepted by children
- Have a shelf life of at least two days at room temperature
- Produced with locally available ingredients
- Affordable <R2

4.4.2 Evaluation of the product

The results showed that a large number (65 percent) of the consumers liked the product very much, and 90 percent found it to be acceptable for inclusion in a school-feeding program.

4.4.3 Biochemical analysis of the vetkoek

The Agricultural Research Council (ARC) an accredited food analysis laboratory in Pretoria did the biochemical food analysis (Annexure8). The vetkoek was analysed for the following: ash, moisture, fat, protein, folic acid, vit A, carbohydrates, vit B1, vit B 2, vit B6, vit B12, vit C, energy, calcium, magnesium, copper, iron and zinc. This was done to compare the theoretical and actual nutrient content (Table 4.9).

The recipe was then finalised. The product was prepared and a sensory analysis was conducted by the target group. The final product was couriered to the ARC for a second nutritional analysis (Annexure9) (Table 4.10).

Table 4.9 Nutritional analysis of the original product done by the ARC (Annexure 8).

		Dietary Manager results	**Analysis by ARC**	**EARs**	**%**
Analysis	*Unit*		*120g sample*		
Moisture	%		34.20		
*Protein	%	12,64	7.29		
Fat (ether extraction)	%	33.72	15.42		
Folic acid	µg /100g	57	1002.52	160µg	337%
Vit A	µg/100g	287 (retinol)	0.06	275µg	25%
Vit B1	mg/100g	0.24	0.43		
Vit B2	mg/100g	0.36	0.15		
Vit B6	mg/100g	0.219	1.35	0.5mg	72%
Vit B12	µg /100g	0.3	5.31	1.0µg	149%
Vit C	mg/100g	2	0.81	22mg	1.9%
Carbohydrates (calculated)	g/100g	34.15	40.66		
Energy (calculated)	kj/100g	2065	1386		
Calcium	mg/100g	198	140.49	800mg	19.5%
Magnesium	mg/100g	85	73.42	110mg	65.5%
Copper	mg/100g	0.24	0.85		
Iron	mg/100g	3.09	98.13	4.1mg	168%
Zinc	mg/100g	1.82	39.61	4.0mg	90%

*For the conversion of nitrogen content to protein content the factor 6.25 was used

Table 4.10 Results of the second test report from the ARC (Annexure 9)

Analysis	Unit	Sample
Moisture	%	29.86
*Protein	%	10.32
Fat (ether extraction)	%	17.79
Folic acid	µg /100g	540
Vit A	mg/100g	0.70
Vit B1	mg/100g	0.41
Vit B2	mg/100g	0.21
Vit B6	mg/100g	0.36
Vit B12	µg /100g	1.49
Vit C	mg/100g	0.42
Carbohydrates (calculated)	g/100g	39.82
Energy (calculated)	kj/100g	1511
Calcium	mg/100g	156.03
Magnesium	mg/100g	72.13
Copper	mg/kg	0.17
Iron	mg/kg	6.90
Zinc	mg/kg	3.60

* For the conversion of nitrogen content to protein content the factor 6.25 was used.

Table 4.11 Results of the third nutritional analysis done by the ARC (Annexure10)

Analysis	Unit	Sample
Moisture	%	39.50
*Protein	%	8.96
Fat (ether extraction)	%	8.21
Folic acid	µg /100g	820
Vit A	mg/100g	0.09
Vit B1	mg/100g	0.40
Vit B2	mg/100g	0.10
Vit B6	mg/100g	0.46
Vit B12	µg /100g	1.27
Vit C	mg/100g	1.27
Carbohydrates (calculated)	g/100g	41.45
Energy (calculated)	kj/100g	1161
Calcium	mg/100g	117.23
Magnesium	mg/100g	72.24
Copper	mg/kg	1.43
Iron	mg/kg	40.25
Zinc	mg/kg	0.46

* For the conversion of nitrogen content to protein content the factor 6.25 was used.

Table 4.12 Comparison of the different nutritional analyses of the product after changes

		Analysis Dietary Manager	**Analysis by ARC**			**EARs Children 9-13 years**
Analysis	*Unit*		*Sample 1*	*Sample 2*	*Sample 3*	
Moisture	%		34.20	29.86	39.50	Not available
*Protein	%	12,64	7.29	10.32	8.96	Not available
Fat (ether extraction)	%	33.72	15.42	17.79	8.21	Not available
Folic acid	µg /100g	57	1002.52	540	820	250 µg
Vit A	mg/100g	287 retinol	0.06	0.70	0.09	445µg/day
Vit B1	mg/100g	0.24	0.43	0.41	0.40	0.7mg
Vit B2	mg/100g	0.36	0.15	0.21	0.10	0.8mg
Vit B6	mg/100g	0.219	1.35	0.36	0.46	0.8mg
Vit B12	µg /100g	0.3	5.31	1.49	1.27	1.5 µg
Vit C	mg/100g	2	0.81	0.42	1.27	39 mg
Carbohydrates (calculated)	g/100g	34.15	40.66	39.82	41.45	100g /day
Energy (calculated)	kj/100g	2065	1386	1511	1161	8368kJ/ Day
Calcium	mg/100g	198	140.49	156.03	117.23	1300mg
Magnesium	mg/100g	85	73.42	72.13	72.24	200mg
Copper	mg/kg	0.24	0.85	0.17	1.43	1.5mg
Iron	mg/kg	3.09	98.13	6.90	40.25	5.9mg
Zinc	mg/kg	1.82	39.61	3.60	34.50	7mg

Table 4.13 Average of the three nutritional analyses

		Dietary Manager	1st Analysis by ARC	2nd Analysis by ARC	3rd Analysis by ARC	Average
Analysis	Unit					
Moisture	%		34.20	29.86	39.50	34.52
*Protein	%	12,64	7.29	10.32	8.96	8.86
Fat (ether extraction)	%	33.72	15.42	17.79	8.21	13.81
Folic acid	µg /100g	57	1002.52	540	820	787.51
Vit A	µg/100g	287 (retinol)	0.06	0.07	0.09	0.7
Vit B1	mg/100g	0.24	0.43	0.41	0.40	0.41
Vit B2	mg/100g	0.36	0.15	0.21	0.10	0.15
Vit B6	mg/100g	0.219	1.35	0.36	0.46	0.72
Vit B12	µg /100g	0.3	5.31	1.49	1.27	2.69
Vit C	mg/100g	2	0.81	0.42	1.27	0.83
Carbohydrates calculated	g/100g	34.15	40.66	39.82	41.45	40.64
Energy calculated	kj/100g	2065	1386	1511	1161	1353
Calcium	mg/100g	198	140.49	156.03	117.23	137.92
Magnesium	mg/100g	85	73.42	72.13	72.24	72.59
Copper	mg/100g	0.24	0.85	1.77	1.43	1.35
Iron	mg/100g	3.09	98.13	69.40	40.25	69.26
Zinc	mg/100g	12,64	1.35	0.36	0.46	0.72

*For the conversion of nitrogen content to protein content the factor 6.25 was used

Three nutritional analyses were conducted by the ARC and an average of the three was used for the actual nutrient content of the final vetkoek.

4.4.4 Shelf life testing results (Annexure 11)

Shelf life testing indicated that the vetkoek stored at 4° C had a seven day shelf life period as depicted in Figure 4.8

Result of Vetkoek stored at 4°C

Sample	Total Aerobic Plate Count Cfu/g	Yeast and Moulds Cfu/g
Day 0	2.0×10^1	< 10
Day 2	$1,0 \times 10^2$	< 10
Day4	$5,0 \times 10^1$	<10
Day 7	$1,6 \times 10^2$	<10

Cfu/g = Colony forming units per gram of sample

Figure 4.2 Results of vetkoek stored at 4° C

The vetkoek stored at 25° C only had a two day shelf life. Although moulds were visible on the vetkoek stored at 25° C on day 4, the counts were very low throughout the trial. This could be due to the fact that the 10g aliquot of sample was taken from the middle of the vetkoek each time, and the visible mould growth was on the upper crust of the vetkoek.

Result of Vetkoek stored at 25°C

Sample	Total Aerobic Plate Count Cfu/g	Yeast and Moulds Cfu/g
Day 0	$1,9 \times 10^2$	< 10
Day 2	$1,3 \times 10^6$	< 10
Day4	$2,4 \times 10^6$	<10
Day 7	$>3,0 \times 10^7$	1

Cfu/g = Colony forming units per gram of sample

Figure 4.3 Results of vetkoek stored at 25° C

The total bacterial count and the yeast and mould counts for the vetkoek stored at 4° C remained low throughout the seven day trial. The total bacterial count and the yeast and mould counts for the vetkoek stored at 25° C increased from log 2 to log 6 on the second day and increased to more than log 7 on the last day of the shelf life trial. Although the yeast and mould count remained very low throughout the 7 days, moulds were visibly detected on day 4 of the trial.

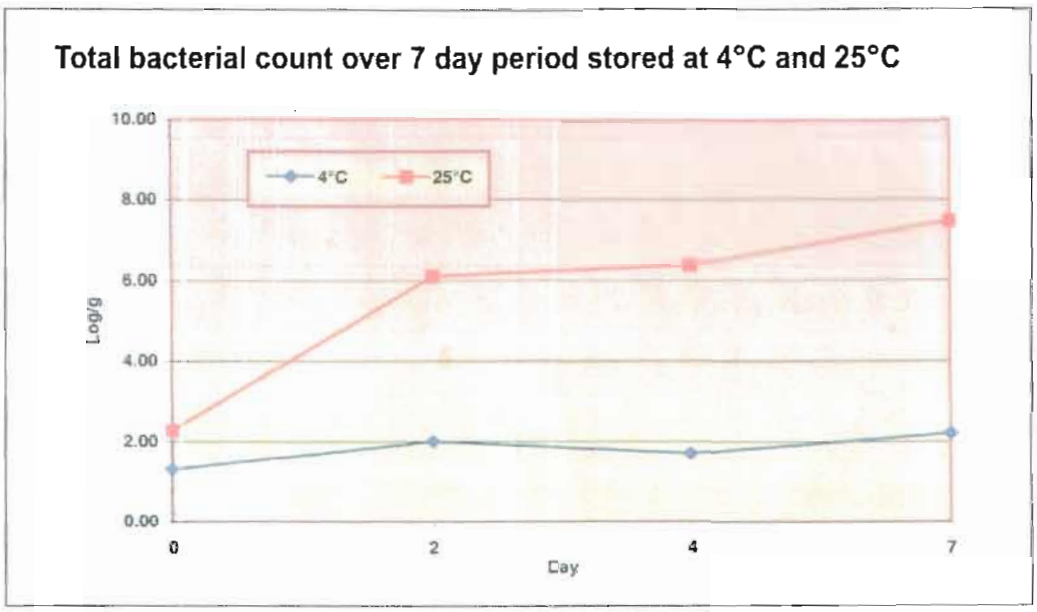

Figure 4.4 Total bacterial count over a seven day period stored at 4° C and 25° C

4.5 Recipe

The original recipes that were adapted and used as the basis for the developed vetkoek are presented below.

Recipe 1 Whole wheat and maize meal vetkoek

g	ml	Ingredient
10g	1 x small packet	Yeast
185g	200ml	Lukewarm water
210g	200ml	Lukewarm milk, full cream
60g	1 each	Egg, large beaten
20g	30ml	Oil, sunflower
15g	15ml	Sugar, white
15g	15ml	Salt
440g	750ml	Wholewheat flour
310g	500ml	Maize meal

Preparation method:

1. Mix milk, water add eggs
2. Mix all dry ingredients with instant yeast
3. Add milk mixture to dry ingredients and blend well
4. Knead well for 5 minutes, to make a soft dough
5. Put dough into a clean bowl and cover with a clean kitchen towel
6. Leave in a warm place to rise for 2 hours
7. Heat sunflower oil in a saucepan or deep fat fryer
8. Put dough on a clean flat surface and lightly roll out the dough
9. Cut with a knife or with the portioning frame
10. Fry for 4 minutes on each side
11. Oil temperature 160°C

Recipe 2 Whole wheat and maize meal vetkoek

G	ml	Ingredient
20g	2 x small packets	Yeast
400g	400ml	Lukewarm water
300g	3 cups	Milk powder, full cream
120g	2 each	Eggs, large beaten
20g	30ml	Oil, sunflower
20g	20ml	Sugar, white
20g	20ml	Salt
900g	7 cups	Whole-wheat flour
500g	3 cups	Maize meal
500g	6 cups	Spinach chopped raw
420g	1 can	Pilchards in tomato sauce, mashed

Preparation method:

1. Mix milk powder with water and add eggs
2. Chop spinach
3. Mix all dry ingredients with instant yeast
4. Add milk mixture to dry ingredients
5. Add chopped spinach and mashed pilchards
6. Knead well for 5 minutes, to make a soft dough
7. Put dough into a clean bowl and cover with a clean kitchen towel
8. Leave in a warm place to rise for 2 hours
9. Heat sunflower oil in a saucepan or deep fat fryer
10. Put dough on a clean flat surface and lightly roll out the dough
11. Cut with a knife or with the portioning frame
12. Fry for 4 minutes on each side
13. Oil temperature 160˚C

Table 4.14 Total cost of the vetkoek calculated in 2004

Ingredient:	Cost
Maize meal (fortified)	R2.91
Whole wheat flour	R7.34
Yeast	R1.29
Salt	R0.45
Sugar, white	R0.89
Eggs, large	R1.06
Oil, sunflower	R5.28
Milk powder	R3.99
Pilchards in tomato sauce	R5.00
Spinach chopped raw	R2.04
Total price per recipe (20 portions):	**R 30.25**

The cost for the vetkoek was R1.51 per person per 120g portion
The product development was completed in April 2004.

4.6 Phase 3: Results of the acceptance testing

4.6.1 Results of the sensory analyses: preference testing

A paired preference test (Annexure 12) was conducted to determine which of the three products the subjects preferred. Of the subjects, 80 percent preferred sample B, the maize meal and whole wheat vetkoek. This vetkoek was therefore used in the intervention study. The method of consumer sensory evaluation was used. The goal was to determine which of the three products was the most popular. In the sensory analysis, it was determined that the 65 percent of the consumers liked the product very much and said it was very tasty, 18 percent liked the product moderately and 17 percent found it acceptable. All subjects in the evaluation were part of the target consumer group, aged six to thirteen years old.

Table 4.15 Results: sensory analyses – preference testing

Sample A Maize meal vetkoek					**Sample B** Maize meal, whole wheat and spinach vetkoek					**Sample C** Maize meal and whole wheat vetkoek				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3%	1%	5%	0	0	43%	37%	1%	0	0	3%	7%	0	0	0
1. Like a lot														
2. Like														
3. Neither like / dislike														
4. Dislike a little														
5. Dislike a lot														

Results of the paired preference evaluation indicated the following:

Of the respondents, 43 percent of the subjects liked the taste of sample B a lot.

Of the respondents, 37 percent of the subjects liked the taste of sample B.

Of the respondents, 1 percent of the subjects neither liked nor disliked sample B.

A total of 10 percent of the respondents found product C, which was the second choice, to their liking.

Only 4 percent of the respondents found sample A to their liking.

4.6.2 Results of the acceptance testing

In the second sensory evaluation, an acceptance test (Annexure 13) was conducted. Children's degree of like or dislike of the vetkoek was determined. A smiley face evaluation sheet was developed for this sensory analysis. The sensory panel consisted of randomly selected representatives from the target group; they tested the developed vetkoek and completed the evaluation sheets. The sensory panel received training and guidelines before the products were tasted. The sensory evaluation process was discussed and an explanation of what was expected from them was provided in Sotho, to ensure all children understood the process.

The most popular vetkoek was re-evaluated according to:

1 taste
2 appearance
3 general acceptability

80 percent of the subjects preferred sample B - the maize meal and whole wheat vetkoek.

A second acceptance testing was performed closer to the end of the intervention in October 2004, to test the children's reaction to the product after having it as part of their breakfast for a period of six months (intervention by C. Napier). The same smiley face evaluation sheet was used in both the acceptance tests.

The product was evaluated again by school children (n=60)

1 62 percent of the subjects liked the taste of the product a lot
2 28 percent of the subjects liked the taste of the product
3 10 percent of the subjects neither liked or disliked the product

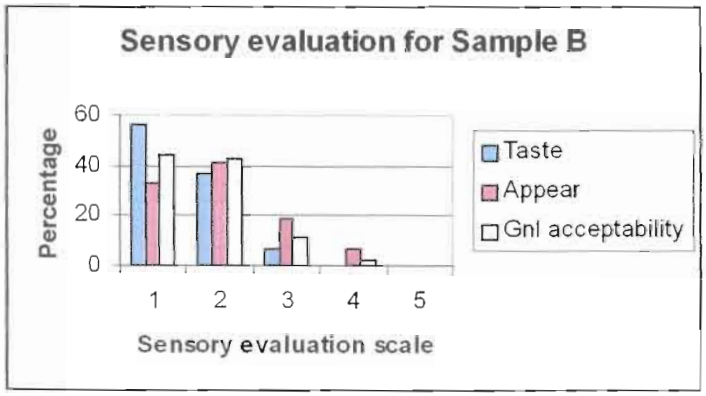

Figure 4.5 Second sensory evaluation for sample B

4.7 Designing a recipe pamphlet

A recipe pamphlet (Annexure 14), containing different vetkoek recipes, was developed and printed for illiterate people and was used to train the mothers and caregivers who is responsible for preparing the maize meal and whole wheat vetkoek, for the school children.

The recipe pamphlet contains the recipe for the vetkoek and another similar recipe that can be prepared with available ingredients in the households, according to the baseline study.

The same recipe pamphlet will be used in future in basic training of caregivers in this and other communities.

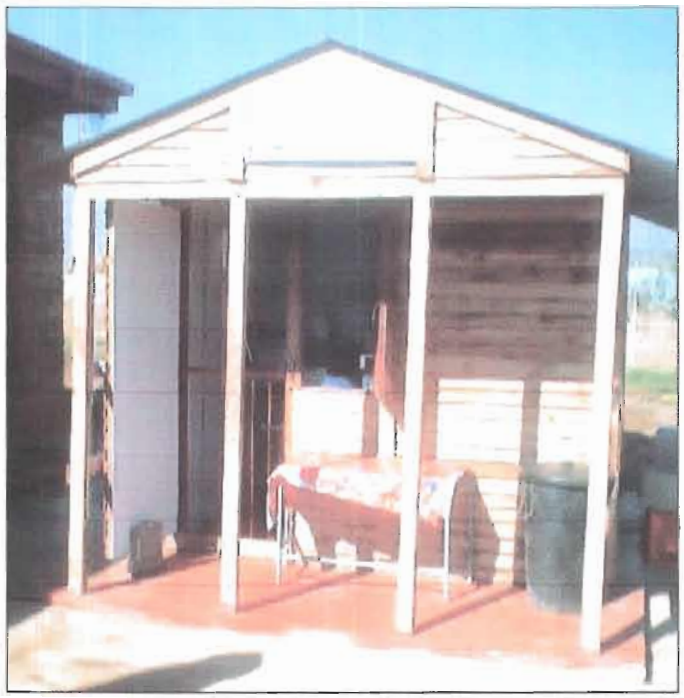

Photo 7 Wooden kitchen erected by the VUT.

4.8 Conclusion

A nutritious novel food product was developed to address specific nutritional deficiencies identified in the baseline study, to be implemented as part of a school feeding programme to assess the impact on the nutritional status of primary school children in an informal settlement.

The criteria for developing the novel food product were; to meet a minimum of 25% of DRIs for energy, iron, zinc, calcium and vitamin A for children aged nine to thirteen years of age, to be easy to prepare with ingredients available in the household. The product should also be cost effective (<R2.00 per person per day) and acceptable to children. Vetkoek was found to be the consumed by the majority of households in this study as it was easy to prepare, and was therefore chosen.

Chapter 5 Discussion, Conclusions and Recommendations

5.1 Discussion

The prevalence of household food insecurity and malnutrition identified in this informal settlement (Oldewage-Theron *et al.* 2005: 13) motivated this study. The objective of this study was to develop a nutrient dense product that could be implemented in a school feeding programme to address malnutrition in primary school children in this community.

5.1.1 Limitations of the study

The most important limitation of this study is the fact that biochemical analyses for the determination of the nutritional values had to be conducted by an accredited laboratory, this was very expensive and a number of analyses were needed to ensure that the nutrient content of the vetkoek remained stable during the daily production process.

5.1.2 Main findings

5.1.2.1 Baseline survey

The baseline survey results indicated that the majority (89%) of primary school children in this sample resided in zinc shacks, with a large percentage (44%) having three to four rooms per house. One hundred percent of the respondents had access to clean, safe, running water outside their houses and the bucket system toilet facilities were used by 97.3 percent of the respondents. Waste removal took place at only 6.2 percent of the houses. A gravel road was existent at 78.9 percent of houses. Ninety three percent of female caregivers were unemployed, 50 percent of the female caregivers were in possession of a primary school qualification and 18.9 percent had no qualifications. This confirmed the findings by Oldewage-Theron *et al.* (2005: 13)

for this community.

The NFCS also reported that in one out of five households the head of the household was unemployed. This was much higher in the households involved in this study, as 93 percent were unemployed. The NFCS however commented that, in rural, tribal and informal urban areas the unemployment figure was higher overall (Labadarios *et al.* 2001:13). The NFCS finding is consistent with this study as this community is situated in an informal urban area.

Household food insecurity was high and 40 percent of the households spent less than R50 per week on food and the top 10 items bought indicated that nutrient dense foods were low on the list. Animal protein was 6th on the bought item list with vegetables featuring 5th on the list. Food was generally bought from spaza shops (57.5 percent) that charge higher prices than large supermarkets. Transport to areas where supermarkets were located was scarce and expensive when available. Comparing the number of children eating a meal at home and the weekly expenditure on food, it can be seen that very little food is available at home. When the income into the household and the number of employed persons, is compared to the number of people in the household, it is evident that little money is available for food. This can possibly be reflected by the prevalence of stunted children in the sample, indicating a chronic rather than acute malnutrition problem. The dietary intake results confirmed the low intake of micronutrients, as less than 67 percent of DRIs was consumed by this sample for calcium, iron, zinc, vitamin A, C, and riboflavin.

The NFCS indicated that children, aged seven to nine years in Gauteng, had a lower intake of nutrients than children in South Africa in general; this is also reflected in the baseline results of this study. Eighty two percent of children in the NFCS obtain less than two-thirds of RDAs for vitamin A in South Africa. In terms of iron status, 10 percent of the children in South Africa are iron depleted or deficient. One in twenty children is severely iron depleted or deficient and one in twenty has iron deficiency anaemia. Anaemia and poor iron status are more prevalent in urban areas (SAVACG 1995:103). According to Vorster *et al.* (1997:3) multiple micronutrient

deficiencies exists in rural black pre-school children in the form of vitamin A, iron, folate, vitamin E and vitamin B6, this was also identified in this study. These micronutrient deficiencies were also found to be present in the subjects for this research, as both iron and zinc deficiencies were present.

When comparing the biochemical and dietary intake results for this study it can be seen that the energy intake is lower and protein higher than the DRIs per day. The high protein intake could be utilised as energy and not for growth purposes, thus resulting in the high percentage of stunting and underweight. The low zinc and ferritin levels confirm the low intake of green vegetables, fish and whole grain products as reflected by the top 15 food items consumed. The marginal ferritin levels found within the primary school subjects in the sample indicate a risk of iron depletion that could lead to iron deficiency anaemia resulting in poor concentration and school performance.

The anthropometric data in this study indicated that stunting and underweight were the main problems as 28.1 percent of boys and 28.3 percent of the girls in this sample were stunted, and 28.1 percent and 21.7 percent of the boys and girls respectively were underweight. The prevalence of wasting was 9.1 percent in boys and 15.2 percent in girls. In this study, the anthropometry is supported by the low energy intake. Zinc and ferritin levels were lower than the normal range for children in this age group. The anthropometric data in this study is consistent with the NFCS findings. The 1999 NFCS indicated that one out of five children in South Africa, aged one to nine years are stunted. Gauteng showed a stunting prevalence of 20 percent. Nationally, the prevalence of stunting decreased with age from 25,5 percent in children aged one to three years, to 21 percent in those aged four to six years to 13 percent in those aged seven to nine years. A similar pattern emerged for the prevalence of underweight, whilst the prevalence of wasting remained constant in all age groups at less than 4 percent (Vitamin Information Centre (VIC) 2001:3).

5.1.2.2 Development of the novel food product.

The criteria for developing the novel food product were: to meet a minimum of 25 percent of DRIs for energy, iron, zinc, calcium, and vitamin A (for children six to 13 years), easy to prepare by illiterate mothers (18.9 percent) and with ingredients available in the households. The results showed that only 17 percent of the households had access to electrical stoves, 8.8 percent used coal and 75.6 percent had access to paraffin stoves. The preparation method thus had to take this into consideration. The product should be furthermore cost effective (less than R2.00 per person per day) and acceptable to children, in order to ensure compliance during the school feeding programme. Vetkoek was found to be consumed by the majority of households in this study as it was easy to prepare. For this reason it was decided to develop a vetkoek that met all the criteria.

This study showed that it is possible to develop an acceptable novel food product meeting specific criteria. Wentzel-Viljoen (2003:224) recommends that at least 25 percent of EARs should be met for micronutrients in a food product to be implemented in school feeding programmes. These criteria were met in the vetkoek recipe for Zn, Fe and energy. It is however, important to use both theoretical calculations for nutrients, because the biochemical results indicated variances from the theoretical calculations.

The sensory evaluation of the vetkoek also showed that the vetkoek was acceptable to the majority of the intended consumers, namely the primary school children, as it received a high score for taste, appearance and general acceptability.

The vetkoek developed was also tested for shelf life and the results showed a recommended shelf life of two days at room temperature (24° C) and seven days when refrigerated.

5.1.3 Conclusion

From the results of this study, the following conclusions are drawn:

- Malnutrition amongst children remains a problem to be addressed not only in South Africa, but worldwide. In this sample the major problems were iron, zinc, energy and protein deficiencies.
- Various strategies may be implemented to address the persistent malnutrition problem and all these have their own advantages and disadvantages.
- School feeding programmes are strategies that are adopted worldwide to alleviate hunger and thus increase concentration and learning capacity. In South Africa an average of 5 million school children have benefited from school feeding during 1994-2002.
- Costs of school feeding programmes are usually high and depend on various mechanisms for successful implementation. Consequently many problems emerge for example irregular supply, food spoilage, disruption of teaching for the preparation of meals and logistical problems.
- An affordable and safe acceptable novel food product, meeting 25% EARs for certain identified micronutrients, can be developed and prepared with minimum effort. No special equipment is needed and ingredients available in the household can be used for preparation.
- The vetkoek developed in this project, met all the criteria for the intended use in a school feeding programme for this community in the Vaal Triangle.
- A sustainable solution for school feeding programmes is thus possible.

5.1.4 Recommendations

This research project provided the opportunity to determine the nutritional status of primary school children in a "poorest of the poor" informal settlement in the Vaal Triangle. The output of this research is the development of a novel food item that is affordable, acceptable, safe for consumption, nutritious and easy to prepare from ingredients usually available in the households in the community; as proposed by the

New Partnership for Africa's Development (NEPAD) and the Comprehensive Agricultural Development Programme (CAADP).

To sustain this initiative, it is recommended that the recipe leaflet be made available to the female caregivers of all the primary school children and that they are trained on the preparation of the vetkoek so that it can be included in the lunch boxes of these children.

The results of the intervention study will address the impact of the vetkoek consumption on the nutritional status of the children in this community. More research is needed to test compliance of consumption over the long term (at least 12 months). Similar products can be developed for other circumstances, such as for HIV/AIDS children and micro enterprises can be the result thereof. However, further research on market needs, packaging materials, product lines and distribution is needed.

It is recommended that all products that are developed, be bio-chemically analysed for actual nutrient content so that sole reliance on theoretic calculations is avoided. Further research on the bio-availability of the nutrients in the vetkoek is required.

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1. SAAFECS 7th National Conference. Unity in Diversity. The Way Forward. Western Cape, SA. 17-20 September 2003.
Title: Breakfast patterns of primary school children in an informal settlement.

2. International Congress of Clinical Nutrition. Brisbane Australia. 11-13 August 2004.
Title: Breakfast patterns of primary school children in an informal settlement.

3. Nutrition Congress. Diversity in Nutrition. Goudini, Western Cape. 23-27 August 2004.
Title: Development of a novel breakfast food product for primary school children in an informal settlement.

4. 18th International Congress of Nutrition. Durban SA. Nutrition Safari for Innovative Solutions. 19-23 September 2005.
Title: Sensory evaluation of a developed novel food product by primary school children in an informal settlement.

Annexure 1

Permission from the Department of Education

Annexure 2

Ethical clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

COMMITTEE FOR RESEARCH ON HUMAN SUBJECTS (MEDICAL)
Ref: R14/49 Napier

CLEARANCE CERTIFICATE PROTOCOL NUMBER M03-05-58

PROJECT Evaluation of a Feeding Programme in Addressing Malnutrition in Primary Schools

INVESTIGATORS Ms C Napier

DEPARTMENT Hospitality & Tourism, Vaal Triangle Technikon

DATE CONSIDERED 03-05-30

DECISION OF THE COMMITTEE Approved unconditionally

Unless otherwise specified the ethical clearance is valid for 5 years but may be renewed upon application
This ethical clearance will expire on 1 January 2008.

DATE 03-08-26 CHAIRMAN.....(Professor P E Cleaton-Jones)

* Guidelines for written "informed consent" attached where applicable.

c c Supervisor: Prof W Oldewage-Theron
Dept of Hospitality & Tourism, Vaal Triangle Technikon
Works2\lain0015\HumEth97.wdb\M 03-05-58

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DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and ONE COPY returned to the Secretary at Room 10001, 10th Floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. I agree to a completion of a yearly progress form. I/we agree to inform the Committee once the study is completed.

DATE .....SIGNATURE .....

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Annexure 3

Written consent from the parents

VAAL UNIVERSITY OF TECHNOLOGY

INFORMED CONSENT : IMPLEMENTING AND EVALUATION OF A SCHOOL FEEDING PROGRAMME

I, the undersigned.....(full names in print) have read the details of the project, or have listened to the oral explanation thereof, and declare that I understand it. I have had the opportunity to discuss relevant aspects with the researcher and declare that I voluntarily participate in the project. I hereby give consent to participate in the project and that blood samples may be taken from my child.

I the parent/legal guardian of..... .....(full names of child), grade....., hereby consent that he/she may participate in this research project and that blood samples may be taken from my child .

Signature ..... Relationship.....

Signed at ..... on ....

Witnesses

Name ..... Name .....

Signature ..... Signature .....

Signed at ..... on .....

For subjects under the age of 21 years, signed consent of a parent or legal guardian is essential.

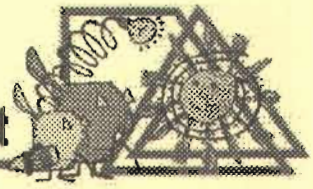
Address of volunteer: .....
.....
.....

Telephone number : .....

Annexure 4

Socio-demographic questionnaire

Community-based integrated nutrition research project



SOCIO-DEMOGRAPHIC QUESTIONNAIRE

This questionnaire covers certain aspects of your life, including work and personal details, health and illness, lifestyle and social life that is relevant to health. The answers to these questions will be kept strictly confidential and the information will not be identifiable from any reports or publications.

1. GENERAL INFORMATION

Date : .....
Name : .....
ID Number : .....
Address : .....
.....
.....

Please answer all questions by marking the correct answer with **X**, except where otherwise indicated.

Example: In what town do you live?

Johannesburg	Bloemfontein	Cape Town	Vanderbijlpark	Durban

2. PERSONAL INFORMATION

2.1 Your role in the family

Mother	Grandmother	Caregiver	Other, specify.....

2.2 When were you born? Year: Month: Day:

2.3 How old are you? _____ years

2.4 Gender:

Male	Female

3. ACCOMMODATION AND FAMILY COMPOSITION

3.1 Where do you live?

Town/City	Farm	Informal settlement	Rural village	Hostel	Other, specify.....

3.2 Do other people live in your house?

Yes
No

3.3 How many people are living in your house?

1	2	3	4	5	6	7	8	9	10	10+

3.4. Please **complete** the table below on all members of the household

Name of household member	Age (yrs)	Gender M / F	Family relationship	Does this person eat and sleep in this house at least 4 days a week?

3.5 Are all members permanent residents in this house?

Yes	No

3.6 If yes, how long have you been staying permanent in this house?

< 1 year	1-5 years	>5 years

3.7 Do you have another home outside the Vaal Triangle?

Yes	No

3.8 In what type of house are you staying and indicate the number of rooms?

Brick	Clay	Grass	Zinc/shack	< 2 rooms	3-4 rooms	> 4 rooms

3.9. Are there other houses/shacks within the same yard of the main house?

Yes	No

3.10 How would you describe the place where you are currently living?

Homeless	
Living with parents	
Living with relatives	
Living with friends	
Hostel accommodation	
Squatter home	
Rented house	
Rented flat	
Own house	
Own flat	
Other, specify.....	

3.11 Do you have the following facilities at home?

3.11.1 Water

Tap in the house	
Tap outside the house (in yard)	
Borehole	
Spring / river / dam water	
Fetch water from elsewhere	

3.11.2 Toilet facilities

None	
Pit latrine	
Flush / sewage	
Bucket system	
Other, specify.....	

3.11.3	Waste removal	Yes	No

3.11.4	Tarred road in front of house	Yes	No
	Gravel road in front of house	Yes	No

3.12 To what extent do you have problems with your housing (e.g. too small, repairs, damp, etc.)?

.....

.....

3.13. Do you have problems with the following?

Mice / Rats	Cockroaches	Ants	Other pests, specify.....

4. WORK STATUS AND INCOME

4.1. Are you currently employed?

Yes	No

If YES, go to Question 4.5.

4.2. If NO, how would you describe your current status (tick one box only)?

Unemployed	Retired	Housewife	Student	Other, specify.....

4.3. Are you actively looking for paid employment at the moment?

Yes	No

4.4. How long have you been unemployed?

< 6 months	6-12 months	1-3 years	> 3 years

4.5. If YES (question 4.1) is your current job a:

Permanent position	Temporary position	Fixed term contract	Other, specify.....

4.6. Is your job?

Full time	< 25 hours per week

4.7 What is the exact title of your current job?
(Including self-employed)

4.8 Do you have a second job for extra cash?

Yes	No

If YES, go to Question 4.10.

4.9 If NO, is your spouse (partner) in paid employment at present?

Yes, full time, permanent	
Yes, part-time, permanent (< 25 hours p w)	
Yes, temporary	
No, unemployed	
No, retired	
No, other, specify.....	

4.10. If YES, what is your spouse (partner)'s occupation or job?

4.11. What is the total income in the household per month?

< R500	R501-R1000	R1001-R1500	R1501-R2000	R2001-R2500	> R2500

4.12. How often does it happen that you do not have enough money to buy food or clothing for you or your family?

Always	Often	Sometimes	Seldom	Never

4.13 How many people e.g. partner, relatives & others (including yourself) contributed to your household income from any source, (including wages/salary from paid employment, money from second or odd jobs income from savings investments, pension, rent or property, benefits and or maintenance etc.) in the last 12 months?

People	0	1	2	3	4	5	6	7	8	9

4.14 How often do you buy food?

Every day	Once a week	Once a month	Other, specify.....

4.15 Where do you buy food?

Spaza shop	Street vendor	Supermarket	Other, specify.....

4.16. How much money is spent on food PER WEEK? (Tick only one box)

R 0 – R 50	R 51 – R 100	R 101 – R 150	R 151 – R 200	R 201 – R 250	R 251 – R 300	> R 300	I do not know

4.17 How much money do you give to each child to take to school for buying food / snacks PER WEEK?

50 c	R 1 – 2	R 2- 3	R 3 - 4	R 4 - 5	> R 5

4.18 Do you buy the following regularly (per month)?

Food item	Yes	No	Food item	Yes	No
Chicken			Cheese		
Beef			Eggs		
Mutton			Fresh milk		
Tripe			Powdered milk		
Fish			Condensed / Ideal milk		
Canned fish eg pilchards			Cremora		
Polony and other processed meat			Frozen vegetables		
Canned meat eg bully beef			Fresh vegetables		
Cold drink			Canned vegetables		
Sugar			Fresh fruit		
Maize meal			Canned fruit		
Oil			Fruit juice		
Butter / margarine			Coffee, instant		
Peanut butter			Tea		
Fish paste			Cheese curls		
Jam			Sweets		

5 EDUCATION AND LANGUAGE

5.1. What is the highest education you have?

None	Primary School	Standard 8	Standard 10	College	Other post school

5.2 What language is spoken mostly in the house?

Sotho	Xhosa	Zulu	Pedi	Other, specify.....

5.3 How many children (in the household) 5 years and under have birth certificates?

None	1	2	3	4	5	6	7	8	All

5.4 How many children 5 years and under have completed their immunisation schedule?

None	1	2	3	4	5	6	7	8	All

5.5 Number of children attending school

None	1	2	3	4	5	6	7	8	All

5.6 How do the children get to school?

Walk	Bus	Taxi	Lift	Other, specify.....

6 ASSETS

Tick one block for every question:	Father	Mother	Sibling	Grandma	Grandpa	Aunt	Uncle	Cousin	Friend	Other
6.1 Who is mainly responsible for food preparation in the house?										
6.2 Who decides on what types of food are bought for the household?										
6.3 Who is mainly responsible for feeding/serving the child?										
6.4 Who is the head of this household?										
6.5 Who decides how much is spent on food?										

6.6 How many meals do you eat at per day?

0	1	2	3	> 3

6.7 Where do you eat most of your meals?

Home	Friends	Work	Buy	Other, specify.....

6.8 Where do your children eat most of their meals?

Home	Friends	School	Buy	Other, specify.....

6.9 Does your home have the following and how many?

	Yes	No	Quantity
Electrical stove			
Gas stove			
Primus or paraffin stove			
Microwave			
Hot plate			
Radio			
Television			
Refrigerator			
Freezer			
Bed with mattress			
Mattress only			
Lounge suite			
Dining room suite			

Annexure 5

Quantitative Food Frequency Questionnaire

QUANTITATIVE FOOD FREQUENCY QUESTIONNAIRE

SUBJECT DATE OF BIRTH: ..... AGE:.....

SUBJECT NUMBER: .....

NAME: .....

INTERVIEWER: .....

ADDRESS: .....

INTRODUCTION:

Greeting

Thank you for giving up your time to participate in this study. Here we want to find out what people living in this area eat and drink. This information is important to know as it will tell us if people are eating enough and if they are healthy.

Please think carefully about the food and drink you have consumed during the past few months. I will now go through a list of foods and drinks with you and I would like you to tell me

- If you eat the food,
- how the food is prepared,
- how much of the food you eat at a time,
- how many times a day you eat it and if you do not eat it every day, how many times a week or a month do you eat it.

To help you to describe the amount of a food you eat, I will show you pictures/examples of different amounts of the food. Please say which picture/example is the closest to the amount that is eaten, or if it is smaller, between sizes or bigger than the pictures.

I will also ask some questions about where you get your food and where you shop. This information is important because it will tell us which foods are easy to obtain and which are not and how the food is prepared and served.

THERE ARE NO RIGHT OR WRONG ANSWERS.

EVERYTHING YOU TELL ME IS CONFIDENTIAL. ONLY YOUR SUBJECT NUMBER APPEARS ON THE FORM.

IS THERE ANYTHING you WANT TO ASK NOW?
ARE YOU WILLING TO GO ON WITH THE QUESTIONS?

INSTRUCTIONS: Circle the subject's answer. Fill in the amount and times eaten in the appropriate columns.

SUBJECT DATE OF BIRTH: .....

I shall now ask you about the type and the amount of food your child has been eating in the last few months. Please tell me if you eat the food, how much you eat and how often you eat it. We shall start with maize meal porridge.

Do you eat maize meal porridge? YES 1 NO 2
If YES, what type do you have at home now?

Brand name: .....
Don't know 2
Grind self 3

If brand name given, do you usually use this brand?
YES 1 NO 2 DON'T KNOW 3
Where do you get you maize meal from? (May answer more than one)

Shop	1
Employer	2
Harvest and grind self	3
Other – specify	4
Don't know	5

FOR OFFICE USE

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Maize meal porridge	Stiff ('pap')						e4225 4250	
Maize meal porridge	Soft ('slap pap')						e4225 4250	
Do you pour milk on your soft porridge? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2 %, fat free, milk blend)? ..... INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your soft porridge? YES 1 NO 2								
If YES, how much sugar?							9012	
Maize meal porridge	Crumbly (phutu)						e4225 4250	
Ting	Maize/mabela							
Mabella Coarse Fine Rice	Stiff						4082	
Mabella Coarse Fine Rice	Soft						4082	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Do you pour milk on your mabella porridge? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2 %, fat free, milk blend)? ..... INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your mabella? YES 1 NO 2								
If YES, how much sugar?							9012	
Oats							4032	
Do you pour milk on your oats? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2 %, fat free, milk blend)? ..... INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your oats? YES 1 NO 2								
If YES, how much sugar?							9012	
Breakfast Cereals	Brand names of cereals at home now: Don't know						4036	
Do you pour milk on your cereal? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2 %, fat free, milk blend)? ..... INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your cereal? YES 1 NO 2								
If YES, how much sugar?							9012	
Samp	Bought Self ground with fat without fat						4043	
Samp and Beans								
	Are the amounts of samp and beans the same as in the picture? YES NO If NO, do you use more beans than in the picture or less? MORE LESS							
Samp and Peanuts								
	Are the amount of samp and peanuts the same as in the picture? YES NO If NO, do you use more peanuts than in the picture or less? MORE LESS							
Rice	White Brown Maize rice						4040 4134 4043	
Pastas	Macaroni Spaghetti Other						4062	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
You are being very helpful. Can I now ask you about meat?								
CHICKEN, MEAT, FISH								
Where do you get your chicken from? (May answer more than 1). How many times per week do you eat chicken?								
	Shop, supermarket, spaza							1
	Employer							2
	Slaughter own							3
	Gift							4
	Other specify:							5
	Do not eat chicken							6
Chicken:	Boiled, nothing added						1521	
	Fried: in butter/crumbs						1634	
	Not coated						1520	
	Roasted, grilled						1520	
	Stewed						1520	
	What vegetables are in the stew?							
	Don't know							
Do you eat chicken skin? ALWAYS 1 SOMETIMES 2 NEVER 3								
Chicken bones stew								
Chicken feet	How do you cook it?						1609	
Chicken offal	How do you cook it?						1610	
Where do you get your MEAT from? (May answer more than 1). How many times per week do you eat meat?								
	Shop, supermarket, spaza							1
	Employer							2
	Slaughter own							3
	Gift							4
	Other specify:							5
	Do not eat red meat							6
Red meat:	How do you like meat? With fat Fat trimmed							
Beef	Fried – with bone							
	Fried – without bone							
	Stewed – with bone							
	Stewed – without bone							
	Grilled – with bone							
	Grilled – without bone							
	Minced						1585	
Mutton	Fried – with bone						1522	
	Fried – without bone						1571	
	Stewed – with bone						1511	
	Stewed – without bone						1511	
	Grilled – with bone							
	Grilled – without bone							
	Minced						1662	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Pork	Fried – with bone							
	Fried – without bone							
	Stewed – with bone							
	Stewed – without bone							
	Grilled – with bone							
	Grilled – without bone							
Beef Offal	Intestines: boiled, nothing added						161	
	Stewed with vegetables							
	Tripe						1546	
	Heart						1565	
	Lungs							
	Liver						1515	
	Kidneys						1518	
	Other specify:							
What vegetables are usually put into meat stews?								
Wors sausage	Fried Grilled						1526	
Bacon							1501	
Cold meats	Polony						1514	
	Ham						1564	
	Viennas						1531	
	Other specify:							
Canned meat	Bully beef						1535	
	Other specify:							
Meat pie	Home made Bought						1548	
Hamburger	Home made Bought							
Dried beans, peas, lentils (10)	How do you prepare them?							
Soya products e.g. Toppers	Brands at home now Don't know..... Show examples						3527	
Pilchards in tomato chilli brine	Whole						2557	
	Mashed with fried onion							
Fried fish	With batter/ crumbs						2523	
	Without batter/crumbs						2509	
Other canned fish	Tuna							
	Pickled fish Other:						2562	
Fish cakes	Home made (describe) Frozen Bought						2531	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Eggs	Boiled poached Scrambled Fried						1001 1025 1003	
WE NOW COME TO VEGETABLES AND FRUIT How many times per week do you eat vegetables? ..... Where do you get your vegetables from? (May answer more than 1) Own vegetable garden Employer's farm Own farm Shops, supermarket, greengrocer Hawker Veld (e.g. morogo) Gifts Other specify								1 2 3 4 5 6 7 8
Cabbage	How do you cook cabbage?							
	Boiled, nothing added						8066	
	Boiled with potato and onion and fat							
	Fried, nothing added							
	Boiled, then fried with potato, onion							
	Other:							
	Don't know							
Spinach / morogo / other green leafy	How do you cook spinach?							
	Boiled, nothing added						8071	
	Boiled fat added						8209	
	Boiled with – onion, tomato & fat							
	-onion, tomato & potato						8212	
	- with peanuts							
	Other:							
	Don't know							
Tomato and onion 'gravy'	Home made - with fat - without fat							
	Canned (Is this the amount of pap you eat? How much more or less?)						8221	
Pumpkin	How do you cook pumpkin?							
	Cooked in fat & sugar							
	Boiled, little sugar and fat							
	Other:							
	Don't know							

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Carrots	How do you cook carrots?							
	Boiled, sugar & fat						8129	
	With potato/ Onion							
	Raw, salad Chakalaka						8015	
	Other:							
	Don't know							
Mealies / Sweet corn	How do you eat mealies? On cob –with fat -without fat						8033	
	Off cob –with fat -without fat						8261	
Beetroot salad	Home made Bought						8005	
Potatoes	How do you cook potatoes?							
	Boiled/baked - with skin						8046	
	- without skin						8045	
	Mashed						8187	
	Roasted						8189	
	French fries						8048	
	Salad						8236	
	Other:							
Sweet potatoes	How do you cook sweet potatoes?							
	Boiled/baked - with skin						8057	
	- without skin						8214	
	Mashed						8058	
	Other:							
	Don/t know							
Salad vegetables	Raw tomato						8059	
	Lettuce						8031	
	Cucumber						8025	
Other vegetables specify:								

FRUIT:

Do you like fruit? YES NO How many times per week do you eat fruit in winter? ...../ in summer? .....

Where do you get your fruit from?

Own fruit trees	1
Farm – employer	2
Farm – own	3
Supermarket/greengrocer	4
Hawker	5
Veld	6
Gifts	7
Other	8

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Apples/Pears	Fresh						7001	
Pears	Fresh Canned						7053 7054	
Bananas							7009	
Oranges / naartjies							7031	
Grapes							7020	
Peaches	Fresh Canned						7036 7038	
Apricots	Fresh Canned						7003 7004	
Mangoes	Fresh						7026	
Guavas	Fresh Canned						7021 7023	
If subject eats canned fruit: Do you have custard with canned fruit? YES 1 NO 2								
Custard	Home made Ultramel						0004	
Wild fruit / berries	Stamvrugte Noen-noem Klappers Maroelas Nastergals Other – specify						7070	
Dried fruit:	Types:							
Other fruit:								
BREAD AND BREAD SPREADS								
Bread Bread rolls	White						4001	
	Brown						4002	
	Whole wheat						4003	
Do you spread anything on the bread? ALWAYS 1 SOMETIMES 2 NEVER 3 If YES, what do you spread?								
Margarine	What brand do you have at home now? ..... Don't know Show examples						6508 6521	
Butter	What brand do you have at home now? ..... Home made Don't know						6502	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Peanut butter							6509	
Jam/syrup/ honey							9008	
Marmite/Fray Bentos etc.							9501	
Fish/meat paste							1512	
Cheese	Type:						0010	
Atchar							3004	
Polony							1514	
Other spreads: specify								
Dumpling							4001	
Vetkoek							4057	
Provita, crackers etc.								
FATS: What fats do you use and where do you use them?								
Margarine	Where used: on bread							
	with vegetables** Number of spoons ..... /number in family							
Butter	on bread with vegetables** Number of spoons ..... /number in family							
Holsum / vegetable fat	Where used: Number of spoons ..... /number in family						6508	
Oil	Where used: Number of spoons ..... /number in family						6510	
Dripping	Where used: Number of spoons ..... /number in family							
Mixed fat (makhuru)	Where used: Number of spoons ..... /number in family							

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
Lard	Where used: Number of spoons ..... /number in family						6520	
Mayonnaise/ salad dressing	Number of spoons ..... /number in family						6573	
Cream	Fresh/Long life /canned Orley whip						6503	
DRINKS:								
Tea							9514	
Sugar/cup tea							9012	
Milk / cup tea	What type of milk do you use in tea?							
	Fresh / long life Whole						0006	
	Fresh / long life 2%							
	Fresh / long life fat free						0072	
	Whole milk powder Brand						0009	
	Skimmed milk powder Brand						0008	
	Milk blend Brand						0068	
	Whitener Brand						0039	
	Condensed milk						0002	
	Evaporated milk						0003	
	None							
Coffee								
Sugar / cup coffee							9012	
Milk / cup coffee	What type of milk do you use in coffee?							
	Fresh / long life whole						0006	
	Fresh / long life 2 %							
	Fresh / long life fat free						0072	
	Whole milk powder Brand						0009	
	Skimmed milk powder Brand						0008	
	Milk blend Brand						0068	
	Whitener Brand						0039	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
	Condensed milk						0002	
	Evaporated milk						0003	
	None							
Milk as such	What type of milk do you drink as such?							
	Fresh / long life whole						0006	
	Fresh / long life 2 %							
	Fresh / long life fat free						0072	
	Sour / Maas						0006	
	Buttermilk						0001	
	Whole milk powder Brand						0006	
	Skimmed milk powder Brand						0072	
	Milk blend Brand						0068	
Milk drinks Brand	Nestle Milo Other						0023	
Yoghurt	Drinking yoghurt Thick yoghurt						0044 0020	
Squash	Sweeto SixO Oros/Lecol - with sugar - artificial sweetner Kool Aid Other						9013 9013 9002 9013 9002	
Fruit juice	Fresh/Liquifruit/Ceres Tropica Concentrates e.g. Halls Nectars Flavour							
Fizzy drinks Coke, Fanta	Sweetened Diet						9001 9013	
Mageu/Motogo							9562	
Home brew							9516	
Tlokwe							9516	
Beer							9506	
Spirits							9510	
Wine red							9508	
Wine white							9518	
Liqueur							9517	
Other: specify								

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
SNACKS AND SWEETS:								
Potato crisps							4275	
Cheese curls Niknaks etc.							4067	
Peanuts	Raw Roasted						6001 6007	
Raisins							7022	
Peanuts and raisins								
Chocolates	Name						9024	
Candies	Sugars, gums, hard sweets						9009	
Sweets	Toffees, fudge, caramels						9014	
Biscuits	Type							
Cakes & tarts	Type							
Scones							4029	
Rusks							4160	
Savouries	Sausage rolls Samoosas Biscuits e.g. Bacon kips Other						1534 4196 4162	
PUDDINGS:								
Canned fruit	Type							
Jelly							9004	
Custard	Homemade Ultramel						0004	
Baked pudding							4181	
Instant pudding							4066	
Ice cream Sorbet							6507 6516	
Other: specify								
SAUCES / GRAVIES / CONDIMENTS:								
Atchar							3004	
Tomato sauce Worcester sauce							3027	
Chutney							9524	
Pickles							8176	
Packet soups							3046	
Others:								
INSECTS:								
Locusts								
Mopani worms								
Others:								

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom Never		
WILD BIRDS OR ANIMALS (hunted in rural areas or on farms)								
MISCELLANEOUS: Please mention any other foods used more than once/two weeks which we have not talked about:								

SALT USE:

The next few questions are to find out if you use salt, where you use it and how much you use.

Do you add salt to food while it is being cooked?

Always	Sometimes	Never	Don't know
1	2	3	4

Do you add salt to food after it has been cooked?

Always	Sometimes	Never	Don't know
1	2	3	4

Do you like salty foods e.g. salted peanuts, crisps?

Very much	Like	Not at all
1	2	3

KEEPING FOOD:

Do you keep food from one meal to eat at the next meal?

Always	Sometimes	Never	Don't know
1	2	3	4

If ALWAYS OR SOMETIMES, what foods do you keep?
Do you eat kept food cold or do you reheat it?

FOOD	Reheated	Eaten cold

Do you use any of the following?

	Name of product	Amount/day
Vitamins/vitamins & minerals		
Tonics		
Health foods		
Body building preparations		
Dietary fibre supplement		
Other: specify		

THANK YOU FOR YOUR COOPERATION AND PATIENCE

GOOD-BYE!

Annexure 6

24-hour recall questionnaire

24 – HOUR RECALL

Subject ID number: _____ Interviewer: _____

Name: _____ Date: _____ / _____ / 200 ___

Address: _____

Tick what the day was yesterday:

Monday	Tuesday	Wednesday	Thursday	Friday

Would you describe the food that you ate yesterday as typical of your habitual food intake?

Yes	1	No	2

If not, why? _____

I want to find out about everything you ate or drank yesterday, including food you pick from the veld. Please tell me everything you ate from the time you woke up to the time you went to sleep. I will also ask you where you ate the food and how much you ate.

Time (approximately)	Place (Home, school, etc)	Description of food and preparation method.	Amount	Amount in g (office use Only)	Code (office use only)
From waking up to going to school, or starting day's activities					
During the morning at work or at school					

Annexure 7

Breakfast consumption questionnaire

Community-based integrated nutrition research project

Assessment of the nutritional status of Primary school children in an informal settlement in the Vaal Triangle

Section A:

1. Name of school: Setlabotiha Primary School 2. Name of the teacher.....

3. Name of the child.....4. Age:..... 5. Grade: .....

6. Name of the parent /caregiver.....

7. Address of the child:.....

8. Do you eat breakfast before coming to school ?	Yes	No

If yes:

9. What did you eat for breakfast ?

Today:

Yesterday:

The day before Yesterday:

What would you like to eat for breakfast ?:

10. Do you eat breakfast over weekends ?	Yes	No

If yes:

11. What do you eat for breakfast over weekends ?

Annexure 8

Nutritional analysis of the original product done by the ARC

ARC • LNR

ARC-Irene Analytical Services
LNR-Irene Analitiese Dienste

Private Bag/Privaatsak X2, Irene, 0062 Tel: (012) 672 9294 Fax: (012) 665 1605

Enquiries: Dr Louwrens Smit
Tel: 012-672 9244

2004-04-07

The Manager
Vaal University of Technology
Hospitality & Tourism Dept
Private Bag X021
Vanderbijlpark
1911

Tel: (016) 950 9878
Fax: (016) 950 9788
016 423 2660
Attention: Ms J Kearney

TEST REPORT

Date received: 18/03/2004
Date completed: Preliminary Report
Test report no: 2004-S-133

RESULTS OF SAMPLES (UNSPECIFIED)

Please take note that:

1. Test results relate only to the samples tested.
2. This report may not be reproduced without the written consent of the Quality Manager.
3. The samples received were thoroughly mixed before analysis.
4. Chromatogrammes are available on request.
5. Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.

Yours sincerely

General Chemistry

Specialised Techniques

ARC-IRENE ANALYTICAL SERVICES

TEST REPORT 2004-S-133

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 : Vetkoek
Ash	ASM 048	%	2.43
Dry matter	ASM 013	%	65.80
Moisture	ASM 013	%	34.20
Fat (ether extraction)	ASM 044	%	15.42
* Protein	ASM 041	%	7.29
Folic acid		µg/100g	1002.52
Vit A		mg/100g	0.06
Carbohydrates (calculated)		g/100g	40.66
Vit B1	ASM 025	mg/100g	To follow
Vit B2	ASM 025	mg/100g	0.17
Vit B6	**	mg/100g	1.35
Vit B12	**	µg/100g	5.31
Vit C	ASM 057	mg/100g	0.81
Energy (Calculated)		kJ/100g	1386
Calcium	**	mg/100g	140.49
Magnesium	**	mg/100g	73.42
Copper	**	mg/kg	0.85
Iron	**	mg/kg	98.13
Zinc	**	mg/kg	39.61

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

Annexure 9

Results of the second test report from the ARC

ARC • LNR

ARC-Irene Analytical Services
LNR-Irene Analitiese Dienste

SANAS ACCREDITED LABORATORY T0003

Private Bag/Privaatsak X2, Irene, 0062 Tel: (012) 672 9294 Fax: (012) 665 1605

Enquiries: Dr Louwrens Smit
Tel: 012-672 9244

2004-05-20

The Manager
Vaal University of Technology
Hospitality & Tourism Dept
Private Bag X021
Vanderbijlpark
1911

Tel: (016) 950 9878
Fax: (016) 950 9788

Attention: Ms J Kearney

TEST REPORT

Date received: 18/03/2004
Date completed: 20/05/2004
Test report no: 2004-S-133

RESULTS OF SAMPLES (UNSPECIFIED)

Please take note that:

1. Test results relate only to the samples tested.
2. This report may not be reproduced without the written consent of the Quality Manager.
3. The samples received were thoroughly mixed before analysis.
4. Chromatogrammes are available on request.
5. Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.

Yours sincerely

..... *General Chemistry*

..... *Specialised Techniques*

ARC-IRENE ANALYTICAL SERVICES

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 : Vetkoek
Freeze drying		%	70.60
Ash	ASM 048	%	2.43
Dry matter	ASM 013	%	65.8
Moisture	ASM 013	%	34.20
Fat (ether extraction)	ASM 044	%	15.42
*Protein	ASM 041	%	7.29
**Folic acid		µg/100g	1002.52
Vit A		mg/100g	0.06
Vit B1	ASM 025	mg/100g	0.43
Vit B2	ASM 025	mg/100g	0.15
**Vit B6		mg/100g	1.35
**Vit B12		µg/100g	5.31
Vit C	ASM 057	mg/100g	0.81
Carbohydrates (calculated)		g/100g	40.66
Energy (Calculated)		kJ/100g	1386
**Calcium		mg/100g	140.49
**Magnesium		mg/100g	73.42
**Copper		mg/kg	0.85
**Iron		mg/kg	98.13
**Zinc		mg/kg	39.61

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

Annexure 10

Results of the third nutritional analysis done by the ARC

ARC • LNR

ARC-Irene Analytical Services
LNR-Irene Analitiese Dienste

SANAS ACCREDITED LABORATORY T0065

Private Bag/Privaatsak X2, Irene, 0062 Tel: (012) 672 9294 Fax: (012) 665 1605

Enquiries: Dr Louwrens Smit
Tel: 012-672 9244

2004-11-24

The Manager
Vaal University of Technology
Hospitality & Tourism Dept
Private Bag X021
Vanderbijlpark
1911

Tel: (016) 950 9878
Fax: (016) 950 9788

Attention: Ms J Kearney

TEST REPORT

Date received: **14/10/2004**
Date completed: **24/11/2004**
Test report no: **2004-S-426**
Order number: **B164883**

RESULTS OF SAMPLES (UNSPECIFIED)

Please take note that:

1. Test results relate only to the samples tested.
2. This report may not be reproduced without the written consent of the Quality Manager.
3. The samples received were thoroughly mixed before analysis.
4. Chromatogrammes are available on request.
5. Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.

Yours sincerely

General Chemistry

Specialised Techniques

ARC-IRENE ANALYTICAL SERVICES

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	
Dry matter	ASM 013	%	60.50	
Moisture	ASM 013	%	39.50	
Fat (acid hydrolysis)	ASM 068	%	8.21	
#Protein*		%	8.96	
Folic acid		µg/100g	820	
Vit A		mg/100g	0.09	
Vit B1	ASM 025	mg/100g	0.40	
Vit B2	ASM 025	mg/100g	0.10	
Vit B6		mg/100g	0.46	
Vit B12		µg/100g	1.27	
Vit C	ASM 057	mg/100g	1.27	
#Calcium		mg/100g	117.23	
#Magnesium		mg/100g	72.24	
#Copper		mg/kg	1.43	
#Iron		mg/kg	40.25	
#Zinc		mg/kg	34.50	
Energy (calculated)		kJ/100g	1161	
Carbohydrates (calculated)		g/100g	41.45	

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

Annexure 11

Results of the shelf life testing

ARC • LNR

ARC-Livestock Business Division

Nutrition and Food Science

Private Bag / Privaatsak X2, Irene, 0062 South Africa / Suid Afrika
Olifantsfontein Road or Nelmapius Road, Irene
Tel: (012) 672- 9111 Int: +27-12-672-9111 Fax: (012) 665-1551 Int: +27-12-665-1551

Enquiries / Navrae
Jansie Krüger
Tel: (012) 672 9392/9338
Fax: (012) 665 1551

2005-10-04

Jeanette Kearney
Fax: (016) 9509788

Jeanette

Please find attached the final report of the Vetkoek shelf life study. If anything is unclear or if you need more information, feel free to contact me.

Regards
Jansie Krüger

Shelf life analysis of Nutritional Vetkoek

Introduction

The Vetkoek was delivered to ARC-Microbiology on Monday afternoon the 12th of September 2005 in a cool box without any cooling blocks. The vetkoek was packed in a foil tray with a carton lid.

Shelf life study

One tray was kept at 4°C and the other tray at room temperature (±25°C). The vetkoek was plated out on day 0 (12 September 2005, day of arrival) day 2 (14 September 2005), 4 (16 September 2005) and day 7 (19 September 2005).

Microbiological analysis

A 10g sample was removed aseptically from the inside of the vetkoek. The samples were homogenized in a Stomacher 400 (DHK Pty Ltd) with 90 ml of diluent (Buffered peptone water). The samples were plated out for a total aerobic plate count on Tryptone soy agar and incubated at 25°C for 72 hours and for yeast and moulds on Rose Bengal agar and incubated at 25°C for 72 hours.

Results

Table1. Result of Vetkoek stored at 4°C

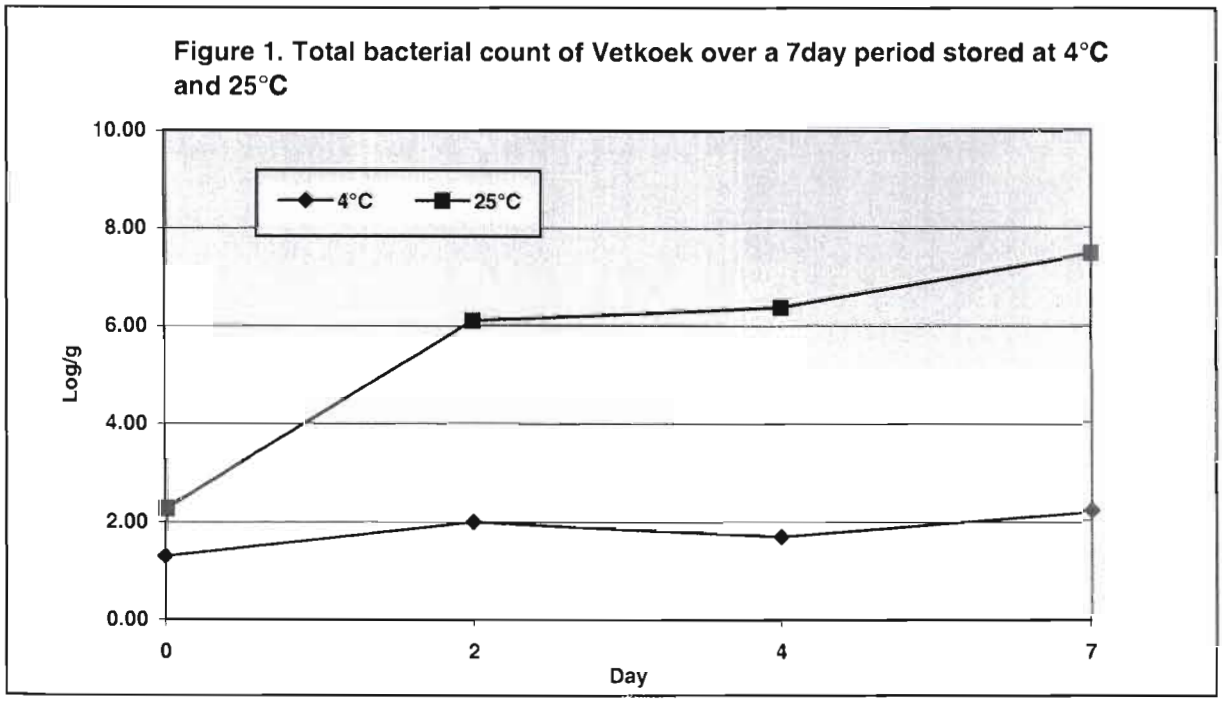
Sample	Total Aerobic Plate count Cfu/g	*Yeast and Moulds* Cfu/g
Day 0	$2,0 \times 10^1$	<10
Day 2	$1,0 \times 10^2$	<10
Day 4	$5,0 \times 10^1$	<10
Day 7	$1,6 \times 10^2$	<10

Cfu/g = Colony Forming units per gram of sample

Table 2. Result of Vetkoek stored at 25°C

Sample	Total Aerobic Plate count Cfu/g	Yeast and Moulds Cfu/g
Day 0	$1,9 \times 10^2$	<10
Day 2	$1,3 \times 10^6$	<10
Day 4	$2,4 \times 10^6$	<10
Day 7	$>3,0 \times 10^7$	1

Cfu/g = Colony Forming units per gram of sample



The total bacterial count as well as the yeast and mould counts for the vetkoek stored at 4°C remained low throughout the seven day trial.

The total bacterial count for the vetkoek stored at 25°C increased from log 2 to log 6 on the second day and increased to more than log 7 on the last day of the shelf life trial. Although the yeast and mould count remained very low throughout the 7 days, moulds were visually detected on day 4 of the trial.

Conclusion

The vetkoek stored at 4°C do have a seven-day shelf life period. The vetkoek stored at 25°C only have a two-day shelf life.

Although moulds were visible on the vetkoek stored at 25°C on day 4, the counts were very low throughout the trial. This could be due to the fact that the 10g aliquot of sample was taken from the middle of the vetkoek each time, and the visible mould growth was on the upper crust of the vetkoek.

Annexure 12

Sensory Evaluation: Paired preference test

Sensory evaluation
Paired preference testing

Name: _____ **Surname:** _____

Grade: _____

Date: _____

1. Please mark with a cross **(X)** under the face which best describes how you feel about the **taste** of product **A.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

2. Please mark with a cross **(X)** under the face which best describes how you feel about the **taste** of product **C.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

3. Please mark with a cross **(X)** under the face which best describes how you feel about the **taste** of product **B.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

4. Please mark with a cross (X) under the face which best describes how you feel about the **texture** of product **A.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

5. Please mark with a cross (**X**) under the face which best describes how you feel about the **texture** of product **C.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

6. Please mark with a cross (**X**) under the face which best describes how you feel about the **texture** of product **B.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

7. Please mark with a cross (**X**) under the face which best describes how you feel about the **color** of product **A.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

8. Please mark with a cross (**X**) under the face which best describes how you feel about the **color** of product **C.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

9. Please mark with a cross (**X**) under the face which best describes how you feel about the **color** of product **B.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

Thank you for your assistance

Annexure 13

Sensory Evaluation: Acceptance testing

Sensory evaluation Acceptance testing

Name: _____ **Surname:** _____

Grade: _____ **Date:** _____

1. Please mark with a cross (**X**) under the face which best describes how you feel about the **taste** of the product.

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

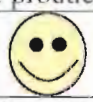
2. Please mark with a cross (**X**) under the face which best describes how you feel about the **texture** of the product.

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

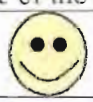
3. Please mark with a cross (**X**) under the face which best describes how you feel about the **color** of the product.

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

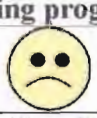
4. Please mark with a cross (**X**) under the face which best describes how you feel about the **smell** of the product.

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

5. Please mark with a cross (**X**) under the face which best describes how you feel about the **portion size** of the product.

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

6. Please mark with a cross (**X**) under the face which best describes how you feel about **receiving this product as part of the school feeding program.**

				
Like a lot	Like a little	Neither like or dislike	Dislike a little	Dislike a lot

Thank you for your assistance

Annexure 14

Recipe pamphlet

Vaal University of Technology

Caregiver training: Eatonside

Recipe 1 Basic Vetkoek

1 x small packet 10g		Yeast
1 cup 200ml 		Lukewarm water
1 cup 200ml 		Fresh milk or milk powder
1		Egg, large beaten
30ml 		Oil, sunflower
15ml 		Sugar, white

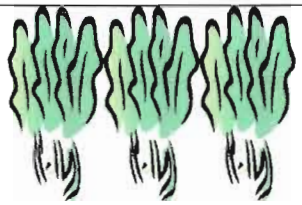
5ml 		Salt
3 cups 		Whole-wheat flour
2 cups 		Maize meal

Preparation method:

1. Mix milk, water add eggs
2. Mix all dry ingredients with instant yeast
3. Add milk mixture to dry ingredients and blend well
4. Knead well for 5 minutes, to make a soft dough
5. Put dough into a clean bowl and cover with a clean kitchen towel
6. Leave in a warm place to rise for 2 hours
7. Heat sunflower oil in a saucepan or deep fat fryer
8. Put dough on a clean flat surface and lightly roll out the dough
9. Cut with a knife or with the portioning frame
10. Fry for 4 minutes on each side
11. Oil temperature 160°C

Recipe 2 Wholewheat and Maize meal " vetkoek"

1 x small packet 10g		Yeast
1 cup 		Lukewarm water
1 cup 		Fresh milk or milk powder
1		Egg, large beaten
15ml 		Oil, sunflower
10ml 		Sugar, white
10ml 		Salt

3 cups 		Whole-wheat flour
2 cups 		Maize meal
3 cups 		Spinach chopped raw
1 small can		Pilchards in tomato sauce, mashed

Preparation method:

1. Mix milk powder with water and add eggs
2. Chop spinach
3. Mix all dry ingredients with instant yeast
4. Add milk mixture to dry ingredients
5. Add chopped spinach and mashed pilchards
6. Knead well for 5 minutes, to make a soft dough
7. Put dough into a clean bowl and cover with a clean kitchen towel
8. Leave in a warm place to rise for 2 hours
9. Heat sunflower oil in a saucepan or deep fat fryer
10. Put dough on a clean flat surface and lightly roll out the dough
11. Cut with a knife or with the portioning frame
12. Fry for 4 minutes on each side
13. Oil temperature 160°C

Annexure 15

Proof of language editing

A E RESEARCH SERVICES

ACADEMIC EDITORIAL RESEARCH SERVICES

(SATI MEMBERSHIP NUMBER 1001593)

19 June 2006

To Whom It May Concern:

This is to certify that I have acted as language editor for the dissertation titled "Development of a novel breakfast food product for primary school children in an informal settlement" submitted by for Jeanette Kearney in fulfillment of the requirements for the degree of Magister Technologiae in the Department of Hospitality and Tourism, Faculty of Human Sciences, Vaal University of Technology.

Yours sincerely

Engelbrecht

Antoinette Engelbrecht

Annexure 16

Article: Development and processing of a novel food product for a school feeding project in South Africa

PUBLIC HEALTH
JOURNAL OF THE ROYAL INSTITUTE OF PUBLIC HEALTH
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Jeanette Kearney
Department: Hospitality and Tourism
Vaal University of Technology
Private Bag X021,
Vanderbijlpark, 1900
SOUTH AFRICA

2 August, 2006

Dear Dr Kearney,

P1814: Development and processing of a novel food product for a school feeding project in South Africa

Received on: 2nd August 2006

Thank you very much for submitting the above paper to *Public Health*. You will be informed as soon as possible whether your manuscript is suitable for publication in this journal.

Yours sincerely,

Hannah Cumber
Managing Editor

Development and processing of a novel food product for a school feeding project in South Africa

J. Kearney, Prof. W. Oldewage-Theron, C. Napier

Vaal University of Technology, Private Bag X021,

Vanderbijlpark 1900, South Africa

Abstract

Objectives

The aim of this project was to develop a nutritious novel food product that is acceptable to children, and rich in energy, protein and micronutrients. This product had to be affordable, cost effective and easy to prepare by the caregivers using locally available raw materials, with minimal waste and no need for specified fortification or enrichment.

Study design

This project formed part of a bigger study where the developed product was used as part of a school feeding scheme and the nutritional impact of the product was monitored. A survey was conducted to determine breakfast consumption patterns of schoolchildren in an informal settlement in the Vaal Triangle. The results were used to identify nutrient deficiencies in the target group and to design a product that will address specific nutritional needs.

Methods

The product developed was a nutritious *vetkoek* (vetkoek: a bread type cake fried in oil). Biochemical food analysis was done to compare the theoretical and actual nutrient content. Acceptance testing and a shelf life analysis were conducted.

Results

Results of the breakfast study indicated that 13.2% of children did not eat breakfast before going to school and of those who ate breakfast, 86.8% had only bread and tea.

Conclusions

This study confirms that an affordable, safe and acceptable novel food product can be developed to be used as part of a school feeding scheme.

Keywords: novel food product, school feeding, product development, malnutrition, schoolchildren

Introduction

Malnutrition is a global problem. In developing countries, deficiencies in iron, iodine, vitamin A and zinc are the main manifestations of malnutrition [1]. According to Maiti [2] malnutrition is one of the most neglected forms of human

deprivation, particularly amongst children. The consequences of malnutrition may include growth stunting, anorexia, susceptibility to infections, behavioural changes, and learning disabilities [3, 4].

The malnutrition problem in South Africa (SA) is a reality. The National Food Consumption Survey conducted in South Africa reported that the average dietary intake of energy, calcium, iron, zinc, selenium, vitamin A, vitamin D, vitamin C, vitamin E, riboflavin, niacin, and vitamin B6 for children was less than 67%, and in some instances below 50% of the recommended daily allowance (RDA). Results of international studies show that by improving the nutritional status of toddlers and schoolchildren, learning, behaviour and growth are beneficially affected. Well-fed children are stronger, brighter and more co-operative [5, 6].

In 1994, President Nelson Mandela introduced the Primary School Nutrition Programme (PSNP) to establish school feeding on a national scale in South Africa. The aim of the PSNP was to improve the active capacity of primary school children by providing them with a nutritious snack. Fortified biscuits or bread and peanut butter was supplied to alleviate temporary hunger, thus contributing to pupils' learning capacity, and improving school attendance and punctuality [7, 8]. An average of 5 million school children in SA have benefited since the programme started in 1994 [9].

This article reports on a study that concentrated on the development and processing of a novel food product that could be introduced into the school-feeding project in a financially disadvantaged community in the Vaal Triangle.

The novel food product developed was a *vetkoek* (whole wheat bread dough fried in oil). The objective was to address deficiencies in iron, zinc, calcium and energy levels as identified in the baseline study [10] in order to improve the nutritional status of previously disadvantaged primary school children in the Vaal Triangle.

The first objective of this study was to develop a nutrient-dense product that could be implemented in the existing school feeding programme to address the problem of malnutrition in primary school children in this community. The second objective was to develop the infrastructure in the school to produce the product.

The baseline survey was undertaken in an informal settlement in the Vaal Triangle, an industrial area situated approximately 70 km south of Johannesburg, South Africa, that has a population of 794 599. The school was identified when a strategic roundtable participatory planning workshop with all stakeholders was held in May 2002. The stakeholders included local government councillors for the region, a Department of Health representative and a Department of Education representative. All the stakeholders identified this poverty-stricken community. It is a low-income community with chronic household food insecurity and compromised nutrition [11]. The nutritional status of the children in the local primary school was assessed by dietary and anthropometrical methods. When compared to the National Centre for Health Statistics standards, the anthropometrical data in this study indicated that 18% of the children were stunted or chronically malnourished and that 25% of the children fell under the 5th percentile for weight-for-age. Twelve percent of the children fell under the 5th percentile for body mass index-for-age and, therefore, suffered from acute

malnutrition [10]. These results compared well with the data of children between seven and 12 years in Gauteng [12], which indicated that 12% of the children fell below the 5th percentile of height-for-age, 18% of the children below the 5th percentile of weight-for-age and 6% below the 5th percentile of weight-for-height.

In this study, the anthropometry was validated by the low energy intake. Zinc and ferritin levels were lower than the normal range for children in this age group and they confirmed the low intake of green vegetables, fish and whole grain products as reflected by the baseline survey on food consumption patterns. The prevalence of stunted children in the sample indicated a chronic rather than acute malnutrition problem. The dietary intake results confirmed the low intake of micronutrients, as less than 67 % of dietary reference intakes (DRI) was consumed by this sample for calcium, iron, zinc, vitamin A, C, and riboflavin.

All the respondents participating in this study resided in an informal settlement with a high unemployment rate (93%). Household food insecurity was high and 40% of the households spent less than R50 per week on food. The top 10 items bought were maize meal, tea, sugar, oil, vegetables, chicken, milk, eggs, fruit and margarine. This indicated that nutrient-dense food was low on the list. On comparing the number of children who ate a meal at home and the weekly expenditure on food, it was evident that very little food was available at home. The top 15 food items most commonly consumed by the children indicated that the diet was mostly carbohydrate-based. Although carbohydrates are regarded as energy-releasing food, the carbohydrates consumed did not contribute much to the overall nutritional status of the children, as they are clearly not nutrient-dense.

The breakfast survey results showed that 13.2% of the children did not eat breakfast before going to school and of those who ate breakfast, 86.8% had only bread and tea. These results correlate with South African studies indicating that 14-19% of schoolchildren do not eat anything before going to school. Results of international studies indicate that breakfast makes a significant contribution to a child's nutrient intake for the day; if breakfast is missed, it is unlikely that the child will make up the deficit in nutrients during the rest of the day [12].

Micronutrient malnutrition can be addressed by supplementation and fortification of food, and by implementing programmes designed to educate people to diversify their diets [13]. Food diversification aims to increase dietary availability, regular access and consumption of vitamin- and mineral-rich foods in at-risk micronutrient deficient groups. It involves the changes in dietary behaviour of the group [8]. Food modification is primarily a strategy to improve either the amount of food in the diet or its bioavailability [14]. This article discusses the development of a nutritious *vetkoek*, and the procedures followed for incorporating the *vetkoek* into the feeding scheme in the participating school.

Aims of the project

The specific aim of this project was to develop a product based on the following criteria:

- The product should provide 25% of the estimated average requirement for children aged 6-9 years old.

- The product should address the specific nutrient deficiencies as indicated in the baseline study, namely zinc, iron, and calcium and low energy value.
- The product should be easy to prepare (the baseline survey indicated that 18.9% of the caregivers are illiterate, and only 17% of the households had access to electrical stoves, 8.8% to coal and 75.6% to paraffin stoves).Ingredients for the product should be available in the households, with minimal waste (ingredients formed part of food items most commonly purchased).
- The product should be cost-effective (<R 2.00 per person per day). *Vetkoek* was consumed by the majority of households in this study as it was inexpensive and easy to prepare with ingredients readily available in the households. Thus, it was decided to develop a nutritious *vetkoek* that met all the criteria.

Outlines of the procedures and methods

Product development and analyses

Initially five different vetkoek recipes were chosen. The recipes chosen were theoretically analysed by using the Dietary Manager Program, based on the South African Food Composition tables. The nutritional content of each recipe was compared to the Recommended Daily Allowance (RDA) of children aged 6-13. Different ingredients from the top 20 consumed foods as indicated in the baseline survey were added and after inclusion of an ingredient or ingredients, the recipe was analysed once more to determine the influence of a single ingredient on the nutritional value of the recipe. The three recipes with nutritional values closest to the RDA of children aged 6-13, were selected. The cost-effectiveness of each

recipe was determined. Three different products were prepared according to the recipes and a paired preference testing was conducted. The general appearance, taste and overall acceptability were evaluated and the most popular product chosen. The Agricultural Research Council, an accredited food analysis laboratory in Pretoria, did biochemical analyses to compare the theoretical and actual nutrient content on the following: ash, moisture, fat, protein, folic acid, vit. A, carbohydrates, vit. B1, vit. B 2, vit. B6, vit. B12, vit. C, energy, calcium, magnesium, copper, iron and zinc. The results indicated a shortfall in energy 429 kJ, Calcium: 156.4 mg and vitamin A (40 retinol equivalents). The shortages were addressed by adding 20 g of milk powder. The final adjustment to the recipe was made to address an average of 25 % of the estimated average requirements for energy, iron, zinc, calcium, and vitamin A for children 6-9 years of age.

Directly after preparation, the prepared *vetkoek* were couriered to the Agricultural Research Council for shelf life testing. Shelf life testing was conducted under controlled test conditions to evaluate the growth of harmful bacteria and micro-organisms after selected time periods to determine shelf life. During testing, the food was periodically examined for changes in appearance, aroma, texture and taste until it became unacceptable. For the shelf life testing, one tray was set aside at 4°C and the other tray at room temperature (±25°C). The *vetkoek* were plated out on day 0 (day of arrival), day 2, 4 and day 7. A 10 g sample was removed aseptically from the inside of the *vetkoek*. The samples were homogenised in a Stomacher 400 (DHK Pty Ltd) with 90 ml of diluted buffered peptone water. The sample was plated out for a total aerobic plate count on Tryptone soy agar and incubated at 25°C for 72 hours and for testing on yeast and moulds on Rose

Bengal agar and incubated at 25°C for 72 hours. Shelf life results indicated a recommended shelf life of two days at room temperature (24%), and seven days when refrigerated.

Training conducted

An illustrated recipe pamphlet containing different recipes for *vetkoek* was developed and printed for illiterate people. It was used in training the caregivers who were responsible for preparing the vetkoek.

The school principal identified caregivers in the community, and training was provided on personal hygiene, basic kitchen hygiene, safety, basic food preparation, cooking methods and the use of electrical equipment. Training included the preparation of the *vetkoek* recipe. These trained caregivers were responsible for the preparation and portioning of the *vetkoek* on a daily basis. Initial training was presented in the student-training restaurant at the Vaal University of Technology (VUT). Thereafter training was provided in the new kitchen that had been built on the premises of the school (see section below). Training on hygiene and safety was given on a continuous basis to maintain standards, and to make sure that a good quality product was prepared daily. The caregivers were responsible for the distribution of the *vetkoek* during school breakfast time daily. The researcher listed the names of children who participated and the caregivers indicated when the children received their *vetkoek*. This was done to ensure that the children received only one 120 g *vetkoek* each.

Development of the infrastructure

A production kitchen had to be erected on the school premises. A wooden hut measuring 4x4 m^2 with a veranda and a corrugated iron roof was built. Part of the researcher's student grant from the National Research Foundation (NRF) was used to fund the building of the kitchen. Insulation panels were installed inside for the walls and ceiling and were painted white. The kitchen had one door and one window, which opened to the outside. The window could be used as a serving hatch. A safety door was installed as a security measure. A square cement slab was laid in front of the kitchen, so that the children did not have to stand in mud during the rainy seasons, and to keep dust from entering the kitchen. Water and electricity were connected via the adjacent building. The kitchen was equipped with all the necessary equipment and small utensils required for production.

Portion standardisation

A portioning frame was designed and made of stainless steel to be used by the community workers to portion each batch of *vetkoek* into 20 x 120 g portions. The frame was 2 cm high, 40 cm long and 25 cm wide. The caregivers were trained to roll the dough the same size as the portioning frame. The frame was placed on the dough and pressed down, and this produced 20 *vetkoek* portions of 120 g each.

Supplies

A local supplier was identified to deliver vegetables and fruit daily, and dry

ingredients weekly. The trained caregivers, assisted by teachers, were responsible for receiving the delivered goods. Deliveries were checked according to the standard order provided by the researcher. Invoices were kept in a file in the kitchen and the researcher collected all the invoices during visits to the school. The finance department of the Vaal University of Technology processed all invoices for payment by the researcher (NRF student grant).

Quality control

After the initial training, the researcher visited the school every day for the first two weeks and thereafter twice a week to ensure that the product was being prepared according to the recipe and specific requirements and that the portion size administered to the schoolchildren was correct. Visits to the school were done randomly. During these visits, quality control was conducted, stock availability was monitored, and purchasing orders were compiled.

Conclusions and recommendations

This research project provided the opportunity to determine the nutritional status of primary school children in a "poorest of the poor" informal settlement in the Vaal Triangle, South Africa. The objective was to develop a novel food item that is affordable, acceptable, safe for consumption, nutritious and easy to prepare from ingredients usually available in the households in the community as proposed by the New Partnership for Africa's Development (NEPAD) and the

Comprehensive Agricultural Development Programme (CAADP).

Malnutrition amongst children remains a problem to be addressed not only in SA, but worldwide. Various strategies are implemented to address the persistent malnutrition problem and all of these have their own advantages and disadvantages. School feeding programmes are a strategy that is adopted globally to alleviate hunger and thus increase concentration and learning capacity. In SA an average of 5 million schoolchildren have benefited from school feeding programmes during 1994-2002. The costs of these programmes are usually high and depend on various mechanisms for successful implementation.

The intervention study conducted by C. Napier investigated the impact of the *vetkoek* consumption on the nutritional status of the children in this community over a period of six months. More research is needed to test compliance of consumption over a long term (at least 12 months). Similar products could be developed for other circumstances, for e.g. HIV/AIDS children and micro-enterprises could flow forth from such studies. However, further research is needed on market needs, packaging materials, product lines and distribution.

To sustain this initiative, it is recommended that the recipe leaflet be made available to the caregivers of the primary school children and that they are trained to prepare the *vetkoek* so that it can be included in the children's lunch boxes.

This study confirms that an affordable, safe and acceptable novel food product,

meeting 25% EAR for certain identified micronutrients, can be developed and prepared with minimum effort. The training programme aimed to provide skills and support the effectiveness and sustainability of the school feeding project. No special equipment is needed for the preparation of the food product and ingredients available in the household can be used for preparation. The *vetkoek* that was developed in this project met all the criteria for the intended use in a school feeding programme for this particular community in the Vaal Triangle. A sustainable solution for school feeding programmes is thus possible.

It is recommended that all products developed, be bio-chemically analysed for actual nutrient content and that researchers should not rely on theoretical calculations only. Further research on the bioavailability of the nutrients in the *vetkoek* is needed.

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