DEVELOPMENT OF THREE MICROBIOLOGICALLY SAFE, SENSORY ACCEPTABLE FOOD PRODUCTS AS POSSIBLE SUPPLEMENTS TO THE DIET OF UNDERNOURISHED CHILDREN (5 – 6 YEARS)

MATTHYS DU TOIT LOMBARD

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Department of Food Science
Faculty of AgriSciences
Stellenbosch University

Study Leader: Prof. R.C. Witthuhn
Co-study Leader: Dr. A. Dalton

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DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the owner of the copyright thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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ABSTRACT

The physical and mental development of underprivileged children, living in developing countries, is detrimentally affected by the exposure to poverty, malnutrition and poor health. The aim of the present study was to determine the possible risk of nutritional deficiencies of children (aged 5 – 6 years) in a low socio-economic community in the Grabouw area of the Western Cape, South Africa. The nutritional status of the children was evaluated by using anthropometric measurements (weight and height). Furthermore, the dietary intake provided by the meals offered at the schools they attended (Agapé 1 and Agapé 2), was assessed using the school menus. The latter were analysed using the FoodFinder3® computer programme (Medical Research Council of SA, Tygerberg, South Africa). Three supplementary food products (biscuit, health bar and soy milk-based drink) were subsequently developed to address possible nutritional deficiencies. The microbial stability of the products was determined, after which sensory acceptability of all three products was determined using a consumer panel consisting of children (n = 51; M:F = 27:24; 5 – 6 years) from the mentioned schools within the low socio-economic community.

Anthropometric results were in agreement with those found by the National Food Consumption Survey (NFCS) (1999) and the South African Vitamin A Consultative Group (SAVACG) (1995), with stunting found to be most prevalent (16%). Only 5% of the children were found to be underweight and none were found to be wasted.

The developed biscuit and health bar was found to be microbiologically safe when stored for at least 30 d at 25° and 35°C respectively, and the soy milk-based drink for 7 d if stored at refrigeration temperatures (5°C). Concerning the sensory preference, no significant difference was found between the preference for any of the developed products by the males and the females. For the specific products the preference for the biscuit did not differ significantly from the health bar, nor did the health bar differ significantly from the soy milk-based drink, but the biscuit did differ significantly ($p = 0.006$) from the soy milk-based drink for preference. The biscuit was found to be the most preferred of the three products and the soy milk-based drink the least.

The majority of the juvenile consumer panel (95%) found all three developed food products acceptable and could, therefore, be considered possible supplementary foods in a school nutrition programme.

The aim of nutritional supplementation is to supplement the existing diet and in doing so ensuring a more ideal nutrient intake closer to what is recommended by the recommended dietary allowance (RDA). It is proposed that nutritional deficiencies should, however, not only be addressed by means of nutritional supplementation, but should also be assisted by the nutrition education of the parent/guardian so as help them to make informed nutritional choices and in doing so providing their children with the nutrients necessary for optimal mental and physical development.

UITTREKSEL

Die fisiese en verstandelike ontwikkeling van minder-bevoorregte kinders wat in ontwikkelende lande woon word nadelig beïnvloed deur die blootstelling aan armoede, wanvoeding en swak gesondheid. Die doel van die huidige studie was om die moontlike risiko van voedingsgebreke van kinders (ouderdom 5 – 6 jaar) in 'n lae sosio-ekonomiese gemeenskap in die Grabouw area van die Wes-Kaap, Suid-Afrika, te bepaal. Die voedingsstatus van die kinders is geëvalueer deur gebruik te maak van antropometriese metings (gewig en lengte). Verder is die voedingsinname van die etes wat verskaf word deur die skool wat hulle bywoon (Agapé 1 en Agapé 2), geassesseer, deur gebruik te maak van die skoolspyskaarte. Laasgenoemde is deur middel van die FoodFinder3® rekenaarprogram (Mediese Navorsingsraad van SA, Tygerberg, Suid-Afrika) geanaliseer. Drie aanvullende voedselprodukte (beskuitjie, gesondheidsstafie en sojamelk-drankie), wat moontlike voedingsgebreke sou kon aanspreek, is derhalwe ontwikkel. Die mikrobiologiese stabiliteit van die produkte is bepaal, waarna sensoriese aanvaarbaarheid van al drie produkte bepaal is deur gebruik te maak van 'n verbruikerspaneel bestaande uit kinders (n = 51; M:V = 27:24; 5 – 6 jaar) van die genoemde skole in die lae sosio-ekonomiese gemeenskap.

Antropometriese resultate was in ooreenstemming met dié gevind deur die National Food Consumption Survey (NFCS) (1999) en die South African Vitamin A Consultative Group (SAVACG) (1995), met dwerggroei as mees oorwegend (16%). Slegs 5% van die kinders was ondergewig en geen uittering is gevind nie.

Die ontwikkelde beskuitjie en gesondheidsstafie is mikrobiologies veilig bevind wanneer opgeberg vir ten minste 30 d by 25° en 35°C onderskeidelik, en die sojamelk-drankie vir 7 d indien dit by yskastemperatuur (5°C) opgeberg word. Geen betekenisvolle verskille vir die voorkeur van enige van die ontwikkelde produkte is tussen die manlike en die vroulike proefpersone gevind nie. Die voorkeur vir die beskuitjie het nie betekenisvol van die gesondheidsstafie verskil nie en die gesondheidsstafie het nie betekenisvol van die sojamelk-drankie verskil nie, maar die beskuitjie het egter, ten opsigte van voorkeur, betekenisvol ($p = 0.006$) van die sojamelk-drankie verskil. Van

die drie produkte is die beskuitjie die meeste verkies en die sojamelk-drankie die minste. Die meerderheid van die jeugdige verbruikerspaneel (95%) het al drie ontwikkelde voedselprodukte aanvaarbaar gevind en laasgenoemde sou, dus, as moontlike aanvullende voedsels vir ‘n skoolvoedingsprogram oorweeg kon word.

Die doel van voedingsaanvulling is om die nutriënte van die bestaande dieet aan te vul om sodoende ‘n meer ideale nutriëntinname, nader aan dit wat deur die daaglikse aanbevole dieettoelating (RDA) aanbeveel word, te verseker. Dit word voorgestel dat voedingstekorte, egter, nie net deur middel van voedingsaanvulling aangespreek moet word nie, maar behoort ondersteun te word deur die voedingonderrig van die ouer/voog om derhalwe ingeligte voedingskeuses te maak en sodoende hul kinders met die nodige nutriënte vir optimale verstandelike en fisiese ontwikkeling te voorsien.

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ABBREVIATIONS

AI	Adequate Intake
ANOVA	Analysis of variance
BP	Baird-Parker agar
CDC	Centers for Disease Control and Prevention
DRI	Dietary Reference Intakes
EAR	Estimated Average Requirement
FAO	Food and Agriculture Organisation of the United Nations
HAZ	Height-for-Age Z-score
HCl	Hydrochloric acid
ISO	Organisation of International Standards
MGRS	Multicentre Growth Reference Study
NCHS	National Center for Health Statistics
NFCS	National Food Consumption Survey
NSNP	National School Nutrition Programme
NRF	National Research Foundation
PCA	Plate Count Agar
PDA	Potato Dextrose Agar
PSS	Physiological Salt Solution
PEM	Protein-Energy Malnutrition
PUFA	Polyunsaturated Fatty Acid
PVM	Protein, Vitamin, Mineral
RDA	Recommended Dietary Allowance
RTUF	Ready-to-Use Therapeutic Foods
RV-medium	Rappaport-Vassiliadis magnesium chloride/malachite green medium
SABS	South African Bureau of Standards
SANS	South African National Standards
SAVACG	South African Vitamin A Consultative Group
SPFS	Special Program for Food Security
UFMR	Under Five Mortality Rate
UL	Tolerable Upper Intake Level

USA	United States of America
VO_2max	Oxygen level at maximum physical exertion
VRBA	Violet Red Bile Lactose Agar
WAZ	Weight-for-Age Z-score
WHO	World Health Organization
WHZ	Weight-for-Height Z-score
XLD	Xylose Lysine Deoxycholate agar

CONTENTS

Language and style used in this thesis are in accordance with the requirements of the *International Journal of Food Science and Technology*.

CHAPTER 1

INTRODUCTION

South Africa is a middle-income developing country with an exceptionally high level of poverty (Johnson, 2001). Of the population of 47 million, 46% live in the rural areas (WHO, 2006b). Half of the South African population is considered poor, with unemployment reaching 26% (LFS, 2008). Because of many contributing factors such as inadequate nutrition, housing, water supply and sanitation, the poor suffer from ill health (Castiglia, 1996; Johnson, 2001), which detrimentally affects their physical and mental development (Faber *et al*., 2005; Grantham-McGregor & Cumper, 1992; Pollitt *et al*., 1993; Schroeder *et al*., 1995). It was estimated that 2.3 million people in South Africa are in need of nutritional assistance (Naidoo *et al.,* 1992). The South African Under Five Mortality Rate (UFMR), that indicates how many children out of every 1000 born alive, die before they reach the age of five years, was 139 per thousand live births in rural areas in 1994 (NFCS, 1999).

The risk of nutritional deficiencies, together with the nutritional status and development of a child can be assessed by means of nutritional intervention anthropometry. Anthropometry refers to the physical dimensions, as well as the measurement of the gross composition of the body (Bender & Bender, 1999; Cataldo *et al*., 1999). The different anthropometric measurements of an individual can be compared to population standards specific for that age and gender to determine how the body composition compares to the norm. Weight and length/height are well-recognised anthropometric measurements that are an integral part of nutritional screenings, as well as nutrition assessments and are regularly used in health care (WHO, 2006a). The anthropometric measurements can be transformed into standardised anthropometric variables, height-for-age z-score (HAZ), weight-for-age z-score (WAZ) and weight-for-height z-score (WHZ), to detect chronic malnutrition (stunting), provide information about the overall nutritional status of the children (underweight) and detect acute malnutrition (wasting), respectively (Mahan & Escott-Stump, 2004).

Two studies conducted in South Africa, the National Food Consumption Survey (NFCS) (1999) and the study of the South African Vitamin A Consultative Group (SAVACG) (1995) used anthropometrics to determine the nutritional status and physical development of children in this country. The NFCS indicated that about one out of every ten children (10.3%) in South Africa aged 1 – 9 years, was underweight and just more than one in five (21.6%) was found to be stunted. The results from SAVACG were in accordance with these findings, indicating that 9.3% of South African children aged between 6 months and 6 years was underweight and 23% in the same age group, was stunted.

Food supplementation has been found to have the greatest impact on human physical growth during the first three years of life (Bhutta *et al*., 2008; Gillespie & Allan, 2002; Pollitt *et al*., 1993; Schroeder *et al*., 1995). Recommendations were, however, made that the supplementary foods provided at schools not only concentrate on energy content, but also on dietary quality and nutrient composition (NFCS, 1999).

It is vital to interpret the nutritional situation and the interrelationship between nutritional status and infection (Schelp, 1998). To prevent protein-energy malnutrition (PEM) the social and economic situation, together with hygienic circumstances should be taken into consideration. Stunted, wasted and underweight children are at a disadvantage as children who suffer from severe PEM in early childhood, have poorer mental development, school achievement and more behavioural problems than their peers (Grantham-McGregor & Cumper, 1992).

Attempts to improve the nutritional status of children might fail if measures to reduce stunting and wasting are aimed solely at enhancing nutritional intake. Focus has to also be on improving the non-hygienic practices that result in diarrhea and a high prevalence of intestinal parasites (Grantham-McGregor & Cumper, 1992). To increase food availability alone would probably not reduce the proportion of stunted and wasted children. Schelp (1998) suggests the initiation of a campaign to treat children with diarrhea at the onset of the disease, to control parasitic infections and take action to prevent the re-occurrence of infection.

The aim of this study was to assess the diets of the children (aged 5 – 6 years) in a low socio-economic community in the Grabouw area of the Western Cape, South Africa by means of analysing the menus of the schools they attended (Agapé 1 and Agapé 2), using the FoodFinder3® computer program (Medical Research Council of SA, Tygerberg, South Africa). Anthropometric measurements (weight and height) of the children were taken to determine whether these children were at risk of a poor nutritional status. Three supplementary food products were subsequently developed to address the possible nutritional deficiencies. The microbial stability of the products was determined, after which sensory acceptability of all three products was evaluated using a juvenile consumer panel of children aged 5 – 6 years and attending the pre-schools Agapé 1 and Agapé 2.

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CHAPTER 2

LITERATURE REVIEW

A. Background

Childhood and maternal under-nutrition is the single leading cause of the global burden of disease (Ezzati *et al.*, 2002; Pongou *et al.*, 2006). In 2000, the total global health loss attributable to under-nutrition was 9.5% of all deaths and in high-mortality developing regions it was 14.9% (Ezzati *et al.*, 2002). According to the World Health Report of 2005 (WHO, 2008), in developing countries poor nutrition contributes to 53% of the deaths associated with infectious diseases among children under the age of five years. Furthermore, one in every four pre-school children in these countries suffers from under-nutrition, which can severely affect the mental and physical development of a child. One out of six infants is born with low birth weight, because of under-nutrition amongst pregnant women in developing countries. This is of great concern, not only because it is a risk factor for neonatal deaths, but also because it causes learning disabilities, mental retardation, poor health, blindness and premature death (WHO, 2008). It was found that, in developing countries, one in three people are affected by vitamin and mineral deficiencies, which lead to a higher risk of infection, birth defects and impaired physical and psycho-intellectual development (WHO, 2008).

South Africa is a middle-income country that has an exceptionally high level of poverty (Johnson, 2001). It has a population of about 47 million (WHO, 2006b), with 46% of the population living in rural areas. About 50% of the South African population is considered poor, with over 26% of the population being unemployed (LFS, 2008). South African individuals are classified as poor if they have an income equal to or less than R19.20 per person per day. The poor suffer more from ill health due to multiple contributing factors including inadequate nutrition, housing, water supply and sanitation (Castiglia, 1996; Johnson, 2001). It was estimated that 2.3 million people in South Africa are in need of some sort of nutritional assistance (Naidoo *et al.,* 1992).

Organisations like the Food and Agriculture Organisation of the United Nations (FAO) and the World Health Organisation (WHO) have initiatives to relieve global hunger, undernourishment and poverty. The flagship initiative of the FAO is the Special Program for Food Security (SPFS), where the goal is to halve the number of hungry individuals in the world by 2015, as part of its commitment to the United Nations Millennium Development Goals (FAO, 2008). Of the 102 countries currently engaged in the SPFS, 30 are developing or operating comprehensive National Food Security Programmes. The WHO, together with international experts has developed two manuals for managing severe malnutrition (WHO, 2003). These sets of guidelines have been developed for doctors, senior nurses and other senior health professionals who are responsible for the care of young children in hospitals. The implementation of these guidelines can reduce child deaths substantially and make a great contribution to achieving the Millennium Development Goals (WHO, 2005).

B. Malnutrition

Even though progress has been made in recent years in some areas of nutrition, 790 million people living in developing countries and 34 million living in developed countries are still undernourished and do not have access to enough food (Oldewage-Theron *et al.*, 2006). Malnutrition causes thousands of deaths worldwide and can be described as the disturbance of form or function arising from the deficiency (under-nutrition) or excess (over-nutrition) of one or more nutrients (Bender & Bender, 1999).

The deaths caused by nutritional deficiencies in 1998 were 1% of the total global mortality, with 95% of these occurring in developing countries (Jones, 1998). In Cameroon, between 1991 and 1998 the prevalence of childhood underweight and stunting (both caused by under-nutrition) increased from 16% to 23% and from 23% to 29%, respectively. This mirrors the trend of the Cameroon Under Five Mortality Rate (UFMR) that increased from 126 to 152 per thousand live births between 1991 and 1998. This implies that 152 of every 1000 children that were born alive, died before they reached the age of five years. A similar trend was noted in South Africa in

1994, with the UFMR for children living in rural areas being 139 per thousand live births (NFCS, 1999).

Protein-energy malnutrition (PEM) is a problem throughout South Africa, as well as many other countries in Africa and the rest of the world (SAVACG, 1995). PEM describes a class of clinical disorders caused by varying degrees and combinations of protein and energy deficiency. These disorders are usually accompanied by other nutritional deficiencies, such as vitamin A deficiency (SAVACG, 1995) and are in many cases aggravated by infections (Gupta, 1990; Stephenson, 1987). The high post-neonatal and toddler mortality ratios of developing countries are mainly caused by PEM and consequent fatal infections (Wharton, 1991).

There are three major forms of PEM, namely marasmus, kwashiorkor and marasmic kwashiorkor. Marasmus is primarily caused by the deficiency of energy-providing foods, whereas kwashiorkor is caused by a protein deficiency (Castiglia, 1996). Marasmic kwashiorkor is a combination of the two, in that it is caused by a deficiency of both energy and protein (Mahan & Escott-Stump, 2004; Shetty, 2006).

A child with marasmus, which is a chronic condition of starvation, adjusts by growth reduction (Shetty, 2006). Muscular wasting and the absence of subcutaneous fat are the symptoms observed in the advanced stages of this condition (Castiglia, 1996; Shetty, 2006). Children of all ages can be affected by marasmus and is usually the result of breastfeeding failure during infancy (Mahan & Escott-Stump, 2004).

Kwashiorkor is usually observed around the weaning age of babies (Fuhrman *et al.*, 2004). This condition is associated with extreme protein deficiency, even though there is no shortage of energy-providing foods in the diet. It leads to reduced growth (Briers *et al.*, 1975), as well as pitting edema and enlarged fatty liver (Mahan & Escott-Stump, 2004). It also leads to a high prevalence of infection and the presence of subcutaneous fat (Shetty, 2006). Even if these children that have or had kwashiorkor are treated, they never recover completely (Castiglia, 1996).

A child or infant sometimes shows features of both marasmus and kwashiorkor, for instance edema (as in kwashiorkor), together with severe muscle wasting (as in marasmus) (Shetty, 2006). This condition would then be known as marasmic kwashiorkor.

C. Anthropometry

In the determination of the nutritional status and development of a child and to assess if the child is at risk of nutritional deficiencies like PEM, anthropometry is used. Anthropometry refers to the physical dimensions, as well as the measurement of the gross composition of the body (Cataldo *et al*., 1999). The different anthropometric measurements of an individual can be compared to population standards specific for that age and gender to determine how the body composition compares to the norm.

Well-recognised anthropometrics include weight, height, fat-fold measurements and various measures of lean tissue (WHO, 2006a). Weight and length/height are routine measurements that are an integral part of nutritional screenings, as well as nutrition assessments and are regularly used in health care. Other measurements still useful in specific situations are the head circumference measurement for the assessment of brain development of infants and the abdominal girth measurement as an indication of possible abdominal fluid retention or enlargement of abdominal organs (Bender & Bender, 1999; Cataldo *et al*., 1999).

The length (applicable to infants and children up to the age of three years) and height (applicable to children over the age of three years) of a child depends on adequate nutrition and are, therefore, particularly valuable in assessing growth (Cataldo *et al*., 1999). To measure the height of children older than three years (or once the child can stand erect) the same method as for measuring the height of adults, is used. This measurement is most accurately taken with the child's back against a wall. A fixed non-stretchable measuring tape or stick is used or alternatively a measuring board, with a sliding headpiece, fixed to the wall, is used. The child should be without shoes and stand erect, heels together, with the child's line of sight being horizontal and the heels, buttocks, shoulders and head touching the wall. In the case of the measuring tape or stick fixed to the wall it is advised that the assessor puts an object, like a ruler or a book, at a right angle on top of the child's head, before checking the height measurement after which the results are recorded. When the measuring board with the sliding headpiece is used, the headpiece is simply lowered onto the child's head. The weight measurement of children is done in the same way as for adults, with the child simply standing on the scale with the assessor recording the measurement (Cataldo *et al*., 1999; NFCS, 1999).

Weight and height measurements have been used for several decades in nutritional studies involving children. In all these studies, the use of weight and height as anthropometric measurements were found to produce reliable results. Eksmyr (1970) investigated and compared the anthropometric data of pre-school, Ethiopian children living under hygienic and socio-economic conditions similar to those of average European and North American children. Weight measurements were done by using a beam scale with weights being accurate to the nearest 0.1 kg. The height was measured using a steel measuring tape attached to the wall, and recorded to the nearest full centimeter. Other anthropometric measurements were also used, including the upper arm circumference, the triceps skinfold thickness, as well as the chest and head circumference. It was found that the children included in this study had approximately the same height, weight and upper arm circumference as children in the industrialised countries of Europe and the United States of America (USA). These subjects were also found to be nutritionally better off than their socially underprivileged counterparts living in the rural districts and towns of Ethiopia.

Kossman *et al.* (2000) used anthropometric measurements to relate under-nutrition and childhood infections to growth in Sudan. The only two anthropometric measurements used in this study were weight and height, which were, together with the age of the children, used to define under-nutrition as underweight, stunted or wasted. According to Kossman *et al.* (2000) early child growth is largely determined by feeding practices and exposure to pathogens, both of which are related to socio-economic, environmental and cultural factors. The results of this study that showed significant and inverse associations between cough and complicated cough caused by exposure to pathogens, and height, weight and stunting are in agreement with those of a Brazilian study (Victoria *et al.*, 1987) that showed positive associations between severe diarrhea and respiratory symptoms, also caused by exposure to pathogens, and wasting found up to the age of four years.

The weight, height and age as anthropometric measurements of children was also used by Moore *et al.* (2003) in which case the impact of nutritional status on the antibody response to different vaccines in undernourished Gambian children, was tested. The nutritional status of the children recruited for this study varied considerably. Reference charts of the United Kingdom were used in calculating z-scores for determining the nutritional status. The z-scores ranged between –4.7 and 0.91, with a mean value of –1.6, suggesting moderate malnutrition.

In the study conducted by Enwonwu *et al.* (2005) weight and height measurements were the two anthropometric measurements used to determine linear growth retardation in Nigerian children. This was done to establish if there is a temporal relationship between the linear growth retardation and the occurrence of fresh noma. From the results of this study it became evident that the occurrence of fresh noma was probably caused early in life by malnutrition and infection, which result from the replacement of breast milk with inferior food substitutes.

In all the above mentioned studies the weight and height measurements of the individual were transformed into the standardised anthropometric variables, weight-for-age z-score (WAZ), height-for-age z-score (HAZ) and weight-for-height z-score (WHZ). This can be done by using the software programmes EPI-INFO or ANTHRO, provided by the Centers for Disease Control and Prevention (CDC) and the WHO. The height and weight measurements, together with the birth date and date when the measurements were taken, can simply be entered into the software programme. The different z-scores are then calculated by comparing the measurements to reference measurements from the National Center for Health Statistics (NCHS)/WHO international growth reference (Hamill *et al.*, 1977).

Information regarding the overall nutritional status (underweight) of the children is provided by WAZ. HAZ is used to detect chronic malnutrition (stunting), whereas WHZ is used to detect acute malnutrition (wasting) (Mahan & Escott-Stump, 2004). The prevalence of underweight, stunting and wasting can be defined as the percentage of individuals who has HAZ, WAZ and WHZ scores below -2 SD of the growth reference median (Anon., 2006). The National Food Consumption Survey (NFCS) (1999) showed that children are severely malnourished when they have HAZ, WAZ and/or WHZ scores below -3 SD.

In 1993 the WHO undertook a comprehensive review in which it was concluded that the NCHS/WHO international growth reference, which had been widely recommended and used internationally since the late 1970s, did not adequately represent early childhood growth (Dibley *et al.*, 1987; De Onis & Jip, 1996; WHO, 2006a). In 1994, the World Health Assembly endorsed this recommendation and between 1993 and 2003 the WHO Multicentre Growth Reference Study (MGRS) was undertaken and implemented for generating new curves to assess the growth and development of children worldwide. Primary growth data was collected from 8440 healthy young children (aged 0 – 5 years) from diverse ethnic backgrounds and cultural settings from Brazil, Ghana, India, Norway, Oman and the USA. These standards depict normal early childhood growth under optimal environmental conditions and can be used to assess children around the world, regardless of socio-economic status, ethnicity and type of feeding (WHO, 2006a).

This development of the new WHO growth charts for children younger than five years lead to the need for the establishment of new growth charts for young children and adolescents between the ages of five and 19 years. Statistical methods were used to construct the growth curves. It was important to provide a smooth transition from the WHO Child Growth Standards (0 – 5 years) previously used to the newly developed reference curves for the ages beyond five years (De Onis *et al.*, 2007).

In May 2000 the CDC of the USA released growth charts (birth to 20 years), which are based on the same principals as the WHO child growth charts (WHO, 2006a). The findings of five nationally representative surveys conducted in the USA between 1963 and 1994 (Kuczmarski *et al.*, 2002) were used in the construction thereof. It was developed to replace the previously used 1977 NCHS growth reference. In the 2006 WHO report (WHO, 2006b) the newly developed WHO growth charts are compared to the previously used NCHS/WHO charts, as well as the 2000 CDC growth charts for the USA

(Kuczmarski *et al.*, 2002). Differences that were found between the WHO growth references and the CDC charts are largely a reflection of differences in the populations on which the two sets of curves are based (WHO, 2006a).

In two studies conducted in Malawi and reported by Espo *et al*. (2002) and Maleta *et al*. (2003) the z-scores (WAZ, HAZ and WHZ) of the individuals were calculated with EPI-INFO 6.04b software as developed by the CDC, which uses the NCHS/WHO international growth references (Hamill *et al*., 1977). It was found that at ages three, six and nine months, respectively 27%, 51% and 63% of the children measured, were stunted (HAZ ≤-2). At the age of 1 year, about 70% of the children were at least moderately stunted (HAZ ≤-2) and about 31% of the children severely stunted (HAZ ≤-3). In Kuwait a study was conducted (Amine & Al-Awadi, 1996) in which the weight and height measurements were converted to z-scores by using the ANTHRO software. The latter uses figures from the NCHS and CDC as an international reference population. The results of the study showed that 11.5% of the children were stunted (HAZ ≤-2) and that 10.8% of the children were wasted.

On a national level, the same methods and software programmes for determining the nutritional status and development of children, are used. The NFCS survey is one of the major nutritional studies that have been conducted in South Africa (NFCS, 1999). One of the primary objectives of the NFCS was to determine the anthropometric status of children aged 1 – 9 years. This was achieved by making use of the EPI-INFO version 6.02. The z-scores that were calculated included HAZ, WAZ and WHZ. Stunting (HAZ ≤-2) was by far the most common nutritional disorder found, affecting one in five children on national level, with the situation taking a turn for the worst in the rural areas where one in every four children are stunted. The prevalence of underweight (WAZ ≤-2) affected one out of ten children nationally and wasting was the least prevalent, with one out of 20 children affected.

It is vital to interpret the nutritional situation and the interrelationship between nutritional status and infection (Schelp, 1998). The social and economic situation, together with hygienic circumstances should be taken in consideration to prevent PEM. Stunted, wasted and underweight children are at a disadvantage as children who suffer from severe PEM in early childhood have poorer mental development, school achievement and more behavioural problems than their peers (Grantham-McGregor & Cumper, 1992). Attempts to improve the nutritional status of children might fail if measures to reduce stunting and wasting are aimed solely at enhancing nutritional intake. Focus also has to be on improving the non-hygienic practices that result in diarrhea and a high prevalence of intestinal parasites (Grantham-McGregor & Cumper, 1992). To increase food availability alone would probably not help reduce the proportion of stunted and wasted children. Schelp (1998) suggests the initiation of a campaign to treat children with diarrhea at the onset of the disease, to control parasitic infections and take action to prevent the re-occurrence of infection.

D. Dietary reference intakes

Nutritional intervention dietary reference intakes (DRIs) could be used in analysing the diets of a specific study group. DRIs are useful in planning and assessing diets and are reference values that are quantitative estimates of nutrient intakes of a population or individual. Four types of reference values, namely recommended dietary allowance (RDA), adequate intake (AI), estimated average requirement (EAR) and tolerable upper intake level (UL) are included (Trumbo *et al.*, 2001). Three of these DRIs are defined by specific criteria of nutrient adequacy (namely RDA, AI and EAR), whereas the UL is defined by a specific indicator of excess (if available).

The RDA can be described as the average daily dietary intake level sufficient for meeting the nutrient requirement of the majority (97 to 98 percent) of healthy individuals in a certain life stage or gender group. AI on the other hand, is a recommended intake value that is based on approximations (observed or experimentally determined) or estimates of nutrient intake by a group(s) of healthy people assumed to be adequate. AI is only used if the RDA cannot be determined, as in a Belgian study (Huybrechts & De Henauw, 2007) where the RDA for children does not include an RDA for fibre intake, therefore the AI was used as a reference value (IOM, 2005). For the assessment of the nutrient adequacy of groups, it is, however, inappropriate to use the RDA or a group mean intake (Murphy & Poos, 2002).

The AI is also of limited value when assessing nutrient adequacy and cannot be used for the assessment of the prevalence of inadequacy.

The EAR can be defined as the daily nutrient intake value estimated to meet the requirement of half the healthy individuals in a certain life stage and gender group. According to Murphy & Poos (2002) EAR is an appropriate DRI to use in the assessment of groups, as well as individuals. UL on the other hand, is the highest level of daily nutrient intake that will most probably pose no risk of adverse health effects to almost all the individuals in the general population. The potential risk of adverse effects increases as intake increases above the UL (Trumbo *et al*., 2001). Murphy & Poos (2002) concluded that the UL is appropriate in the assessment of the proportion of a group at risk of adverse health effects.

Huybrechts & De Henauw (2007) aimed at determining the energy and nutrient intakes of pre-school children living in Flanders-Belgium. The diets of the children were evaluated and compared to national and international recommendations in terms of the DRIs. It was found that the diets of these children were adequate in most nutrients. The sodium intake of the study group, however, exceeded the UL, which could lead to cardiovascular disease as the excessive intake of sodium can be seen as a potentially modifiable risk factor for cardiovascular disease later in life.

In a study conducted by Powers & Patton (2003) the nutrient intake of infants and toddlers with cystic fibrosis was compared to that of children without the disease. These researchers used the DRIs as a guideline for the micro-nutrient and energy intake of the population. Previous studies suggested an energy intake of at least 120 – 150% of the RDA for energy, with at least 35 – 40% of the energy derived from fat (Ramsey *et al*., 1992; Tomezsko *et al*., 1992). It has been shown that children with cystic fibrosis do not meet this minimum energy intake of 120%, which would then be a contributory factor to these children being underweight (Powers *et al*., 2002). The results of this study showed that most infants and toddlers with and without cystic fibrosis meet the DRI standards for most of the micro-nutrients by means of their diet. Only 90% of their energy intake, however, is met. These researchers suggest that to maximise the growth and development of children the optimal energy intake should be a nutritional goal.

E. Supplementary food products used in nutritional intervention studies

Institutions like the WHO have initiatives in place with the aim to relieve the hunger situation and improve the overall nutritional status specifically in developing countries. These initiatives not only include providing nutritional products, but also aim to educate individuals to empower them to make sound nutritional decisions. Early child development programmes aim to improve the survival, growth and development of young children, as well as to prevent the occurrence of health risks (Engle *et al*., 2007).

Bhutta *et al*. (2008) reviewed several papers concerning interventions for child and maternal under-nutrition and survival. The interventions included strategies to promote complementary feeding (with or without provision of food supplements), micronutrient interventions, general supportive strategies for the improvement of family and community nutrition and the reduction of the disease burden. It was found that in populations with sufficient food, education about complementary feeding increased the HAZ score by 0.25. The provision of food supplements (with or without the provision of nutritional education) in populations where food was insufficient increased the HAZ score by 0.41. According to WHO guidelines the management of severe acute malnutrition reduced the case-fatality rate by 55% (WHO, 2003).

In recent studies it was suggested that newer commodities such as ready-to-use therapeutic foods (RTUF), can be used in community settings to manage severe acute malnutrition. Briend *et al*. (1999) conducted a study to show the effective use of RTUF for the treatment of marasmus. Children with severe wasting are usually treated with a liquid diet (F100) which contains 418 kJ/100 mL. F100 is an excellent medium for bacterial growth, so it has to be prepared on the day of use and only handled by experienced staff. In the study conducted by Briend *et al*. (1999) a RTUF was, therefore, developed to replace the F100. The developed RTUF has a composition similar to that of F100, but could be eaten as is. It provided 2270 kJ/100 g and looked and tasted like peanut butter. When bacteria was deliberately added to the product they failed to grow, which showed that the RTUF could, therefore, be useful in contaminated environments or in the case where residential management is not possible, such as during a disaster or war. It could also be useful for home-based treatment or in centres which do not have kitchen facilities.

Bhutta *et al*. (2008) recently reviewed the current knowledge of micronutrient interventions. Interventions with the aim to improve nutrition and prevent related diseases could reduce stunting at three years of age by 36% and the mortality between birth and three years by 25%. For long term elimination of stunting, these authors suggested that these interventions be supplemented by improvements in the underlying determinants of under-nutrition, namely poverty, disease burden and poor education. Martorell *et al*. (1988) also showed that stunting is associated with poor development, as well as with poor environments and that it is difficult to separate nutritional effects from the effects of poverty in purely observational studies.

The findings of Martorell *et al*. (1988) inspired Grantham-McGregor & Cumper (1992) to conduct a 2-year trial of nutritional supplementation to determine whether stunting is caused by poor nutrition. Stunted children (n = 129) between the ages of nine and 24 months were enrolled. The supplement that was provided comprised of 1 kg milk-based formula per child per week. The children were evaluated every six months using the four sub-scales (locomotor, hand- and eye-coordination, performance, hearing and speech) of the Griffiths' (1967) mental development scales. It was concluded that stunted children's development improves with the aid of nutritional supplementation. It can, therefore, be said that at least part of the deficit in development of the children is directly attributed to poor nutrition.

An experimental trial was conducted by Simeon & Grantham-McGregor (1989) with stunted and non-stunted children aged between 9 and 11 years, missing breakfast. It was found that the cognitive functions of the stunted children were detrimentally affected when they did not consume food in the early morning, while the non-stunted children's cognitive functions were unaffected. Especially in developing countries these findings have implications for school feeding programmes concerning the times the children receive food supplementation.

Strategies and development programmes to improve the developmental potential in more than 200 million children in the developing world were investigated (Engle *et al*., 2007). The effectiveness of the intervention programmes in developing countries was examined, assessing programmes that promote child development through preventing or improving the effects of stunting. In both efficacy trials and programme evaluations it was found that improvement of the diets of pregnant women, infants and toddlers can prevent stunting and also result in improved motor and mental development (Faber *et al*., 2005; Gillespie & Allan, 2002; Pollitt *et al*., 1993; Schroeder *et al*., 1995). It was also found that the cognition at three years of age and beyond is improved with food supplementation during the first two or three years of life (Gillespie & Allan, 2002; Schroeder *et al*., 1995).

Schroeder *et al*. (1995) examined the impact of nutritional supplementation on annual growth rates in length and weight of 1208 rural Guatemalan children from birth to 7 years. In this study children from four rural villages of similar ethnicity and development were randomised and received one of two supplements, either a high-energy, high-protein beverage (Atole) or a low-energy, no-protein beverage (Fresco). Atole contained 682 kJ and 11.5 g of protein per serving (180 mL), while Fresco only contained 247 kJ and no protein. Both of these supplements were enriched with equal amounts of minerals and vitamins. It was found by these researchers that nutritional supplementation had the greatest impact on growth from birth up to three years of age. Consumption of 418 kJ per day lead to an additional gain in length of between 4 – 9 mm per year during the first three years, with the greatest gain in the first year. There was an additional weight gain of approximately 350 g during the first year and 250 g during the second year of life.

Subjects (n = 364) aged 11 – 27 years, who earlier had participated in a nutritional supplementation experiment, were used in the follow-up study with the objective to assess the long-term effects of the nutrition intervention on their physical work capacity (Haas *et al*., 1995). The same supplements as was the case in the study conducted by Schroeder *et al*. (1995), Atole and Fresco, were provided to the subjects and their mothers in the four villages. Atole was provided at two of the villages and Fresco at the other two. The work capacity was determined on a motorised treadmill as the oxygen level at maximum physical exertion (VO_2max). In both sexes in the follow-up the VO_2max was significantly greater in subjects consuming Atole than in subjects consuming Fresco. It was also found that males (14 – 19 years) consuming Atole, who had been exposed to supplementation throughout gestation and the first three years of life, had a significantly higher VO_2max than those males who consumed Fresco. The differences remained significant when looking at body weight and fat-free mass. When the amount of supplementation consumed is considered it was found that there is a positive correlation between the amount consumed and the VO_2max. Haas *et al*. (1995) concluded that improving early nutrition can have long-lasting effects on physical performance.

Other than physical performance, a study was conducted to test the effect of nutritional supplementation during early childhood on bone mineralisation during adolescence (Caulfield *et al*., 1995). Guatemalan children (n = 356) between birth and 7 years of age were studied. The same supplements as in the studies reported by Haas *et al*. (1995) and Schroeder *et al*. (1995) were used. The results of this study showed that the children who had consumed the high-energy supplement had greater bone mineral content, bone width, as well as bone mineral density during adolescence than the children that consumed less energy. The supplementation of malnourished children can, therefore, have a long-term impact on bone mineralisation.

Food supplementation can reverse the effects of stunting, provided that intervention takes place before the age of three years. This was found when the effectiveness of a supplementation programme referred to as the PEM Scheme in the Northern Cape Province of South Africa was evaluated (Hendricks *et al*., 2003). In this PEM Scheme supplements were provided to children younger than 6 years of age, pregnant and lactating women, as well as those with chronic illnesses. Supplements were provided on a monthly basis, with infants aged 0 – 6 months receiving 2 kg full-cream milk powder and infants and children aged 6 – 71 months receiving 4 kg of a protein, vitamin – mineral (PVM) mixture. Pregnant and lactating women received 1 kg of full-cream milk and 4 kg of the PVM mixture monthly. This PVM mixture consisted of a fortified maize and milk mixture, with 100 g providing 1881 kJ of energy and 12.5 g protein. The mixture was also enriched with an array of vitamins and minerals. Anthropometric measurements and consequent z-score calculations were done over a one year period. It was found that the body weight of only 10% of the children that were found to be underweight, increased to the normal percentile range. This is in contrast to other studies (Schroeder *et al.*, 1995) where it was found that the recovery rates were between 29% and 53%. The difference found could, however, be ascribed to the lack of data on the heights of the children, as stunting may have been a contributing factor to poor growth increase of some of the children (Hendricks *et al*., 2003). Further large-scale studies need to be done to confirm whether the effects of stunting really are irreversible by means of supplementation beyond the age of 3 years (Bhutta *et al*., 2008).

An example of a product that could be used as a nutrition intervention tool is e'Pap as was developed in South Africa. This nutraceutical porridge was developed specifically to address the food and nutrition crisis in Africa, specifically for people living on or below the poverty line, who consume a diet mainly consisting of refined maize meal which as such does not provide the adequate amounts of fat, minerals or vitamins needed. Per 50 g serving the e'Pap provides about 900 kJ of energy, 5.78 g protein and an array of vitamins and minerals (Scotcher & Scotcher, 2006). This product is currently being used successfully in different settings or types of communities and organisations such as schools, shelters, clinics, hospitals and different feeding schemes.

F. Calculated and chemical analysis of nutrients

Calculation and chemical analysis of nutrients are the two methods used in the determination of the nutritional composition of a product or of an individual's diet. Hakala *et al*. (1996) compared the calculated and the analysed nutrient composition of a variety of foods in weight reduction diets. The Nutrica computer program (developed by the Social Insurance Institution in Finland), which contains 70 nutrient factors for about 600 different food items and 600 prepared dishes, was used for calculating the nutrient contents of the diets. The values are based on recent data analysed and published in Finland, with other data sources including Swedish, Danish, German, English and American food composition tables. For the chemical analysis the protein analysis was done by using the Kjeltec auto 1030 Analyzer and the fat was hydrolysed by hydrochloric acid (HCl) and extracted by ether (AOAC, 1980). Gas chromatography was used to analyse fatty acids (Saastamoinen *et al*., 1989) and a method introduced by Prosky *et al*. (1988) was used to analyse dietary fibre. The carbohydrates were determined according to the "difference method", where the sum of ash, protein and fat were subtracted from the dry weight of the product. Different methods (Koirtyohann *et al*., 1982; Kumpulainen & Paakki, 1987; Kumpulainen & Saarela, 1992) were used to analyse the mineral content.

It was found that for most of the nutrients the calculated values were slightly higher than those for the analysed samples. It was concluded that the calculation method can provide a reasonably good estimation for protein, fat, fatty acids, dietary fibre, calcium, magnesium, potassium and manganese as the differences between the calculated and analysed data were around 4%. A moderate estimation for iron, sodium, zinc and selenium was provided with a difference of about 10%, but the calculation method does provide a poor estimation for copper, molybdenum, cadmium and lead where the difference was around 20% (Hakala *et al*., 1996). The differences between the calculated values and those for the analysed samples could be ascribed to various factors such as the effects of geographical origin and seasons, as well as the effects of processing on the foods (Nyman *et al*., 1994; Hakala *et al*., 1996).

The nutrient content data from four nutrient databases (ESHA Food Processor, Minnesota Nutrition Data System, Moore's Extended Nutrient Database and Nutritionist IV) were compared to data obtained from chemical analysis (McCullough *et al*., 1999). The data for 13 nutrients, namely energy, total fat, saturated fatty acids, mono-unsaturated fatty acids, poly-unsaturated fatty acids, carbohydrate, protein, cholesterol, calcium, potassium, magnesium, iron and sodium were compared. These results showed that the data from the databases and values obtained from the chemical analysis were generally accurate within 5% for most of the nutrients and within 10% for the remaining few. Database values for the tested nutrients were thus useful.

In South Africa the two available nutrient databases (FoodFinder3® and Dietary Manager Software) were compared to the chemical analysis of nutrients (Van der Watt *et al*., 2007). Nutrients tested in this study included carbohydrate, total fat, protein, saturated fatty acids, mono-unsaturated and poly-unsaturated fatty acids, total fibre as well as insoluble and soluble fibre. Statistically it was found that the values from the two nutrient databases did not differ significantly from each other (p-value ≤0.05), but some differences between the values from the databases and those from the chemical analyses were found. No significant differences were found for the amount of total energy, protein, carbohydrate, poly-unsaturated fatty acids and total fibre. The total fat, saturated fatty acid and mono-unsaturated fatty acid content were significantly higher in the nutrient databases when compared to that of the chemical analyses. This could be ascribed to the differences in fat content of the South African reared meats compared to those found in other countries. Concerning the soluble and insoluble fibre content, FoodFinder3® produced a significantly higher value compared to the chemical analyses. These differences can be ascribed to the lack of information in the computerised nutrient databases due to the unclear distinction in analytical methodology and physiological effects. Van der Watt *et al*. (2007) concluded that nutrient databases are useful, but recommended, however, that the latter should be used in conjunction with chemical analyses for the determination of nutrient content.

G. Sensory evaluation

Together with the nutritional analyses of a product it is important to conduct sensory evaluation as the sensory properties of a food product are important determinants of its acceptability and preference among consumers. In the sensory testing with children, a few special problems are involved not usually encountered when working with a consumer panel consisting of older age groups (Kroll, 1990). These problems include limited verbal skills (Wadsworth, 1984), short attention span (Moskowitz, 1994) and the difficulty children experience with standard sensory tests (Moskowitz, 1985). Children between the ages of five and seven years are either preliterate or they only have rudimentary reading skills which make personal interviews a requirement (Kroll, 1990).

There are two types of sensory tests that children may be asked to perform, namely difference or scaling tests (which are seldom used) and paired-preference, preference ranking and hedonic scaling tests (Guinard, 2001). With the difference tests the ability of children to perform a paired comparison test, duo-trio test and ranking test for sweetness intensity were tested with children aged 2 – 10 years using a fruit-flavoured beverage sweetened with various concentrations of sucrose (Kimmel *et al*., 1994). In all three difference tests it was found that children in the 4 – 5, 6 – 7 and 8 – 10 year age groups could reasonably perform these tests, but children in the 2 – 3 year age group experienced some difficulties. Another type of difference test, the "same-different" test, was performed with children aged 5 – 8 years where it was found that children in this age group could perform the test reliably (Thomas & Murray, 1980). It was also found that children aged 6 – 12 years could scale the sweet, sour and orange flavour intensity of orange flavoured beverages (Zandstra & De Graaf, 1998). The suitability of the paired-preference, preference ranking and hedonic scaling tests were evaluated in the same study of Kimmel *et al*. (1994) mentioned above using the 2 – 10 year old children. It was found that the paired-preference test could be performed reliably by children older than 2 years, which is in agreement with results from Birch & Marlin (1982) who found the paired-preference method to be used successfully in assessing intentional food choices in children as young as 2 years. The more complex tests like hedonic scaling and preference ranking were found to be reliable with children over 4 years (Kimmel *et al*., 1994).

The use of facial hedonic ordinal scales is popular in determining the preference of children, as well as those with limited reading and comprehension skills (Resurrecion, 1998). The face scales range from simple "smiley face" scales to scales that depict a popular cartoon character. According to Stone & Sidel (1993) caution should be taken when using the facial hedonic ordinal scales, as children may not be able to infer that some of these scales are supposed to indicate their internal responses to the specific product being tested. Children aged 6 years and younger can be distracted by the pictures or even be disturbed by the look of the frowning face. In children older than 3 years simple face scales have shown to be used successfully (Johnson *et al*., 1991), but researchers are not in agreement as to which scale length is appropriate to be used with which age group. The most popular has been the 3-point scale (Birch & Sullivan, 1991; Phillips & Kolasa, 1980; Birch *et al.*, 1990). It is recommended that unstructured scales not be used as children tend to place their responses on the extreme ends of the scale, rather than using the entire scale (Moskowitz, 1991). The results from the studies of Kroll (1990) and Kimmel *et al*. (1994) indicated that children are able to reliably use the 7-point facial hedonic ordinal scale from the age of 4 years. This is in accordance with the results of Chen *et al*. (1996) who found that children aged 3 – 6 years are able to reliably use the 3-, 5- and 7-point facial hedonic ordinal scales for expressing their degree of liking of food products.

In the assessment of the relative merit of the different rating scales that can be used in the sensory testing of children (Kroll, 1990) a standard hedonic scale, a face scale, a child-oriented verbal scale and paired comparison, were compared. This was done with children of 5 – 10 years. It was found that in terms of discrimination the child-oriented verbal scale performed better than the hedonic or face scale.

Three non-verbal hedonic methods in children from 4 – 10 years were compared assessing their food choices using the same stimuli, namely biscuits (Léon *et al*., 1998). Biscuits of the same shape and dough composition, but dressed with five different types of jam (apricot, strawberry, raspberry, lemon, banana) were used. The three methods that were compared included paired comparison, ranking-by-elimination (Birch, 1979) and a simple categorisation method. The latter used a face scale where the child had to associate the biscuit tasted several times per session with one of four proposed faces (dislike very much, dislike, like, like very much) on the face scale. The comparison of these methods was done with regard to the discrimination between products, the repeatability and the validity. Age and gender effects were also studied. The results showed that there were no significant differences between the methods regarding discrimination of the stimuli (Léon *et al*., 1998). However, it was found that only the hedonic categorisation method distinguished between the preference for the strawberry and raspberry jams. All three methods showed a preference towards the strawberry, raspberry and apricot jams, rather than the banana and lemon jam biscuits. This may be due to familiarity as the strawberry, raspberry and apricot jam biscuits are available commercially whereas the banana and lemon jam biscuits were developed specially for the study.

Based on their results Léon *et al*. (1998) could not make a definite decision on which of the three methods tested were preferred. All the methods lead to the same results, but with the hedonic categorisation method performing slightly better in respect to discriminability, repeatability and sensitivity to taste differences. Regarding the differences between the boys and girls, it was found that in the paired comparison method, the results provided by the girls were slightly more repeatable than those of the boys (Léon *et al*., 1998). These differences, however, were not significant. Other than this no differences were found between the boys and girls of the specific age groups. This is in accordance with the study by Cowart (1981) which found no significant difference in the taste perception between boys and girls. The authors concluded that children between the ages of 5 – 10 years are able to provide relatively reliable and consistent results. It was further concluded that in comparative methods colour influences the children more strongly concerning their food choices than in monadic methods (hedonic scale), but in hedonic categorisation the results on the discrimination on taste are slightly more repeatable.

It has been found that children prefer sweet foods early in their development. Cowart (1981), Klaus & Klaus (1985) and Lawless (1985) found that infants showed a liking for sweet-tasting substances through pleasant facial expressions, while showing a dislike for salty, acidic or bitter substances. Furthermore, it was found that children put more emphasis on the sweetness of foods at the expense of its other sensory attributes (Guinard, 2001; Tuorilla-Ollikainen *et al.*, 1984). Concerning the odor of substances, it was also found that there is a difference between both the odor tolerances and odor preferences of children and adults (Mennella & Beauchamp, 1991). These findings should be considered when developing products specially aimed at children.

H. Conclusion

Even though progress has been made in recent years in some areas of nutrition, 790 million people living in developing countries and 34 million living in developed countries are still undernourished and do not have access to enough food (Oldewage-Theron *et al.*, 2006). It has been found that the high post-neonatal and toddler mortality ratios of developing countries are mainly caused by PEM, which describes a class of clinical disorders caused by varying degrees and combinations of protein and energy deficiency (Wharton, 1991).

The determination of the nutritional status and development of a child is of importance to assess if the child is at risk of nutritional deficiencies like PEM. Nutritional intervention anthropometry is consequently used (Cataldo *et al*., 1999) with weight and length/height being well-recognised anthropometrics. These anthropometrics are an integral part of nutritional screenings, as well as nutrition assessments and are regularly used in health care (WHO, 2006a). The measurements can be transformed into standardised anthropometric variables, WAZ, HAZ and WHZ, to provide information about the overall nutritional status (underweight) of the children, detect chronic malnutrition (stunting) and acute malnutrition (wasting), respectively (Mahan & Escott-Stump, 2004).

It was found that stunted children's development improves with the aid of nutritional supplementation (Grantham-McGregor & Cumper, 1992). Therefore, it can be said that at least part of the deficit in development of the children is directly attributed to poor nutrition. Further, large-scale studies need to be done to confirm whether the effects of stunting really are irreversible by means of supplementation beyond the age of 3 years (Bhutta *et al*., 2008) as found by Hendricks *et al*. (2003).

The nutritional situation can be addressed by the development of supplementary products which then can be tested with the children by means of different sensory evaluation techniques. The sensory tests most often used with children include paired-preference, preference ranking and hedonic scaling tests (Guinard, 2001), with facial hedonic ordinal scales being one of the most popular in determining the preference (Resurrecion, 1998). It has been found that children from the age of 4 years are able to reliably perform these sensory tests (Kimmel *et al*., 1994).

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CHAPTER 3

DEVELOPMENT OF THREE SUPPLEMENTARY FOOD PRODUCTS TO ADDRESS POSSIBLE NUTRIENT DEFICIENCIES IN CHILDREN (5 – 6 YEARS) FROM A LOW SOCIO-ECONOMIC COMMUNITY IN SOUTH AFRICA

Abstract

Many children in developing countries are exposed to poverty, malnutrition and poor health which detrimentally affect their physical and mental development. The aim of the current study was to determine whether the children (aged 5 – 6 years) in a low socio-economic community in the Grabouw area of the Western Cape, South Africa were at risk of nutritional deficiencies by means of dietary analysis and anthropometric measurements. The dietary intake provided from the menus offered at the schools they attended (Agapé 1 and Agapé 2), was assessed using the FoodFinder3® computer programme (Medical Research Council of SA, Tygerberg, South Africa). Three supplementary food products (biscuit, health bar and soy milk-based drink) were subsequently developed to address possible nutritional deficiencies. The microbial stability of the products was determined, after which sensory acceptability of all three products was tested by means of a juvenile consumer panel (n = 51; M:F = 27:24; 5 – 6 years) derived from the schools within the low socio-economic community. Anthropometric results were in agreement with those found in the National Food Consumption Survey (NFCS) (1999) and the South African Vitamin A Consultative Group (SAVACG) (1995), with stunting found to be most prevalent (16%). Only 5% of the children tested were found to be underweight and none were wasted. Of the three developed supplementary food products the biscuit and health bar was found to be microbiologically safe for at least 30 d at 25° and 35°C while the soy milk-based drink was microbiologically safe for 7 d at 5°C. No significant difference was found between the sensory preference of the males and females. The overall preference for the biscuit did not differ significantly from the health bar, nor did the overall preference for the health bar differ

significantly from that of the soy milk-based drink, but the biscuit did score significantly higher (p = 0.006) for preference when compared to the soy milk-based drink. All three products were found to be acceptable by the majority of the consumer panel (95%) and could be used as supplementary foods in a school nutrition programme.

Introduction

Even though progress has been made in recent years in certain areas of worldwide human nutrition, 790 million people living in developing countries and 34 million living in developed countries are still undernourished and do not have the disposal of enough food (Oldewage-Theron *et al.*, 2006). The deaths caused by nutritional deficiencies in 1998 were 1% of the total global mortality, with 95% of these occurring in developing countries (Jones, 1998).

South Africa is a developing country that has an exceptionally high level of poverty (Johnson, 2001). It has a population of about 47 million (WHO, 2006b), with 46% of the population living in rural areas. About 50% of the South African population is considered poor, with 26% of the population being unemployed (LFS, 2008). In South Africa the Under Five Mortality Rate (UFMR) that indicates how many children out of every 1000 born alive, die before they reach the age of five years, was 139 per thousand live births in rural areas in 1994 (NFCS, 1999).

To determine if a child is at risk of nutritional deficiencies the nutritional status and development of the child is assessed by using anthropometry. Weight and length/height are well-recognised anthropometrics that are an integral part of nutritional screenings, as well as nutrition assessments and these anthropometrics are regularly used in health care (WHO, 2006a). These anthropometric measurements can be transformed into the standardised anthropometric variables, weight-for-age z-score (WAZ), height-for-age z-score (HAZ) and weight-for-height z-score (WHZ), to provide information about the overall nutritional status of the children (underweight), to detect chronic malnutrition (stunting) and to detect acute malnutrition (wasting), respectively (Mahan & Escott-Stump, 2004).

The National Food Consumption Survey (NFCS) (1999) conducted in South Africa indicated that one out of every ten children aged 1 – 9 years in South Africa was underweight and one in five was found to be stunted. According to the NFCS (1999) and the South African Vitamin A Consultative Group (SAVACG) (1995) stunting had to be urgently addressed. Recommendations were made that the supplementary foods provided at schools not only concentrate on energy content, but also on dietary quality and nutrient composition (NFCS, 1999).

The aim of this study was to take anthropometric measurements (weight and height) of the children (aged 5 – 6 years) in a low socio-economic community in the Grabouw area of the Western Cape, South Africa, to determine their nutritional status. Furthermore, the dietary intake provided from the menus offered at the schools they attended (Agapé 1 and Agapé 2), was assessed using the FoodFinder3® computer programme (Medical Research Council of SA, Tygerberg, South Africa). Three supplementary food products were subsequently developed to address possible nutritional deficiencies. The microbial stability of the products was determined, after which sensory acceptability of all three products was tested by a consumer panel consisting of children aged 5 – 6 years.

Materials and methods

Anthropometric measurements

All the children (n = 78) from two pre-primary schools (Agapé 1 and Agapé 2) aged 5 – 6 years were enrolled into the study. The inclusion criteria consisted of healthy children (male and female) of mixed ancestry (African and Malay), between the ages of five and six years attending the pre-schools selected for the study. The language used by the children was Afrikaans. The Sub Committee A Ethics Committee of the Stellenbosch University granted permission for taking anthropometric measurements and performing sensory evaluation with the children. Permission was also obtained from the relevant schools and the parent/guardian of the participating children by means of consent forms (Appendix).

Weight and height measurements were taken in light clothing (without shoes) as described by Jeliffe & Jeliffe (1989) and the age of the children was determined from birth records. The weight of the children was measured to the nearest 0.05 kg using a calibrated load cell operated digital scale (UC-300 Precision Health Scale), while the height of the children was measured to the nearest 0.1 cm using a stadiometer attached to a wall. These weight and height measurements were transformed into standardised anthropometric variables: height-for-age (HAZ); weight-for-age (WAZ) and weight-for-height (WHZ) z-scores, using the ANTHRO version 1.01 program developed by the United States Center for Disease Control in collaboration with the Nutrition Unit, World Health Organization (Hamill *et al.*, 1979). The prevalence of stunting, underweight and wasting was defined as the percentage of individuals who had HAZ, WAZ and WHZ scores, respectively below -2 SD of the World Health Organisation (WHO) reference median (Anon., 2006).

Current pre-school menus

To determine the nutritional intake of children (aged 5 – 6 years) in a low socio-economic community in the Grabouw region, Western Cape, South Africa, the children's food consumption whilst at pre-school, was recorded. The menus offered at the schools (Agapé 1 and Agapé 2) were analysed by making use of the FoodFinder3® computer program. In the informal settlement where the study was executed, children may not receive all the nutrients needed for optimal growth as their parents/guardians earn meager salaries which do not allow them to provide in the nutritional needs of their offspring. In many cases the meals provided by the school will be the only food eaten by the child on a specific day (A. Coetzee, Agapé, Grabouw, South Africa, personal communication).

The specific food types included in the school menu and exact portion sizes were determined with help from school staff. After plating, random weights of each respective food type consumed, was determined. Two meals were served per day, namely breakfast at 09:00 and lunch at 12:00. A weekly cycle menu was used with different menu options served each day from Monday to Friday (Table 1). The nutrient deficiencies found in the children's

Table 1. Cycle menu options served at Agapé 1 and Agapé 2.

	Breakfast		Lunch	
	Food type	**Amount**	**Food type**	**Amount**
Monday	Wheat cereal	20 g	Bread (white)*	1 slice (30 g)
	Milk powder	2.8 g	Jam	10 ml
	Sugar	4 g	Peanut butter	10 ml
Tuesday	Maize porridge	125 ml	Macaroni	125 ml
	Milk powder	2.8 g	Tinned fish	14 g
	Sugar	4 g		
Wednesday	Wheat cereal	20 g	Bread (white)*	1 slice (30 g)
	Milk powder	2.8 g	Scrambled eggs	30 g
	Sugar	4 g		
Thursday	Maize porridge	125 ml	Vegetable soup	130 ml
	Milk powder	2.8 g	Bread (white)*	½ slice (15 g)
	Sugar	4 g		
Friday	Wheat cereal	20 g	Bread (white)*	1 slice (30 g)
	Milk powder	2.8 g	Fish paste	10 ml
	Sugar	4 g		

*Day-old white bread is donated to the pre-schools by a local business diets based on the menu options provided, were then used as a guideline for the development of three supplementary food products.

South African National School Nutrition Programme (NSNP)

The aim of the National School Nutrition Programme (NSNP) is to supplement the insufficient diets of children in targeted rural schools and schools located on farms. Different menu options are proposed ensuring meals that include a variety of food, namely starch food, protein-rich food and a fruit or vegetable all included in one meal. The NSNP guidelines (NSNP, 2005) state that meals included as a menu option should provide at least 20 – 30 % of the RDA for a specific age group for the different macro-nutrients.

The cost of the different menu options of the NSNP was determined by using current supermarket food prices. The determined prices were used as a guideline for the price range of the supplementary products intended for development in the present study, so as to determine whether the developed supplementary products would be a viable option for possible integration into a school feeding scheme.

Development of the three supplementary food products

The three supplementary food products developed were a biscuit, a health bar and a soy milk-based drink. All three products were aimed to appeal to the sensorial preferences of children between 5 and 6 years. These products were developed on experimental scale only, therefore, if possible commercialisation of any of the products were to happen, the necessary up scaling of the formulas, as well as possible adjustments in terms of manufacturing practices need to be done.

<u>Biscuit</u>

A biscuit was chosen as a product to be developed because it can easily be distributed and can also be stored at room temperature for reasonably long periods of time, which makes it ideal for food supplementation schemes. The biscuit was developed during different experimental trials until the desired product was obtained. Using a standard biscuit recipe, half the cake flour was replaced by that same weight of oats.

The oats provided numerous nutritional benefits (Arens *et al*., 2000; Figoni, 2004), and enhanced flavour and textural properties. The butter asked for in the original recipe was replaced by a combination of the same weight of solid vegetable fat and canola oil, which ultimately not only lowered the cost of the product, but also added nutritional benefits (Ackman, 1990). Eggs used in the initial recipe were replaced with egg powder (supplied by Ovipro, Bronkhorstspruit, South Africa) and milk replaced with milk powder, as these commodities are more suitable in a manufacturing environment. The formula of the biscuit is presented in Table 2. All the dry ingredients (except for the bicarbonate of soda) were sieved and the sugar was added. The vegetable fat was then rubbed into the dry mixture and canola oil was added. The bicarbonate of soda was dissolved into the milk (milk powder dissolved in water according to manufacturer's instructions) and added to the mixture. Water was added to the egg powder according to instructions and mixed until smooth, after which it was added to the dough and thoroughly mixed. Pieces of dough of approximately 10 g each were placed on a baking sheet and baked in a pre-heated oven at 170°C for 11 min. It was removed from the oven and left to cool.

Chocolate was the carrier ingredient for the vitamin mixture (Vitamin IS-140 Premix, supplied by MacCullum & Associates SA Pty Ltd, Cape Town, South Africa) used in the filling between two biscuits. The vitamin mixture consists of the fat-soluble vitamins A, D and E and the water-soluble vitamins B_1, B_2, B_6, B_{12}, niacin, biotin and folic acid. Chocolate was placed in a double boiler to melt, where after the vitamin mixture was added and stirred. Of this chocolate-vitamin mix, 2 ml was poured onto the bottom of an inverted biscuit. Another biscuit was then placed on top of the first one to form a double layered biscuit.

<u>Health bar</u>

The health bar, chosen as the second product, is also a baked product that can be easily distributed and can be stored for reasonably long periods of time, making it an attractive option for nutrition supplementation schemes. The health bar was developed during different experimental trials until the

Table 2. Formula for the biscuit.

Raw materials	Weight in g	Baker's percentage (%)
Cake flour	5.51	100.0
Sugar	5.51	100.0
Oats	3.97	72.0
Vegetable fat	1.38	25.0
Canola oil	1.38	25.0
Cream of tartar	0.15	2.8
Egg powder and water	1.01	18.4
Milk powder and water	0.55	10.0
Bicarbonate of soda	0.07	1.2
Vanilla essence	0.11	2.0
Salt	0.04	0.8
Milk chocolate	2.20	40.0
Vitamin-supplement	0.11	2.0
TOTAL	22.00	399.2

desired product was obtained. Instead of cake flour, a combination of sugar bean flour and maize flour was used, rendering a health bar which is a wheat-free supplementary product and simultaneously providing a complete protein. Oats was incorporated into the product for its flavour and textural properties, but also for the nutritional benefits. The same weight of a combination of solid vegetable fat and canola oil were used as the fat component, which ultimately not only lowered the cost of the product, but also added nutritional benefits due to the use of canola oil. Egg powder was used instead of raw egg as it is more practical during large scale manufacturing. The formula of the health bar is presented in Table 3.

The sugar bean flour was prepared using dried sugar beans, milled (1 mm blades) in a hammer mill (Retch, supplied by Cape Scientific Service). During the milling process the sugar beans were added slowly to prevent the sugar beans from obstructing the mill blades, hence obtaining the required particle size.

The first step in the production process of the health bar was to combine all the dry ingredients. Following this the vegetable fat was melted with the golden syrup in a 900W microwave oven for 60 s and, together with the canola oil, added to the dry ingredients. The egg powder was hydrated with water according to the manufacturer's instructions and mixed until smooth, after which it was added to the rest of the ingredients and blended thoroughly. The dough was pressed flat in a baking sheet to a height of 1 cm. The baking sheet was placed in a pre-heated oven at 170°C for 20 min. After the baking process the baking sheet was removed from the oven and, while still hot, the bars were cut into uniform slices of 30 g each.

Soy milk-based drink

The third product developed was a soy milk-based drink consisting of soy milk powder, apple concentrate and oats (Table 4). Guar gum (1%, m/v) (supplied by Savannah Fine Chemicals (Pty) Ltd) was used as a stabiliser. Prior to the mixing of ingredients, the guar gum was prepared. In a glass beaker containing a magnetic stirrer, 100 ml water was heated to 80°C and 1 g of guar gum powder was added slowly whilst stirring to prevent the

Table 3. Formula for the wheat-free health bar.

Raw materials	Weight in g	Percentage (%)
Maize meal	5.35	17.82
Oats	5.76	19.21
Sugar bean flour	1.92	6.40
Coconut	2.40	8.00
Sugar	6.02	20.06
Salt	0.03	0.11
Cinnamon	0.08	0.27
Vegetable fat	2.00	6.67
Canola oil	2.00	6.67
Golden syrup	0.60	2.00
Egg powder and water	3.84	12.80
TOTAL	30.00	100.00

Table 4. Formula for the concentrated soy milk-based drink.

Raw materials	Weight in g	Percentage (%)
Soy milk powder	30.00	20.69
Apple concentrate	42.48	29.30
Oats	22.50	15.52
Guar gum 1% (m/v)	0.02	0.01
Water	50.00	34.48
TOTAL	145.00	100.00

formation of lumps. All the ingredients were subsequently blended to ensure even distribution thereof. The result was a thick, concentrated drink that needed to be diluted with water (2:1) when needed for consumption.

All apparatus and glassware used during the product development stage were steam sterilised in an autoclave at 121°C for 15 min prior to use. When exposure to high temperatures and pressure were not possible, equipment was sterilised with a 12.5% (v/v) liquid sterilising solution (Milton®) for 30 min.

Microbiological content

After production of the three products (biscuit, health bar and soy milk-based drink), 15 g samples of each were packed in sterile plastic containers and samples of the biscuits and the health bars were stored at 25° and 35°C, respectively, for 30 d, whereas samples of the soy milk-based drink were stored at 5°, 25° and 35°C, respectively, for 7 d. The biscuits and health bars were sampled on day 1, 7, 14 and 30, whereas samples of the soy milk-based drink were taken on day 1, 4 and 7. The growth media used for the determination of the microbiological content of all three products were plate count agar (PCA), potato dextrose agar (PDA), violet red bile lactose agar (VRBA), Baird-Parker agar (BP) and xylose lysine deoxycholate agar (XLD) (Biolab, all supplied by Merck, Cape Town, South Africa). The determination of the microbiological content of the products was carried out according to the South African Bureau of Standards (SABS)/South African National Standards (SANS) and Organisation of International Standards (ISO) standard procedures. The total viable cell count and endospores were counted on PCA (SABS ISO, 1991), the yeasts and mycelial fungi on PDA (SABS ISO, 1987), the coliforms on VRBA (SABS ISO, 1991), *Staphylococcus aureus* on BP (SANS, 1999) and *Salmonella* spp. on XLD (SABS ISO, 1993).

Duplicate samples of each product were stored at the different temperatures and 8 g of each were aseptically removed and placed in sterile bags with 72 ml of physiological salt solution (PSS) (0.85% (m/v) NaCl) to obtain a 10^{-1} dilution. The contents of the bags were mixed using a Stomacher (BagMixer® W, supplied by Instrulab cc) for 90 s to obtain a homogeneous mixture. From this dilution further dilutions were prepared in the PSS to obtain a dilution series (10^{-1} – 10^{-5}). The dilutions for each medium were plated in triplicate, with control plates containing only media. PCA plates were incubated at 30°C for 3 d, PDA plates at 25°C for 3, 4 and 5 d, respectively, and VRBA and BP plates at 37°C for 24 h. The dilution series of each of the samples were then heat shocked at 80°C for 10 min and triplicate PCA plates for each dilution were poured and incubated at 37°C for 24 h to detect the endospores present.

For the isolation of species of *Salmonella* samples of 25 g of each of the three products were aseptically removed and placed in sterile Stomacher bags containing 225 ml pre-enrichment medium (2% (m/v) buffered peptone water (Biolab, supplied by Merck)). These bags were placed in the Stomacher and the contents were mixed for 90 s to obtain a homogeneous mixture. After mixing, the bags were incubated for 16 h at 37°C. The incubation step was followed by selective enrichment where 0.1 ml of the mixture was added to 10 ml Rappaport-Vassiliadis magnesium chloride/malachite green medium (RV-medium), prepared according to the SABS ISO (1993) procedure. The RV-medium consists of three solutions (A, B and C). Solution A was prepared by mixing 5.0 g tryptone, 8.0 g sodium chloride and 1.6 g potassium dihydrogen phosphate (KH_2PO_4) with a litre of water and solution B was prepared by mixing 400.0 g magnesium chloride hexahydrate ($MgCl_2.6H_2O$) with a litre of water (Biolab, all supplied by Merck). Solution C was prepared by mixing 0.4 g malachite green oxalate with 100 ml water (Biolab, supplied by Merck). The RV-medium was prepared by adding 100 ml of solution B and 10 ml of solution C to 1000 ml of solution A. The inoculated RV-medium was incubated at 42°C for 24 h. This was followed by plating and identification during which two Petri dishes with XLD were streaked out one after the other by means of the same inoculation loop (SABS ISO, 1993). These plates were inverted and incubated at 37°C for 24 h and examined for possible growth of *Salmonella* species. Typical colonies are colourless with black centres. If no growth was present, the plates were incubated for a further 24 h, after which plates were again examined for growth.

%Moisture

The %moisture of the biscuit and the health bar was measured in triplicate by using a vacuum oven at 70°C (James, 1996). The measurement was done by drying the moisture dishes in the oven for 30 min and leaving them to cool in a desiccator. Each moisture dish was then weighed (W_1), where after 10 g of each of the samples was weighed into the dish (W_2). All the samples were placed in the vacuum oven for 18 h to dry. The moisture dishes were removed from the vacuum oven and placed in a desiccator to cool. The mass of the moisture dishes with the samples (W_3) were determined and the moisture percentage was calculated.

The following equation was used in the calculation of the moisture percentage:

$$\%\,\text{Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

where: W_1 = Mass of moisture dish

W_2 = Mass of moisture dish + sample (before drying)

W_3 = Mass of moisture dish + sample (after drying)

Sensory evaluation

All the children (n = 51; M:F = 27:24; 5 – 6 years) from the schools (Agapé 1 and Agapé 2) within the low socio-economic community in Grabouw were used for the juvenile consumer panel. The Sub Committee A Ethics Committee of the Stellenbosch University granted permission for performing sensory evaluation of the products using these children. Permission was also obtained from the respective schools and the parent/guardian of the participating children by making use of consent forms (Appendix A). Each of the panel members participating in the study evaluated all three of the developed food products. The samples of the biscuits and the health bars had a mass of 15 g each. The soy milk-based drink was served in a 90 ml cup with a serving size of 30 ml.

Sensory evaluation was conducted inside an empty activity room, as this is a familiar setting and would, therefore, assist in optimising the attention span of the children. The researcher explained the process to all the children before the evaluation of the products was done. Throughout the process, the researcher and assistant communicated in a friendly manner to establish a bond and relieve possible anxiety. The researcher collected four children at a time and took them to the room where the testing was done. The researcher and assistant each interviewed one child at a time. The panel members were each seated at a table, facing away from one another. The score sheet and testing procedure were explained in detail to each child.

The panel members received the three previously randomised coded samples on a sample layout sheet and were instructed to taste the samples from top to bottom. Apples were used as palate cleansers between samples. The panel members communicated their response verbally to the researcher or simply pointed to the relevant Smiley face on the 5-point facial hedonic ordinal scale (Appendix B), after which the researcher recorded the score on the score sheet. After completion of the sensory session panel members were awarded with candy.

Statistical analysis

The data obtained from the sensory evaluation were analysed by means of analysis of variance (ANOVA) using Statistica 8 (version 8.0.360.0). A p-value of ≤ 0.05 was considered significant. The data was analysed to determine if there was a significant difference between the degree of liking for the three developed supplementary food products. The data for the three products was further analysed to determine if there was a significant difference between the degree of liking of the male and female respondents for the three products.

Results and discussion

Anthropometric measurements

The aim of evaluating the anthropometric measurements (weight and height) was to determine the anthropometric status of the children, to assess if these children are at risk of being stunted (HAZ ≤-2 SD), underweight (WAZ ≤-2 SD) or wasted (WHZ ≤-2 SD). The anthropometric data obtained were compared to the results of two studies conducted in South Africa (NFCS (1999) and SAVACG (1995)).

One of the primary objectives of the NFCS was to determine the anthropometric status of children aged 1 – 9 years (NFCS, 1999). A total number of 3 120 children from all 9 provinces of South Africa from both urban and rural areas participated in the study. To determine the anthropometric status of children was also one of the main objectives of the SAVACG survey, but they assessed children aged 6 months – 6 years from urban, as well as rural areas nationally (SAVACG, 1995). The total number of children participating in this survey was 11 430.

As with the present study, the NFCS and SAVACG studies used weight and height measurements to determine the anthropometric status of the children. In Fig. 1 the anthropometric results from the present study is compared to those of the NFCS and SAVACG surveys. The results from the surveys depicted in the graph only represent those of children aged 5 years as to best compare it to the present study where the age of the study population ranged from 5 – 6 years.

From the results it is clear that stunting amongst the children is of great concern in the low socio-economic community in Grabouw (Fig. 1) as 16% of the study group was found to be stunted. From Fig. 1 it is evident that this is also true for the rest of South Africa. The fact that the percentage of stunted children in the present study is less than is the case in the other two studies (19% and 24%, respectively), can be ascribed to the fact that in the present study only one area was targeted, whilst the results of the NFCS and SAVACG represent areas in all 9 provinces of the country.

In Fig. 2 the results of the anthropometric measures of the present study are compared to those of the NFCS and SAVACG studies, where only the results from the Western Cape areas are taken into consideration. Data for specific age groups in each province were provided by the NFCS. Only the data for the 4 – 6 year age group were used in constructing this graph. However, for the SAVACG survey no data for the specific age groups were available for each of the nine provinces. Data for all ages (6 months – 6 years) for the Western Cape were thus used. This posed no problem as the prevalence of stunting, underweight and wasting for the 1 – 2, 2 – 3, 3 – 4, 4 – 5 and 5 – 6 years age groups differed at most two percentage points at a

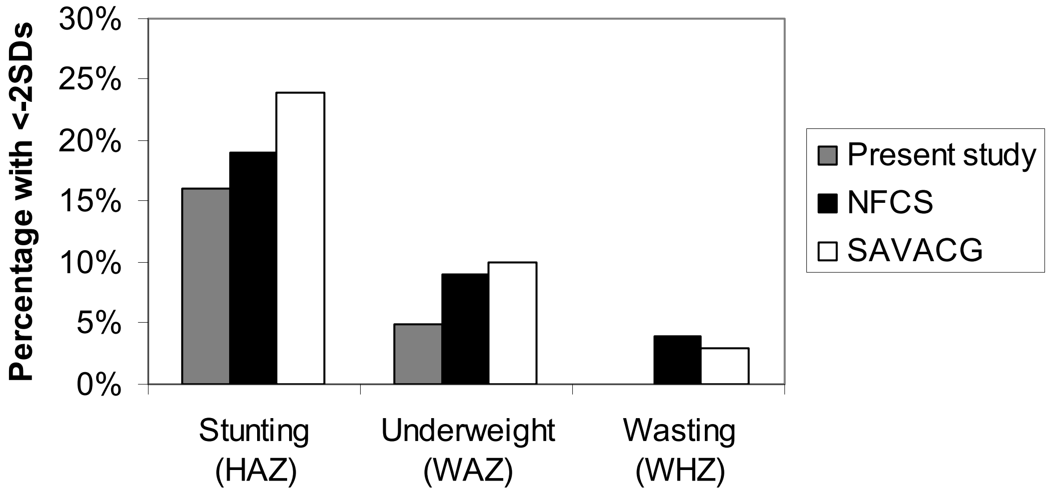

Figure 1. Percentage of stunted, underweight and wasted children (aged 5 – 6 years) of the present study compared to the NFCS and the SAVACG surveys (children aged 5 years) nationally.

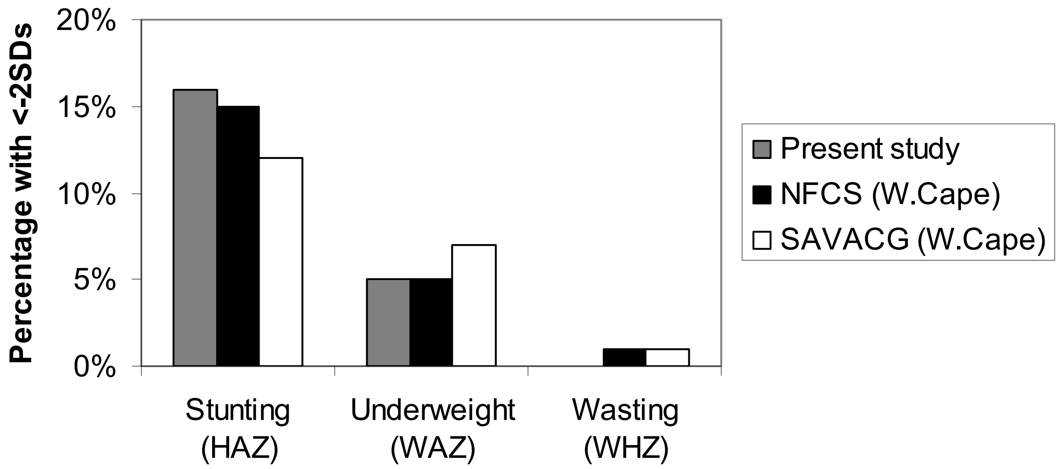

Figure 2. Percentage of stunted, underweight and wasted children of the present study compared to the NFCS and the SAVACG surveys for the Western Cape province, South Africa.

national level in the SAVACG survey. The results from the present study compared well with those of the other two studies, with the present study showing the percentage of stunted children as 16%, the NFCS study as 15% and the SAVACG study as 12% in the Western Cape.

When underweight in children in the present study is compared to that of the other two studies at national level (Fig. 1), the present study had a lower incidence of underweight (5%) compared to the NFCS (9%) and SAVACG (10%) surveys. Compared to the NFCS data obtained from the Western Cape, the results show the present survey to be in agreement, with 5%, compared to the SAVACG survey with 7% of the children considered as being underweight.

Concerning the prevalence of wasting none of the assessed children in the present study were found to be wasted. Results of the NFCS and the SAVACG surveys do, however, show wasting for 4% and 3%, respectively, on a national level (Fig. 1). On a provincial level, though, in both the NFCS and the SAVACG survey only 1% of the children were found to be wasted in the Western Cape (Fig. 2).

Stunting has been shown to reflect low socio-economic standards and should urgently be addressed (NFCS, 1999). According to Kossmann *et al.* (2000) early child growth is largely determined by nutritional intake and exposure to pathogens, both of which are related to socio-economic, environmental and cultural factors. Their results showed significant and inverse associations between cough and complicated cough and height, weight and stunting. These results are in agreement with those of a Brazilian study (Victoria *et al.*, 1987) that also shows positive associations between severe diarrhea and respiratory symptoms and wasting found up to the age of four years.

It is of great importance to evaluate the interrelationship between nutritional status and infection (Schelp, 1998). The social and economic situation, together with hygienic circumstances should be taken into consideration to prevent PEM. Stunted, wasted and underweight children are at a disadvantage as children who suffer from severe PEM in early childhood have poorer mental development, school achievement and more behavioural problems than their peers (Grantham-McGregor & Cumper, 1992). Attempts to improve the nutritional status of children might fail if measures to reduce stunting and wasting are aimed solely at enhancing nutritional intake. Focus also has to be on improving the non-hygienic practices that result in diarrhea and a high prevalence of intestinal parasites. To increase food availability alone would probably not help reduce the proportion of stunted and wasted children (Schelp, 1998).

Improvements in socio-economic conditions and better and more accessible health care facilities can significantly reduce the prevalence of stunting, but by no means can it be eliminated (NFCS, 1999). South Africa is, therefore, likely to be faced with the problem of stunting for several years to come. The intervention programmes of the Department of Health appeared to have been successful in the prevention of deterioration of the nutritional status of South African children (NFCS, 1999), so it should receive much greater priority to urgently address this problem.

It was found that food supplementation has the greatest impact on physical growth in the first three years of life (Bhutta *et al*., 2008; Gillespie & Allan, 2002; Pollitt *et al*., 1993; Schroeder *et al*., 1995). The study of Schroeder showed that consumption of every additional 418 kJ in supplementary feeding per day lead to an additional gain in length of between 4 – 9 mm per year during the first three years, with the greatest gain in the first year. Further, an additional weight gain of approximately 350 g during the first year and 250 g during the second year of life was found. Nutritional intervention should, therefore, mainly be aimed at the preschool child, and especially the very young children (1 – 3 years). Stunted, underweight and wasted children should be targeted. Attention should also be given to nutritional education of the mothers, as they make the nutritional choices that determine which nutrients and how much thereof the child receives (Engle *et al*., 2007).

In nutritional intervention the mere provision of supplementary foods is not enough if the composition of these foods is not considered. Energy is very important in supplementary foods, but the overemphasis thereof should be avoided. Neither energy nor any of the known nutrients have proven to have a consistent effect on linear growth on their own (Allen, 1993). The inadequate intake of energy is usually associated with a diet consisting of poor dietary quality and inadequate intake of micro-nutrients (Allen *et al*., 1991). The supplementary foods that are currently used or are considered being used in nutritional intervention should, therefore, not only concentrate on providing energy, but also dietary quality and micro-nutrients.

Current pre-school menus

Analysis of the pre-schools' (Agapé 1 and Agapé 2) menus was done by using the FoodFinder3® computer program. Recently a study was conducted to test the reliability of using nutrient databases, specifically FoodFinder3® and Dietary Manager Software, compared to chemical analyses (Van der Watt *et al*., 2007). No significant differences were found for the amount of total energy, protein, carbohydrate, poly-unsaturated fatty acids and total fibre. The total fat, saturated fatty acid and monounsaturated fatty acid content were significantly higher in the nutrient databases than was the case in the chemical analyses. This difference found could be ascribed to the differences in fat content between the South African meats and those of other countries.

Table 5 reflects the summarised results of the nutrients obtained from analysing the school menus (breakfast and lunch) using the FoodFinder3® program and the calculated percentages of the RDA for the macro and micro-nutrients provided by the foods per day. The RDA for children aged 4 – 6 years were used as a guideline, as the age of the children in the present study was between 5 and 6 years.

From Table 5 it can be seen that the food provided at the pre-school is not sufficient in supplying the children with all the nutrients they require daily. The meals provided at the pre-schools are important as these are, in the case of some of the children, the only meals they receive throughout the day (A. Coetzee, Agapé, Grabouw, South Africa, personal communication). Table 5 shows that the children ingested all the necessary nutrients by means of the meals provided at the pre-schools, although not all in the adequate amounts for their age group. Folate is the only nutrient ingested in sufficient quantities as 115% of the RDA is provided. Except in the case of folate and vitamin B_{12}, the feeding program of the schools involved in the present study provide less

Table 5. The average nutrient content and percentage thereof of the recommended dietary allowances as provided by the daily school food options.

Nutrients (unit)		**Nutrient content of meals**	**RDA (4 - 6 years)**	**% of RDA**
Macro-nutrients	Energy (kJ)	1856	7531	25
	Protein (g)	12	24	50
	Fat (g)	5.2	59	9
Minerals	Ca (mg)	100	800	13
	Fe (mg)	2.6	10	26
	Mg (mg)	68	120	57
	P (mg)	197	800	25
	Zn (mg)	1.58	10	16
	Se (µg)	17.7	20	89
	I (µg)	13	90	14
Vitamins	Vitamin A (µg)	52	500	10
	Vitamin D (µg)	0.59	10	6
	Vitamin E (mg)	0.96	7	14
	Vitamin K (µg)	2.17	20	11
	Vitamin C (mg)	11	45	24
	Thiamin (mg)	0.25	0.9	28
	Riboflavin (mg)	0.24	1.1	22
	Niacin (mg)	3.3	12	28
	Vitamin B_6 (mg)	0.32	1.1	29
	Folate (µg)	86	75	115
	Vitamin B_{12} (µg)	0.5	1	50

than 30% of the RDA for vitamins. This is also the case for energy, with the school meals only providing 25% of the energy requirement according to the RDA. In the present study these problems were addressed by the development of supplementary food products that are nutritious and provide macro-, as well as micro-nutrients. Introducing a supplementary product into the school feeding programme, would daily increase the intake of the different nutrients lacking in the children's diet. The introduction of these products will lead to the children consuming the relevant nutrients in quantities closer to, equal to or even higher than the recommended quantities, which would, ultimately lead to better nutrition and overall improved health (Bhutta, 2008; Engle *et al*., 2007; Gillespie & Allan, 2002).

South African National School Nutrition Programme (NSNP)

The aim of analyzing the present NSNP menus in this study was to determine the average cost of the 14 different menu options prescribed by the Department of Education for school feeding programmes (NSNP, 2005). The costs were calculated using current supermarket food prices. These average calculated costs were used as a guideline for the cost range of the supplementary products that were developed in the present study, so as to determine whether the developed supplementary food products would be a viable option for possible integration into a school feeding scheme.

The costs of the 14 menu options of the NSNP ranged between R1.50 and R6.00 per meal, with an average of R3.15 per meal. According to the Department of Education, South Africa, the current tender price for meals at schools is R1.10 per meal (De Wee, 2008). No guidelines were provided for food products which could be supplementary to the meals served at school, therefore the costs of the three developed supplementary products were kept at a minimum. For the costing of the developed products current supermarket prices were used.

Development of the three supplementary food products

Biscuit

The biscuit consisted of a double cookie layer with a vitamin-enriched chocolate filling. Different fats and oils are used in baked goods depending on the type of product and desired effect. To lower the cost and to reduce the ingestion of saturated animal fat, a solid vegetable fat (in combination with canola oil) was used instead of butter. The physical state of the fat is important for the proper dispersion of the fat/syrup phase over flour particles in preparing dough (Manley, 1991). Canola oil was used for nutritional reasons, as it has a balanced mixture of fatty acids for human nutrition and health (Ackman, 1990). Canola oil typically contains oleic (62%), linoleic (22%), linolenic (10%), palmitic (4%) and stearic (2%) fatty acids and has less saturated fatty acids than any other commodity oil (Mag, 1990). It has been found that oleic acid, which is the majority of the fatty acids present in canola oil, is nearly as effective in the reduction of the risk of cardiovascular heart disease as is the long chain polyunsaturated fatty acid (PUFA), linoleic acid (Gunstone, 2004). The essential fatty acid, linoleic acid, is needed by humans only on a scale of a few grams (2 – 5 g) per day (Gunstone, 2004). Without any major modification to popular food habits, the 22% content of this fatty acid present in canola oil would sufficiently provide in these needs. Canola oil, furthermore, provides an ideal ratio of 2:1 of linolenic acid to linoleic acid (Ackman, 1990). Concerning the saturated fatty acids, stearic acid has been singled out as being the relatively harmless saturated fatty acid present in the general range of dietary fats. Palmitic acid is, however, still an important cardiovascular risk factor, but canola has a low content of this fatty acid compared to other vegetable oils (Gunstone, 2004). The increase in the amount of fat consumed through the children's diet would also help to facilitate the absorption of the fat-soluble vitamins A, D, E and K (Berger *et al.*, 2004).

Oats was also incorporated into the biscuit dough. This consequently increases the nutritional value of the biscuit as oats contains beta-glucan, essential as dietary fibre (Figoni, 2004). All types of whole grain contain dietary fibre, but the solubility of the dietary fibre in oats plays a different role in human digestion and nutrition than the insoluble dietary fibre found in whole wheat products (Manley, 1991). Soluble dietary fibre lowers blood cholesterol levels and hence the risk of coronary heart disease (Arens *et al.*, 2000; Figoni, 2004). This is achieved by soluble dietary fibre binding to cholesterol in the bile. The latter is subsequently removed with the fibre as waste, instead of being re-absorbed (Arens *et al.*, 2000). The intake of soluble dietary fibre is also beneficial especially to diabetics as it slows the absorption of glucose into the bloodstream in the small intestine, consequently preventing a sudden rise in the blood sugar level (Arens *et al.*, 2000).

The determination of the nutrient composition of the biscuit by means of FoodFinder3® revealed its nutritional benefit. These results are reflected in Table 6. In the last column presented in Table 6 the values of the different nutrients for the product were added to those obtained from the current menu of the school so as to forecast the nutritional intake of the children when provided with this supplementary product at school.

From Table 6 it can be seen that a portion of the biscuit product (representing 2 biscuits with the filling) provides 12% of the RDA for energy, 10% for protein and 21% for fat, increasing the total RDA of respectively the energy, protein and fat ingested by the children to 37%, 60% and 30%. The addition of the supplementary product to the existing school feeding programme for the schools investigated, therefore, increases the RDA to beyond the Department of Education, South Africa NSNP's recommendation of 20 – 30% (NSNP, 2005) for macro-nutrients that should be provided by the menu's offered at the school.

The biscuit with chocolate filling as a supplementary product does not provide sufficient mineral quantities. Fortunately the quantities provided by the school's existing menu, in most cases, match or exceed the 20 – 30% recommended mineral intake (NSNP, 2005). One of the main aims of developing this specific product, however, was for it to act as a carrier for the vitamin-mixture aimed at providing the children with all the vitamins needed. The inclusion of vitamins was achieved by incorporating the vitamin-mixture into the chocolate filling used for layering the biscuit. From Table 6 it can be seen that the vitamin-mixture provides more than 100% of all the vitamins

Table 6. Nutrient content provided by school feeding and biscuit* per day and percentage representation of each of the recommended dietary allowance.

Nutrients (unit)		**RDA (4 – 6 years)**	**Nutrient content provided by school feeding**	**% of the RDA provided by school feeding**	**Nutrient content of the biscuit**	**% of the RDA provided by the biscuit**	**Total RDA provided by school feeding and the biscuit**
Macro-nutrients	Energy (kJ)	7531	1856	25	935	12	37
	Protein (g)	24	12	50	2.4	10	60
	Fat (g)	59	5.2	9	12.5	21	30
Minerals	Ca (mg)	800	100	13	16.8	2	15
	Fe (mg)	10	2.6	26	0.6	6	32
	Mg (mg)	120	68	57	15.2	13	69
	P (mg)	800	197	25	61.4	8	32
	Zn (mg)	10	1.58	16	0.34	3	19
	Se (µg)	20	17.7	89	1.8	9	98
	I (µg)	90	13	14	2.9	3	18
Vitamins	Vitamin A (µg)	500	52	10	1 040	208	218
	Vitamin D (µg)	10	0.59	6	5.24	52	58
	Vitamin E (mg)	7	0.96	14	15.33	219	233
	Vitamin K (µg)	20	2.17	11	0.08	0	11
	Vitamin C (mg)	45	11	24	60	133	158
	Thiamin (mg)	0.9	0.25	28	1.48	164	192
	Riboflavin (mg)	1.1	0.24	22	1.66	151	173
	Niacin (mg)	12	3.3	28	18.2	152	179
	Vitamin B_6 (mg)	1.1	0.32	29	2.02	184	213
	Folate (µg)	75	86	115	208	277	392
	Vitamin B_{12} (µg)	1	0.5	50	1	100	150

*portion = two biscuits (22 g each)

needed except for vitamins D (52%) and K (0%). This does not pose a problem in South Africa as vitamin D can be produced by the human body through exposure of the skin to the sun's ultraviolet rays. The amount of vitamin K in the diet could potentially be increased by providing the children and their parents with information on how to increase the intake of the food types, such as spinach and cabbage, which are natural sources of this specific vitamin (Arens *et al*., 2000).

Health bar

Some of the ingredients in the health bar were similar to those used in the biscuit. The fat used in this product consisted of a combination of solid vegetable fat and canola oil. Oats is one of the main ingredients of this product due to its textural properties, providing a coarser, chewier texture for the health bar (Figoni, 2004). Wheat flour, one of the main ingredients normally used in the majority of baked products, was, however, replaced by a combination of maize and sugar bean flour.

The proteins present in maize and bean flour are considered to be incomplete proteins and singly does not provide all the amino acids necessary for human health. The protein in maize is deficient of lysine, as well as tryptophan (Milner *et al*., 1978). It would, therefore, be an advantage to combine the maize flour with another protein source rich in the mentioned amino acids. The proteins of all leguminous species on the other hand are high in lysine, but low in methionine and other sulfur-bearing amino acids (Milner *et al*., 1978). Milner *et al*. (1978) suggested that if the cereal and legumes are taken together, in normal rates of ingestion, they present an ideal balance of amino acids. This makes cereals and legumes (such as maize and beans), therefore, a favourable combination.

FoodFinder3® was used to determine the nutrient composition of the health bar. The nutritional benefit this product provides can be seen in Table 7 where the nutritional information of the health bar was compared to that of the current menu of the schools partaking in the study. Table 7 also gives an indication of what the nutritional intake of the children would be if their diets were supplemented with this health bar.

Table 7. Nutrient content provided by school feeding and health bar* per day and percentage representation of each of the recommended dietary allowance.

Nutrients (unit)		**RDA (4 – 6 years)**	**Nutrient content provided by school feeding**	**% of the RDA provided by school feeding**	**Nutrient content of the health bar**	**% of the RDA provided by the health bar**	**Total RDA provided by school feeding and the health bar**
Macro-nutrients	Energy (kJ)	7531	1856	25	1180	16	40
	Protein (g)	24	12	50	4.6	19	69
	Fat (g)	59	5.2	9	13	22	31
Minerals	Ca (mg)	800	100	13	16.4	2	15
	Fe (mg)	10	2.6	26	1.2	12	38
	Mg (mg)	120	68	57	37	31	88
	P (mg)	800	197	25	119.8	15	40
	Zn (mg)	10	1.58	16	0.8	8	24
	Se (µg)	20	17.7	89	3.8	19	108
	I (µg)	90	13	14	6.2	7	21
Vitamins	Vitamin A (µg)	500	52	10	39	8	18
	Vitamin D (µg)	10	0.59	6	1	10	16
	Vitamin E (mg)	7	0.96	14	1.6	23	37
	Vitamin K (µg)	20	2.17	11	0.02	0	11
	Vitamin C (mg)	45	11	24	0.2	0	25
	Thiamin (mg)	0.9	0.25	28	0.2	22	50
	Riboflavin (mg)	1.1	0.24	22	0.1	9	31
	Niacin (mg)	12	3.3	28	0.6	5	33
	Vitamin B6 (mg)	1.1	0.32	29	0.04	4	33
	Folate (µg)	75	86	115	26	35	149
	Vitamin B12 (µg)	1	0.5	50	0.2	20	70

*portion = two health bars (30 g each)

It was determined that a portion of two health bars (30 g each) will provide the children with 16%, 19% and 22% of the RDA, respectively, for energy, protein and fat. Providing this supplementary product, together with the existing meals at the school, the recommended 20 – 30% of the RDA as prescribed by the Department of Education, South Africa, for the NSNP (NSNP, 2005) is for all the macro-nutrients, by far exceeded. This finding especially pertains to the fat content of the school's diet where the fat content was 9% of the RDA, and with addition of the health bar, 31% of the RDA for fat was provided. Due to the inclusion of canola oil in this product, essential fatty acids were also included in the diet.

After inclusion of the health bars, the recommended 20 – 30% of the RDA (NSNP, 2005) for all minerals would be met or exceeded, with the exception of calcium. Nutritional information on which food types to be consumed to increase the amount of calcium in the diet would be advantageous. Examples of foods providing calcium include milk, sardines (eaten with their bones) and dark leafy vegetables (Arens *et al*., 2000).

Due to the lack of inclusion of a vitamin-mixture, the health bar does not contain as many vitamins as the biscuit (Table 6). It does, however, increase the amount of some vitamins, such as vitamin E, thiamin, riboflavin, niacin and vitamin B_6 to over the 20 – 30% of the RDA recommended for these vitamins (NSNP, 2005). The amount of vitamin A, D and K provided by the menu together with the health bar does not meet the recommended 20 – 30% of RDA for these vitamins. As mentioned previously, vitamin D can in South Africa be produced by the human body due to exposure of the skin to the sun and, therefore, a shortfall in the diet does not pose a problem. The shortage of vitamin A and K would most probably best be addressed by providing nutritional information to the parents about food choices that could increase the intake of these specific vitamins. Vitamin A could be derived from the beta-carotene found in carrots or other yellow vegetables, whereas vitamin K, as mentioned earlier, is present in leafy vegetables (Arens *et al*., 2000). Alternating supplementation of the health bar with the biscuit could overcome the problem of the health bar *per se* not providing sufficient vitamins.

<u>Soy milk-based drink</u>

In South Africa 95% of the black ethnic group of the population are lactose-intolerant (Myburgh, 2001). This indicates the impaired ability to digest lactose due to the lactase enzyme in the small intestinal mucosa (Bender & Bender, 1999), resulting in symptoms such as nausea, abdominal pain, distension, bloating and diarrhea after ingestion of foods containing lactose (Ferguson, 1981; McSherry, 1982). Bearing this in mind a lactose-free drink was developed during the present study as the study population consisted of African and Malay children. Soy milk, which contains no lactose, was used in this product as it is high in protein and energy and contains many vitamins and minerals. The apple concentrate was used due to its high energy value, vitamin and mineral content, as well as its flavour profile. Oats was used in this product due to its numerous nutritional benefits and textural properties. The FoodFinder3® computer software programme was used to determine the nutrient content of the product. The results are reflected in Table 8. In the last column of Table 8 the percentages of the RDA of the different nutrients for the product were added to those of the current menu of the school so as to give a summary of what the nutritional intake of the children would be at school if they were to be provided with this supplementary product.

Considering the macro-nutrients it can be seen that 19%, 42% and 15% of the RDA for the energy, protein and fat respectively, are provided by a single portion (165 ml) of the soy milk-based drink, increasing the total intake for these macro-nutrients to 44%, 92% and 24% of the RDA, respectively when added to the school menu. The amount of energy and protein provided in total, therefore, exceed the 20 – 30% of the RDA recommended by the Department of Education of South Africa (NSNP, 2005) for these macro-nutrients.

Concerning the minerals this supplementary product provides 49%, 40%, 33% and 46% of the RDA, respectively for calcium, iron, magnesium and phosphorus, increasing the total amount consumed to 62%, 66%, 90% and 70% of the RDA for these minerals, respectively when consumed combined with the existing school menu. The soy milk-based drink, however,

Table 8. Nutrient content provided by school feeding and soy milk-based drink* per day and percentage representation of each of the recommended dietary allowance.

Nutrients (unit)		**RDA (4 – 6 years)**	**Nutrient content provided by school feeding**	**% of the RDA provided by school feeding**	**Nutrient content of the soy milk-based drink**	**% of the RDA provided by the soy milk-based drink**	**Total RDA provided by school feeding and the soy milk-based drink**
Macro-nutrients	Energy (kJ)	7531	1856	25	1452	19	44
	Protein (g)	24	12	50	10	42	92
	Fat (g)	59	5.2	9	9	15	24
Minerals	Ca (mg)	800	100	13	395	49	62
	Fe (mg)	10	2.6	26	4	40	66
	Mg (mg)	120	68	57	40	33	90
	P (mg)	800	197	25	365	46	70
	Zn (mg)	10	1.58	16	0	0	16
	Se (µg)	20	17.7	89	0	0	89
	I (µg)	90	13	14	0	0	14
Vitamins	Vitamin A (µg)	500	52	10	137	27	38
	Vitamin D (µg)	10	0.59	6	0.6	6	12
	Vitamin E (mg)	7	0.96	14	1.1	16	29
	Vitamin K (µg)	20	2.17	11	0	0	11
	Vitamin C (mg)	45	11	24	22.4	50	74
	Thiamin (mg)	0.9	0.25	28	0.18	20	48
	Riboflavin (mg)	1.1	0.24	22	0.22	20	42
	Niacin (mg)	12	3.3	28	2	17	44
	Vitamin B_6 (mg)	1.1	0.32	29	0.22	20	49
	Folate (µg)	75	86	115	22.4	30	145
	Vitamin B_{12} (µg)	1	0.5	50	0.12	12	62

*portion = 165 ml prepared soy milk-based drink does not provide zinc, selenium or iodine, but by means of the meal provided by the school alone, the children already receive 89% of the RDA for selenium. Through nutritional information to or education for the parents/guardian and small changes in the diets of the children, their intake of iodine and zinc could be increased.

The soy milk-based drink provides various vitamins. From Table 8 it can be found that the addition of this product to the school menu could increase the intake of all the vitamins, except for vitamins D, E and K, to beyond the 20 – 30% of the RDA recommended for the NSNP for the respective vitamins. The amount of vitamin E consumed could be increased to meet the recommended amount, because the total intake would, after addition of this supplementary product to the existing school menu, be 29% of the RDA for vitamin E. Vitamin D could be produced by the human body through exposure to the sun. For vitamin K the recommendation of consuming green leafy vegetables could be made as they are good sources of this vitamin (Arens *et al*., 2000).

Even though the meals the children daily receive at the schools are in some cases the only meal these children receive per day (A. Coetzee, Agapé, Grabouw, South Africa, personal communication), some of the children do receive food at home. Due to financial and safety constraints, it was not within the framework of this study to investigate the food intake of the children at home. The food given at home, however, could potentially provide the children with some of the nutrients not obtained through the diet at school. The provision of information about nutritional choices is, therefore, advantageous and desired, as Bhutta *et al*. (2008) found that in populations with sufficient food, education about complementary feeding increased the stunting z-score by 0.25. By means of educated food choices the parents could then provide in the needs of the children and in doing so decrease the chance of the children being stunted.

It has also been found that nutritional supplementation can reverse the effects of stunting provided that the intervention takes place before the age of three years (Hendricks *et al*., 2003; Simeon & Grantham-McGregor, 1989). Preventing the incidence of stunting is not only important for the children in the present study, but is also crucial for the youth population of the rest of

South Africa as stunting was found to be the main nutritional problem in this country. Considering energy intake, Schroeder *et al*. (1995) found an additional gain in length of between 4 – 9 mm per year during the first three years of a child's life when an additional 418 kJ per day was consumed, with the greatest gain in the first year. An additional weight gain of 350 g during the first year and 250 g during the second year of life was observed. The use of each of the three developed supplementary food products shows potential for implementation into school feeding schemes as each of the three products provide energy of at least 900 kJ per serving.

Implementation of one of the three developed supplementary food products into a feeding scheme (Tables 6, 7 and 8) would also be advantageous with regard to the motor and mental development of the children. Faber *et al*. (2005), Gillespie and Allan (2002), Pollitt *et al*. (1993) and Schroeder *et al*. (1995) found that improvements of the diets of pregnant women, infants and toddlers can prevent stunting and also result in improved motor and mental development. It was also found that cognition at age three years and beyond is improved with food supplementation during the first two or three years of life (Gillespie & Allan, 2002; Schroeder *et al*., 1995).

An experimental trial was conducted by Simeon & Grantham-McGregor (1989) with stunted and non-stunted children aged between 9 and 11 years and not consuming breakfast. It was found that the cognitive functions of the stunted children were detrimentally affected when they did not consume food early morning, while the non-stunted children's cognitive functions were unaffected. Especially in developing countries these findings have implications for school feeding programmes regarding the times the children receive food supplementation. It could, therefore, be suggested to schools to provide the children with breakfast early in the mornings and a supplementary snack later in the day. In this way the children would have sustained energy throughout the day, which would most probably increase their concentration and result in better learning.

<u>Costing of three developed food products</u>

Seeing that the three developed food products in this study were aimed to be used as supplementary products to the existing school menu and because these products are aimed at children living in a low socio-economic community, the costs of these products were kept at a minimum. The costing of these products was calculated by only taking into account the raw ingredients at current supermarket prices. The price per item could, therefore, still be less when the raw ingredients are bought in bulk. The price of these supplementary food products per serving was calculated to be R0.72 for both the biscuits (two biscuits of 22 g each) and the health bars (two health bars of 30 g each) and R2.37 for the soy milk-based drink (165 ml).

The costs of the 14 menu options of the NSNP were calculated and ranged between R1.50 and R6.00 per meal, with an average of R3.15 per meal. The biscuits and health bars appear to be viable options for implementation into a school feeding scheme as the price per portion is much less than the minimum amount in the calculated cost range of the NSNP menus. The researcher is not aware of any existing product in South Africa which combines sugar bean flour and maize flour to form a complete protein, which makes the health bar an attractive option for providing an inexpensive complete protein to the children. The soy milk-based drink, however, is too highly priced to be considered as a supplementary product to the feeding scheme, but given the high protein content (10 g per serving), providing 42% of the RDA for protein, and the relatively high energy content (1452 kJ per serving), providing 19% of the RDA for energy for children aged 4 – 6 years, as well as the vitamin and mineral content, this product might even be considered as a replacement for an existing meal in a feeding scheme.

Microbiological content

The determination of the microbiological content of the health bar and the biscuit was based on the specifications for egg-containing products in the *Foodstuffs, Cosmetics and Disinfectants Act and Regulations 54 of 1972* (Anon., 1972). No specifications exist for soy products, thus the same specifications were used for the soy milk-based drink as for the biscuit and health bar. An additional test (not specified in the *Foodstuffs, Cosmetics and Disinfectants Act and Regulations 54 of 1972*) was performed to detect endospores in all three the developed products.

The microbiological content of the biscuit and health bar, both stored for 30 d at 25°C and 35°C, is summarised in Tables 9 and 10, respectively. These storage temperatures were chosen as these products would be kept at room temperature (25°C) under normal circumstances, but may be exposed to higher temperatures (35°C) before consumption, especially during the summer months. The microbiological content for the soy milk-based drink in its undiluted form and stored for 7 d at 5°C, 25°C and 35°C, respectively, is summarised in Table 11. These temperatures were chosen as the soy milk-based drink should most probably be stored at refrigeration temperatures (5°C) seeing that no preservatives were used in the formulation. The effect of storage at higher temperatures on the product when it might be left at room or higher temperatures, were also examined.

From Tables 9 and 10 it is evident that almost all the microorganisms were destroyed during the baking process of the biscuit and the health bar, as extremely low colony forming units per gram (cfu.g^{-1}) were detected on all the different media. The highest average count on any of the PCA plates, detecting total viable cell count (aerobic), was 100 cfu.g^{-1}. The average number of colonies found remained the same throughout storage of 30 d. This can be ascribed to the low %moisture of the products which does not favour microbial growth. The endospore growth, with an average of no more than 30 cfu.g^{-1}, is irrelevant as literature citations indicate that at least 10^5 – 10^6 cells.g^{-1} (of the endospore-former *Bacillus cereus*) are required to initiate food borne illness (Ahmed *et al.*, 1983; CDC, 1979; Morris, 1981). Furthermore, it is evident from Tables 9 and 10 that no coliforms, *Staphylococcus aureus* or *Salmonella* spp. are present in either the biscuit or the health bar, which is of importance as these organisms may cause severe food borne illness when ingested (Prescott *et al.*, 2002). These two products can, therefore, be considered as safe for human consumption at temperatures as high as 35°C for at least 30 d.

As expected the viable cell count (aerobic) for the soy milk-based drink is higher than for the other two products as no preservatives were added or heating applied in the production process. At refrigeration temperatures the average viable cell count (aerobic) remains low over the 7 d period, with average PCA counts ranging between 100 – 970 cfu.g^{-1}. The viable cell count

Table 9. Growth media used, specification guidelines and enumeration of microbes from duplicate samples of the biscuit after storage for 30 d at 25°C and 35°C, plated in triplicate.

				Enumeration at 25°C		Enumeration at 35°C	
Organism tested	**Growth medium used**	**Specification (Anon., 1972)**	**Time (in days)**	**Variance ($cfu.g^{-1}$)**	**Average ($cfu.g^{-1}$)**	**Variance ($cfu.g^{-1}$)**	**Average ($cfu.g^{-1}$)**
Viable cell count (aerobic)	Plate Count Agar (PCA)	2×10^4 $cfu.g^{-1}$	1	0 - 40	30	spreader	0
			7	90 - 120	100	0 - 10	10
			14	10 - 140	70	10 - 40	20
			30	spreader	0	spreader	0
Yeasts and mycelial fungi	Potato Dextrose Agar (PDA)	2×10^2 $cfu.g^{-1}$	1	0	0	0	0
			7	0 - 20	10	0	0
			14	0	0	0	0
			30	0	0	0	0
Coliforms	Violet Red Bile Agar (VRBA)	5×10^1 $cfu.g^{-1}$	1	0	0	0	0
			7	0	0	0	0
			14	0	0	0	0
			30	0	0	0	0
Staphylococcus aureus	Baird-Parker Agar Base (BP agar)	No *S. aureus* in 1 g	1	0	0	0	0
			7	0	0	0	0
			14	0	0	0	0
			30	0	0	0	0
Salmonella spp.	Xylose Lysine Deoxycholate Agar (XLD agar)	No *Salmonella* spp. in 25 g	1	0	0	0	0
			7	0	0	0	0
			14	0	0	0	0
			30	0	0	0	0
Endospores	Plate Count Agar (PCA)	Not specified	1	0	0	0	0
			7	0	0	0	0
			14	0 - 90	30	0	0
			30	0 - 40	20	0 - 20	10

Table 10. Growth media used, specification guidelines and enumeration of microbes from duplicate samples of the health bar after storage for 30 d at 25°C and 35°C, plated in triplicate.

				Enumeration at 25°C		Enumeration at 35°C	
Organism tested	**Growth medium used**	**Specification (Anon., 1972)**	**Time (in days)**	**Variance (cfu.g^{-1})**	**Average (cfu.g^{-1})**	**Variance (cfu.g^{-1})**	**Average (cfu.g^{-1})**
Viable cell count (aerobic)	Plate Count Agar (PCA)	2×10^4 cfu.g^{-1}	1	150 - 220	200	70 - 150	110
			7	0 - 120	60	100 - 120	110
			14	110 - 240	190	120 - 430	270
			30	210 - 230	210	200 - 400	310
Yeasts and mycelial fungi	Potato Dextrose Agar (PDA)	2×10^2 cfu.g^{-1}	1	0	0	0	0
			7	0	0	0	0
			14	0	0	0	0
			30	0	0	0	0
Coliforms	Violet Red Bile Agar (VRBA)	5×10^1 cfu.g^{-1}	1	0	0	0	0
			7	0	0	0	0
			14	0	0	0	0
			30	0	0	0	0
Staphylococcus aureus	Baird-Parker Agar Base (BP agar)	No *S. aureus* in 1 g	1	0	0	0	0
			7	0	0	0	0
			14	0	0	0	0
			30	0	0	0	0
Salmonella spp.	Xylose Lysine Deoxycholate Agar (XLD agar)	No *Salmonella* spp. in 25 g	1	0	0	0	0
			7	0	0	0	0
			14	0	0	0	0
			30	0	0	0	0
Endospores	Plate Count Agar (PCA)	Not specified	1	0 - 50	40	0 - 30	20
			7	0	0	0 - 10	10
			14	0 - 60	40	10 - 70	40
			30	0	0	20 - 70	50

Table 11. Growth media used, specification guidelines and enumeration of microbes from duplicate samples of the soy milk-based drink after storage for 7 d at 5°C, 25°C and 35°C, plated in triplicate.

Organism tested	**Growth medium used**	**Specification (Anon., 1972)**	**Time (in days)**	**Enumeration at 5°C** Variance ($cfu.g^{-1}$)	**Enumeration at 5°C** Average ($cfu.g^{-1}$)	**Enumeration at 25°C** Variance ($cfu.g^{-1}$)	**Enumeration at 25°C** Average ($cfu.g^{-1}$)	**Enumeration at 35°C** Variance ($cfu.g^{-1}$)	**Enumeration at 35°C** Average ($cfu.g^{-1}$)
Viable cell count (aerobic)	Plate Count Agar (PCA)	Not specified	1	70 - 130	100	450 - 770	600	4.2×10^4 - 5.5×10^4	5×10^4
			4	110 - 270	190	9.8×10^5 - 1.7×10^6	1.4×10^6	1.5×10^7 - 2.2×10^7	1.9×10^7
			7	920 - 990	970	5.6×10^5 - 1.7×10^6	1.1×10^6	6.2×10^6 - 6.9×10^6	6.7×10^6
Yeasts and mycelial fungi	Potato Dextrose Agar (PDA)	Not specified	1	100 - 260	170	370 - 430	410	9.1×10^4 - 1.3×10^5	1.1×10^5
			4	270 - 380	330	1.7×10^6 - 2.2×10^6	2.0×10^6	2.4×10^7 - 6.9×10^7	4.6×10^7
			7	170 - 290	220	$> 1.5 \times 10^6$	$> 1.5 \times 10^6$	6.3×10^5 - 7.0×10^5	6.8×10^5
Coliforms	Violet Red Bile Agar (VRBA)	Not specified	1	0	0	0	0	0	0
			4	0	0	0	0	0	0
			7	0	0	0	0	0	0
Staphylococcus aureus	Baird-Parker Agar Base (BP agar)	Not specified	1	0	0	0	0	0	0
			4	0	0	0	0	0	0
			7	0	0	0	0	0	0
Salmonella spp.	Xylose Lysine Deoxycholate Agar (XLD agar)	Not specified	1	0	0	0	0	0	0
			4	0	0	0	0	0	0
			7	0	0	0	0	0	0

(aerobic) at 25°C and 35°C, after 4 d is higher for the other two products than specified by the *Foodstuffs, Cosmetics and Disinfectants Act and Regulations 54 of 1972* (Anon., 1972), with counts ranging between 1.1×10^6 – 1.9×10^7 $cfu.g^{-1}$. The same trend was observed for the yeast and mycelial fungi counts. These counts are acceptable at refrigeration temperatures, with average counts between 170 – 330 $cfu.g^{-1}$, but at 25°C and 35°C after 4 d, higher than specified (Anon., 1972) with counts ranging from 6.8×10^5 – 4.6×10^7 $cfu.g^{-1}$. This product should, therefore only be consumed if the cold chain had been maintained from production through to consumption.

It is evident from Table 11 that as with the biscuit and the health bar, no coliforms, *Staphylococcus aureus* or *Salmonella* spp. are present. This, together with the low viable cell count (aerobic) and yeast and mycelial fungi count, renders this product safe for consumption for at least 7 d if kept at refrigeration temperatures.

%Moisture

Most spoilage bacteria and pathogens require a %moisture higher than 90% to be able to grow, with most spoilage yeasts and mycelial fungi requiring a %moisture higher than 88% and 80%, respectively (Prescott *et al*., 2002). The %moisture of baked goods such as the biscuit and the health bar are typically about 2.5 – 3.0% (Manley, 1991). %Moisture obtained from the triplicate samples from both the biscuit and the health bar were 4.2% and 5.7%, respectively. As can be concluded from the results mentioned before no pathogenic growth is, therefore, to be expected.

The %moisture of the soy milk-based drink is 90%. Pathogenic and other microorganism growth can be expected under favourable conditions in products with such a high %moisture. Refrigeration of the soy milk-based drink is, therefore, of utmost importance to minimise the possibility of microbial contamination.

Sensory evaluation

In sensory testing unique problems are encountered when using a consumer panel consisting of children (Kroll, 1990). These problems include limited verbal skills (Wadsworth, 1984), short attention span (Moskowitz,

1994) and the difficulty children experience with standard sensory tests (Moskowitz, 1985). Children between the ages of five and seven years have basic reading skills or may be preliterate which make personal interviews a requirement (Kroll, 1990).

The use of facial hedonic ordinal scales, as were used in this study, is popular in determining the preference of children, as well as those with limited reading and comprehension skills (Resurrecion, 1998). In children older than 3 years simple face scales have shown to be used successfully (Johnson *et al*., 1991), but researchers are not in agreement as to which scale length is appropriate to be used with which age group. Results from the studies of Kroll (1990) and Kimmel *et al*. (1994) indicated that children are able to reliably use the 7-point facial hedonic ordinal scale from the age of 4 years. This is in accordance with the results of Chen *et al*. (1996) who found that children aged 3 – 6 years are able to reliably use the 3, 5 and 7-point facial hedonic ordinal scales for expressing their degree of liking of food products.

In the present study a 5-point facial hedonic ordinal scale was used to indicate the degree of liking of the children. A score of 1 – 5 was awarded to the three samples tested according to the degree of liking, with 1 representing “Dislike very much” to 5 representing “Like very much”. A p-value of ≤0.05 was considered as significant. From Table 12 it is evident that no significant difference was found for the preference of the products between the male and female respondents (p = 0.208). This is in accordance with results from studies of Cowart (1981) and Léon *et al*. (1998) who found no significant difference in the taste perception between boys and girls. Table 12 does, however, indicate a significant difference between the three products evaluated (p = 0.019). The differences found between the three products, represented in Table 13, were not significant for the biscuit and the health bar (p = 0.396) or the health bar and the soy milk-based drink (p = 0.054), but a significant difference was found between the biscuit and the soy milk-based drink (p = 0.006).

The comparison between the scores of the three products is represented as the combined observations of the males and females as no significant difference was found for the preference between the male and

Table 12. ANOVA table indicating which effects are significant.

Effect	F-value	p-value*
Products	4.130	0.019
Sex (M/F)	1.628	0.208

*LSD – p-values reported

Table 13. Sensory preferences for the three developed food products given in a summary table of ANOVA by ranks for both sexes, as well as for females and males separately.

Sex	Product	Valid n	Mean (SE)	p-value*	
Both sexes	Biscuit	51	3.58 (0.11)	0.396 (Biscuit vs Health bar)	0.006 (Biscuit vs Soy milk-based drink)
	Health bar	51	3.49 (0.11)	0.054 (Health bar vs Soy milk-based drink)	
	Soy milk-based drink	51	3.26 (0.11)		
Female	Biscuit	24	3.50 (0.16)	**	
	Health bar	24	3.42 (0.16)		
	Soy milk-based drink	24	3.08 (0.16)		
Male	Biscuit	27	3.67 (0.15)		
	Health bar	27	3.56 (0.15)		
	Soy milk-based drink	27	3.44 (0.15)		

*LSD – p-values reported

**p-values not given because interactions were not significant female respondents (Fig. 3). Figure 3 indicates the difference between the degree of liking for the three products, with the biscuit having the highest scores, followed by the health bar and lastly the soy milk-based drink. The frequency scores represented in Figure 4 illustrates that approximately 95 % of the panel members found all three products acceptable as they mostly selected "Like very much" and "Like" on the facial hedonic ordinal scale. Even though the preference rating for the biscuit was higher than that of the soy milk-based drink, all three products would be accepted by the majority of the children if they were to be introduced as supplements into a school feeding scheme.

Conclusions

Evaluating the menus of two pre-schools (Agapé 1 and Agapé 2) in a low socio-economic community in the Grabouw region, Western Cape, South Africa, showed that the meals provided does not meet the children's (aged 5 – 6 years) nutritional requirements. From the present investigation it was clear that they receive all the nutrients needed, although not sufficient according to the RDA for their specific age group. Introducing a supplementary product(s) into the daily diets of these children would increase the nutrient content of the children's diets per day. The addition of a supplement to the school feeding menu will result in the children consuming the various nutrients in quantities closer to, equal to or even higher than what is recommended by the RDA for this age group. This could ultimately lead to better nutrition and overall improved health (Bhutta, 2008; Engle *et al*., 2007; Gillespie & Allan, 2002).

Anthropometric measurements were done to determine the nutritional status of the children so as to determine whether the children are at risk of any nutritional deficiency. The results showed that stunting is of great concern in the study community as 16% of the children were found to be stunted. It was found that 5% of the children were underweight and that none of the assessed children were wasted. Stunting should, therefore be addressed as it has been shown to reflect low socio-economic standards (NFCS, 1999). Attempts to improve the nutritional status of children might fail

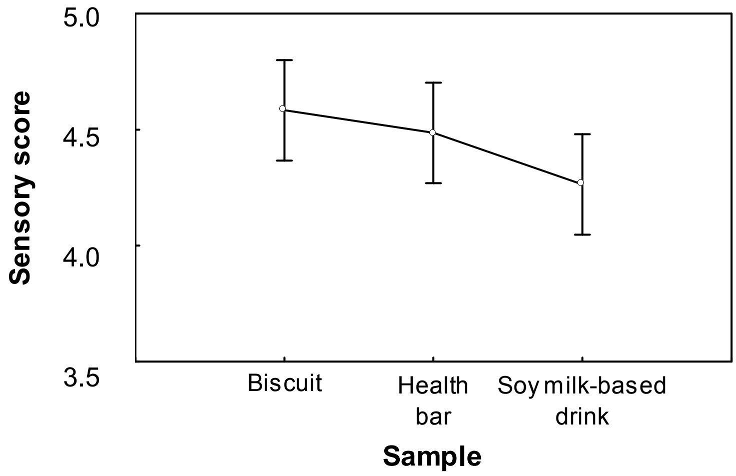

Figure 3. Comparison between the scores allocated to the three developed products according to the degree of liking for both sexes.

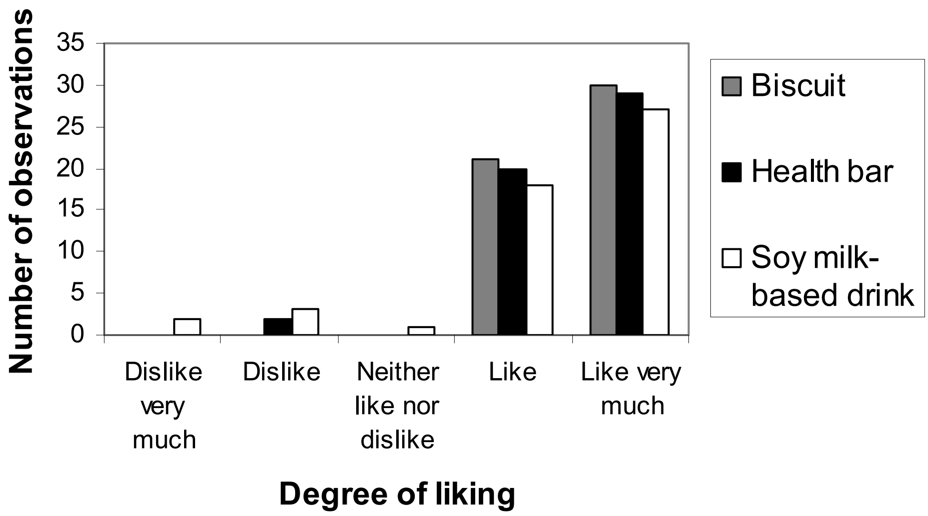

Figure 4. Acceptability of the samples as evaluated by both sexes.

if measures to reduce stunting are aimed solely at enhancing nutritional intake. Focus also has to be put on improving the non-hygienic practices, as improvements in socio-economic conditions and better, more accessible health care facilities can significantly reduce the prevalence of stunting (NFCS, 1999). Food supplementation has the greatest impact on physical growth during the first three years of life (Bhutta *et al*., 2008; Gillespie & Allan, 2002; Pollitt *et al*., 1993; Schroeder *et al*., 1995).

Three supplementary food products, a biscuit with a vitamin-enriched filling, a wheat-free health bar and a soy milk-based drink were developed. The biscuit and health bar was found to be microbiologically safe for human consumption for at least 30 d at 25°C and 35°C respectively, based on the specifications for egg-containing products in the *Foodstuffs, Cosmetics and Disinfectants Act and Regulations 54 of 1972* (Anon., 1972). No specifications to date exist for soy products, thus the same specifications were used for the soy milk-based drink as for the other two products. The soy milk-based drink was rendered safe for human consumption for at least 7 d if kept at refrigeration temperatures of 5°C.

The sensory testing using the 5-point facial hedonic ordinal scale with children (aged 5 – 6 years) from pre-schools Agapé 1 and Agapé 2 showed no significant difference between the preference for the products for males and females. The comparison of the scores indicated a difference between the acceptability of the products, but a significant difference was found only between the biscuit and the soy milk-based drink. No significant difference was found in the degree of liking of the products between the biscuit and the health bar or the health bar and the soy milk-based drink. Even though the soy milk-based drink scored significantly lower than the biscuit, all three products developed in the present study would be acceptable for the majority of the children when introduced into a school feeding scheme as 95% of the panel members scored “Like very much” and “Like” on the 5-point facial hedonic ordinal scale for all three products developed.

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APPENDIX

Appendix A

Consent forms (English (A_1), Afrikaans (A_2) and Xhosa (A_3))

Appendix B

The 5-point facial hedonic ordinal scale used for sensory evaluation of the three developed products.

Appendix A_1

UNIVERSITY OF STELLENBOSCH
CONSENT FORM TO PARTICIPATE IN RESEARCH

TITLE: Development of three food products to address possible nutrient deficiencies of children (5 – 6 years) in a community

Dear parent/guardian

The aim of this study is to develop three microbiologically safe (without germs) products, which the children like, which is specifically rich in those nutrients that were found to be insufficient in the diets of children (5 – 6 years) in this community and which will provide the children with a third of the RDA (Recommended Dietary Allowance).

- ✓ **Why is this study done and what benefits does it hold?**

Malnutrition is an epidemic that causes thousands of deaths worldwide each year. Protein-energy malnutrition (PEM) describes a class of clinical disorders usually caused by varying degrees and combinations of protein and energy deficiency. These disorders are usually accompanied by other nutritional deficiencies like vitamin (especially vitamin A) and mineral deficiencies.

Weight and height measurements are often used in such studies and can easily be transformed into standardized anthropometric variables, weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ). Information about the overall nutritional status of the children is provided by WAZ. HAZ is used to detect chronic malnutrition (stunting), which indicates if the child is too short for his/her age, whereas WHZ is used to detect acute malnutrition (wasting), which indicates if the child is too light/heavy for his/her height.

The development and implementation (after the study) of the food product into the child's diet would directly by advantageous to the children participating in this study as they will be getting a food product which specifically addresses the deficiencies in their diets. This product will better the child's health and wellbeing by providing him/her with the nutrients necessary for normal growth.

If the children like these products it could mean great progress in the sense that it might not only provide the children of this school with better health, but maybe in communities across the country with similar problems.

After completion of the study, the product(s) will be provided to the children free of charge if funding is provided from local organizations.

- ✓ **What will be done in this study?**

The weight and height of the children that participate in this study (whose parent(s)/guardian(s) gave permission) will be measured in light clothing (without shoes). These measurements will be done only once and the researchers will bring the necessary apparatus to the school where the measurements will be done.

The evaluation of the diets of the children will be done based on the school's menu.

The researchers then need a few weeks to develop the three products. After the development the children will be asked to taste the (safe) products. A questionnaire will be given to the child. The questionnaire will be thoroughly explained to him/her. He/she will then taste the products and thereafter use the questionnaire to indicate how much he/she likes or dislikes the products. This test will only be done once with him/her.

- ✓ **What about confidentiality?**

If the results were to be published in a scientific journal or presented at a congress the confidentiality would be maintained. This study has been approved by the Committee of Human Research of Stellenbosch University and would be conducted according to the Declaration of Helsinki and to MRC and ICH guidelines.

- ✓ **Are there any risks or discomfort for my child?**

None!

- ✓ **Will my child be paid to participate in the study?**

No.

- ✓ **Will it count against my child if I withdraw him/her from the study?**

Not at all! You can choose if your child should be in this study or not. If so, you can withdraw him/her from the study at any time, without any consequences.

- ✓ **Do you have any further questions?**

If you have any further questions or you seek more information, you can contact Prof Corli Witthuhn (021 8083654) or Mr Matthys Lombard (084 220 0677) during office hours.

If you decide to let your child participate in the study, please read and sign the attached consent form.

Thank you!

Hereby I declare that I understand the above information and that I was given the opportunity to ask questions if there was anything that was not clear.

I understand the aim of this study, the benefits it holds, as well as the way in which the study will be conducted.

Furthermore, I understand that there will be no risks or discomfort for my child resulting from the study and that I may withdraw him/her or he/she may withdraw himself/herself from the study at any time, without any consequences.

I (parent/guardian) ……………………………………………… hereby give permission that my child

………………………………………………. may participate in this study.

Signed: ………………………………………… Date: ……………………………………………

(Parent/Guardian)

Signed: ………………………………………… Date: ……………………………………………

(Researcher)

Appendix A_2

UNIVERSITEIT VAN STELLENBOSCH
TOESTEMMINGSVORM OM DEEL TE NEEM AAN NAVORSING

TITEL: Ontwikkeling van drie voedselprodukte om moontlike nutriënttekorte van kinders (5 – 6 jaar) in 'n gemeenskap aan te spreek

Geagte ouer/voog

Die doel van hierdie studie is om drie mikrobiologies veilige (sonder kieme) voedselprodukte, waarvan die kinders hou, te ontwikkel wat spesifiek ryk is aan die voedingstowwe wat daar gevind is waaraan daar 'n tekort in die diëte by die kinders (5 – 6 jaar) in hierdie gemeenskap is en wat die kinders met 'n derde van die RDA ("Recommended Dietary Allowance") sal verskaf.

✓ **Waarom word hierdie studie gedoen en watter voordele hou dit in?**

Wanvoeding veroorsaak elke jaar die dood van duisende mense wêreldwyd. Proteïen-energie wanvoeding beskryf 'n klas van kliniese steurnisse wat gewoonlik veroorsaak word deur verskillende grade en kombinasies van proteïen en energie tekorte. Hierdie steurnisse gaan gewoonlik saam met ander voedingstekorte, soos vitamien- (veral vitamien A) en mineraaltekorte.

Gewig- en lengtemetings word dikwels in so 'n studie gebruik en kan maklik in standaard antropometriese veranderlikes, gewig-vir-ouderdom (WAZ), lengte-vir-ouderdom (HAZ) en gewig-vir-lengte (WHZ), omgeskakel word. Inligting oor die algehele voedingstatus van die kinders word aangedui deur WAZ. HAZ word gebruik om chroniese wanvoeding (dwerggroei) aan te dui, wat wys of die kind te kort vir sy/haar ouderdom is, waar WHZ gebruik word om akute wanvoeding aan te dui, wat wys of die kind te lig/swaar vir sy/haar lengte is.

Die ontwikkeling en implementering (na die studie) van die voedselproduk in die kinders se diëte sal direk voordelig wees vir die kinders wat aan die studie deelneem, want hulle sal 'n voedselproduk, wat spesifiek die tekorte in hul diëte aanspreek, kry. Hierdie produk sal die kind se gesondheid en welstand verbeter deur die nutriënte nodig vir normale groei aan hom/haar te verskaf.

Indien die kinders van hierdie produkte hou kan dit groot vooruitgang beteken in die sin dat dit dalk vir nie net die kinders van hierdie skool vir beter gesondheid kan sorg nie, maar dalk in gemeenskappe reg oor die land waar daar soortgelyke probleme is.

Na afloop van die studie sal die produk(te) gratis aan die kinders verskaf word indien fondse deur plaaslike organisasies verskaf word.

✓ **Wat gaan in hierdie studie gedoen word?**

Die kinders wat aan die studie deelneem (wie se ouer(s)/voog(de) toestemming gegee het) se gewig en lengte gaan gemeet word in ligte klere (sonder skoene). Hierdie metings gaan slegs een maal gedoen word en die navorsers sal die nodige apparaat na die skool toe bring waar die metings gedoen word.

Die evaluasie van die kinders se diëte gaan gedoen word gebaseer op die skool se spyskaart.

Die navorsers benodig dan 'n paar weke om die drie produkte te ontwikkel. Na die ontwikkeling sal die kinders gevra word om die (veilige) voedselprodukte te proe. 'n Vraelys word aan die kind gegee. Daar sal deeglik aan hom/haar verduidelik word hoe die vraelys werk. Hy/sy proe dan die produkte en dui daarna op die vraelys aan hoeveel hy/sy daarvan hou of nie hou nie. Hierdie toets sal net een keer met hom/haar gedoen word.

✓ **Wat van vertroulikheid?**

Indien die resultate in 'n wetenskaplike joernaal gepubliseer of by 'n kongres aangebied sou word, sal vertroulikheid gehandhaaf word. Hierdie studie is goedgekeur deur die Kommittee vir Menslike Navorsing van Stellenbosch Universiteit en sal volgens die Verklaring van Helsinki en MRC en ICH riglyne uitgevoer word.

- ✓ **Is daar enige risiko's of ongemaklikheid vir my kind?**

Geen!

- ✓ **Gaan my kind betaal word om aan die studie deel te neem?**

Nee.

- ✓ **Gaan dit teen my kind tel as ek hom/haar uit die studie onttrek?**

Glad nie! U kan kies of u kind in hierdie studie moet wees of nie. Indien wel, kan u hom/haar teen enige tyd, sonder enige gevolge, uit die studie onttrek.

- ✓ **Het u enige verdere vrae?**

Indien u enige verdere vrae het of nog inligting soek, kan u Prof Corli Witthuhn (021 8083654) of Mnr Matthys Lombard (084 220 0677) tydens kantoorure skakel.

Indien u besluit om u kind aan die studie te laat deelneem, lees en teken asseblief die aangehegde toestemmingsvorm.

Baie dankie!

Hiermee verklaar ek dat ek die bogenoemde inligting verstaan en die geleentheid gegun is om vrae te vra indien daar enige onduidelikheid was.

Ek verstaan die doel van die studie, die voordele wat dit inhou, sowel as die manier waarop die studie uitgevoer gaan word.

Verder verstaan ek ook dat daar geen risiko's of ongemaklikheid vir my kind sal wees as gevolg van die studie nie en dat ek hom/haar of hy/sy hom-/haarself te eniger tyd uit die studie kan onttrek sonder enige gevolge.

Ek (ouer/voog) ………………………………………………… gee hiermee toestemming dat my kind

……………………………………………….. aan hierdie navorsingsstudie mag deelneem.

Geteken: ……………………………………… Datum: ……………………………………….
(Ouer/Voog)

Geteken: ……………………………………… Datum: ……………………………………….
(Navorser)

UXWEBHU LWAMAPHEPHA EMVUME OKUTHABATHA INXAXHEBA KUPHANDO YIDYUNIVESITHI YASE-STELLENBOSCH

IGAMA: Uphuhliso lweemveliso zokutya ezintathu ukwenza intetho enokwenzeka ngentswelo yezondlo yabantwana ekuhlaleni (abakwiminyaka emi-5 – 6).

Mzali Obekekileyo

Injongo yesi sifundo kukuphuhlisa iimveliso ezintathu ezingesifundo ngeentsholongwane esikhuselekileyo, kutheni abantwana bethanda ngokukodwa ezo zondlo zityebileyo ezifumaniseke ukuba azanelisi kwizondlo zabantwana ekuhlaleni (abakwiminyaka emi-5 – 6) nezizakunika abantwana isithathu secebo lesondlo esivunyelweyo.

- ✓ **Kutheni kusenziwa esi sifundo kwaye loluphi uncedo oluphethweyo?**

Ukungondleki komzimba yeyona ndyikitya yesifo esibangela amawaka-waka endyikitya yokufa emhlabeni ngokubanzi kunyaka ngamnye. Ukungondleki komzimba okubangelwa kukunqongophala kweprothini namandla (PEM) kuchaza udidi lweziphazamiso zesibhedlele oludla ngokubangelwa ngamaqondo awohlukeneyo nendibanisela yokuswela iiprothini namandla. Ezi ziphazamiso zidla ngokukhatshwa zezinye iintswelo zezondlo ezinjengeevithamin (ingakumbi uvithamin A) nentswelo yeetyuwa zendalo.

Umlinganiselo wobunzima nobude usoloko usetyenziswa kwisifundo esinje kwaye singaguqulwa lula sibe kumgangatho we-anthrophomethrikhi eguqu-guqukayo, ubunzima ngokweminyaka (WAZ), ubude ngokweminyaka (HAZ) nobunzima bobude (WHZ). Ulwazi malunga newonga lilonke lezondlo zomntwana elinikezwa yi-WAZ. I-HAZ isetyenziswa ukufumana ukungondleki komzimba okungapheliyo (ukuthintela ukukhula), okubonisa ukuba umntwana mfutshane kakhulu kuneminyaka yakhe, nalapho I-WHZ isetyenziswa ukufumana ingozi ngokungondleki komzimba, ebonisa ukuba umntwana ngoku uceke-ceke okanye mkhulu kunobude bakhe.

Uphuhliso nokuphunyezwa kwale mveliso yokutya (emva kwesi sifundo) ukuba ibe yimveliso yokutya komntwana kuza kujonga ngqo ngokuncedayo emntwaneni othabatha inxaxheba kwesi sifundo njengoko bezakube befumana le mveliso yokutya ethi ngokukodwa ichaze ngakumbi ngentswelo yesondlo. Le mveliso iza kuba ngcono kakhulu kwimpilo yomntwana nokonwaba kwakhe ngokumnika izondlo eziyimfuneko ukuze akhule kakuhle nangendlela efanelekileyo.

Ukuba abantwana bayazithanda ezi mveliso, loo nto iza kuthetha inkqubela enkulu ngohlobo lokuba ingathi ingancedi abantwana besi sikolo ngempilo engcono kuphela kodwa mhlawumbi noluntu kwilizwe lonke olunale ngxaki ifana nale.

Emwa kokugqiba esi sifundo. Abantwana baza kufumana izinto zesimahla. Kufuneka sifumane imali kuqala.

- ✓ **Yintoni elindeleke ukuba yenziwe kwesi sifundo?**

Ubunzima nobude bomntwana othabatha inxaxheba kwesi sifundo (abazali babo abanike imvume) baza kuthathwa imilinganiselo kwimpahla eceke-ceke (benganxibanga zihlangu). Le milinganiselo iza kwenziwa kube kanye kuphela nabaphandi baza kuza nezixhobo eziyimfuneko esikolweni apho le milinganiselo iza kwenziwa khona.

Uvavanyo lwezondlo zabantwana luza kwenziwa lusekelwe kuludwe lwezidlo zesikolo.

Abaphandi baza kufuna ithuba elingangeeveki ezimbalwa ukuphuhlisa ezi mveliso zontathu. Emva kokuba iphuhlisiwe abantwana baza kucelwa ukuba bangcamle ezi mveliso (ngokukhuselekileyo). Iphepha lemibuzwana liza kunikwa umntwana. Eli phepha lemibuzwana liza kuchazwa ngokugqibeleleyo emntwaneni. Aze emva koko angcamle iimveliso ukuze emva koko asebenzise iphepha lemibuzwana ukubonisa ukuba uzithanda kangakanani ezi mveliso. Olu vavanyo luza kwenziwa kube kanye kuphela nomntwana.

- ✓ **Le nto emayingathethwa?**

Iziphumo zesi sifundo ziza kupapasha kwingxelo yenzululwazi. Ikomiti kaHuman Research yase-university yaseStellenbosch yayisamkela esi sifundo. Le nkqubo iza kuqhubela phantsi kwemithetha kaDeclaration kaHelsinki, MRC, kunye ne-ICH.

✓ **Ingaba akukho bungozi okanye bunzima kumntwana wam?**
Hayi!

✓ **Uza kufumana imali, umntwana wam?**
Hayi.

✓ **Ingaba kungayingxaki ukuba ndiyamrhoxisa kwesi sifundo?**
Akunjalo konke-konke! Ungakhetha ukuba umntwana ufuna abe kwesi sifundo okanye hayi. Ukuba kunjalo, ungamrhoxisa kwesi sifundo nangaliphi na ixesha ngaphandle kweembophelelo.

✓ **Ingaba unayo eminye imibuzo?**
Ukuba unemibuzo okanye ufuna ulwazi oluthe vetshe, ungaqhakamshelana no – Prof Corli Witthuhn (021 8083654) okanye u Mnu Matthys Lombard (084 220 0677) ngamaxesha omsebenzi.

Ukuba ugqibe ekubeni umntwana wakho athabathe inxaxheba kwesi sifundo, nceda ufunde ukuze usayine la maxwebhu emvume angasemva.

Enkosi!

Ndazisa ukuba ndiyaluqonda ulwazi olungentla nokuba ndiye ndanikwa ithuba lokubuza ukuba kukho into engacacanga.

Ndiyayiqonda nenjongo yesi sifundo, uncedo esiluqulathileyo, kananjalo nendlela esiza kuqhutywa ngayo esi sifundo.

Ngaphezu koko, ndiyaqonda ukuba akukho bungozi okanye bunzima obuza kuba semagxeni omntwana wam ngenxa yesi sifundo nokuba ndingamrhoxisa okanye arhoxe nangaliphi na ixesha ngaphandle kwazimbophelelo.

Mna (umzali) ……………………………………………………….. ndinika imvume ukuba umntwana wam u

………………………………………………… angathabatha inxaxheba kwesi sifundo.

Usayino: …………………………………… Umhla: ……………………………………..
(Umzali)

Usayino: …………………………………… Umhla: ……………………………………..
(Umphandi)

SENSORIESE EVALUERING

PANEELLID NR.: ....   DATUM: ....

OUDERDOM: ....   GESLAG: ....

OPDRAG AAN FASILITEERDER:

1. Verduidelik kortliks die betekenis van die vyf verskillende gesiggies aan die kind.
2. Bedien die produkte aan die kind soos u dit ontvang het deur te begin by die **boonste produk** totdat u al 3 produkte bedien het.
3. Dui die keuse vir die produkte aan deur ‘n kruis deur die toepaslike gesiggie, vanuit die ry gesiggies vir daardie spesifieke produk te trek.
4. Verseker dat die kind ‘n stukkie appel eet voor elke produk.
5. **Verseker dat die kodenommer op die vraelys met die kodenommer op die produk wat getoets word, ooreenstem.**

KODE NR: ....

Baie sleg | Sleg | Onseker | Lekker | Baie lekker

KODE NR: ....

Baie sleg | Sleg | Onseker | Lekker | Baie lekker

KODE NR: ....

Baie sleg | Sleg | Onseker | Lekker | Baie lekker

CHAPTER 4

GENERAL DISCUSSION AND CONCLUSIONS

Even though progress has been made in recent years in some areas of nutrition, 790 million people living in developing countries and 34 million living in developed countries are still undernourished and do not have access to enough food (Oldewage-Theron *et al.*, 2006). The poverty, malnutrition and poor health many children in the developing countries are exposed to, detrimentally affect their physical and mental development (Faber *et* al., 2005; Grantham-McGregor & Cumper, 1992; Pollitt *et al.*, 1993; Schroeder *et al.*, 1995).

Evaluating the menus of two pre-schools (Agapé 1 and Agapé 2) in a low socio-economic community in the Grabouw region, Western Cape, South Africa showed that the food served at school does not completely provide in the children's (aged 5 – 6 years) nutritional needs. It was found that they receive all the necessary nutrients, although not in sufficient quantities for their age group according to the RDA. Introducing a supplementary product into the diets of these children would provide an increase in the nutrient content of the children's daily diet. The introduction will thus lead to the children obtaining a diet with a nutrient content closer to, equal to or even higher than what is recommended by the RDA for the specific age group. This could ultimately lead to better nutrition and overall better health of the children (Bhutta, 2008; Engle *et al.*, 2007; Gillespie & Allan, 2002).

The anthropometric status of the children, to assess if they were at risk of being stunted (HAZ ≤-2 SD), underweight (WAZ ≤-2 SD) or wasted (WHZ ≤-2 SD), were determined by means of anthropometric measurements (weight and height). The results showed that stunting is of great concern in the community investigated as 16% of the study group were found to be stunted. These results are in accordance with those of the National Food Consumption Survey (NFCS) (1999) and the South African Vitamin A Consultative Group (SAVACG) (1995) which, respectively, found 15% and 12% of the children in the Western Cape to be stunted. It was also found that 5% of the children in the present study group were underweight which is in agreement with results from the NFCS for children aged 4 – 6 years in the Western Cape (5%) and in the same range as results from the SAVACG for children aged 6 months – 6 years in the Western Cape (7%). Furthermore, it was found in the present study that none of the assessed children were suffering from wasting. Again on provincial level these results agreed with those of the NFCS and the SAVACG surveys which both show only 1% of the children to be wasted. Attempts to improve the nutritional status of children might fail if measures to reduce stunting are aimed solely at enhancing their nutritional intake. Focus also has to be placed on improving the non-hygienic practices. Improvements in socio-economic conditions as well as better and more accessible health care facilities can significantly reduce the prevalence of stunting (NFCS, 1999).

Three supplementary food products, a vitamin-enriched biscuit, a wheat-free health bar and a soy milk-based drink were developed. The main aim of the biscuit was to act as a carrier for a vitamin-mixture providing more than 100% of the RDA for the 4 – 6 year age group for all the vitamins except vitamin K (provided 0%) and vitamin D (provided 52%). This product also contained canola oil providing essential fatty acids (Gunstone, 2004) and oats, acting as a source of soluble dietary fibre (Arens *et al*., 2000; Figoni, 2004). The health bar was manufactured by combining sugar bean flour and maize flour, together providing a complete protein. It also contained canola oil and oats, not only because of their nutritional benefits, but also because of the flavour and texture qualities the oats provide. Soy was used as basic ingredient for the soy milk-based drink seeing that 95% of the black ethnic group of the South African population is lactose-intolerant (Myburgh, 2001). This product was found to be high in protein (42% of RDA for protein for ages 4 – 6 years per serving), providing 1856 kJ energy per serving and various vitamins and minerals. Seeing that food supplementation has been found to have the greatest impact on physical growth during the first three years of life (Bhutta *et al*., 2008; Gillespie & Allan, 2002; Pollitt *et al*., 1993; Schroeder *et al*., 1995), possible nutritional supplementation using one or more of the developed products should be aimed at this age group.

The determination of the microbiological content of the health bar and the biscuit was based on the specifications for egg-containing products in the

Foodstuffs, Cosmetics and Disinfectants Act and Regulations 54 of 1972 (Anon., 1972). No specifications to date exist for soy products, therefore in the present study the same specifications were used for the soy milk-based drink as were used for the other two products. An additional test was performed to detect endospores in all three products. The biscuit and health bar was found to be safe for human consumption for at least 30 d at 25° and 35°C. The soy milk-based drink was rendered safe for human consumption for at least 7 d when kept at refrigeration temperatures (5°C).

The sensory testing using the 5-point facial hedonic ordinal scale with children (aged 5 – 6 years) from the two pre-primary schools Agapé 1 and Agapé 2, found no significant difference between the preference for the developed products for male and female respondents. A significant difference was found between the preference for the biscuit and the soy milk-based drink, with the biscuit showing the highest score of the three developed products with the soy milk-based drink the lowest score. No significant differences were found between the biscuit and the health bar or the health bar and the soy milk-based drink. Even though the soy milk-based drink was scored significantly lower than the biscuit, all three products would be acceptable to the majority of the children when introduced into a school feeding scheme as 95% of the consumer panel members scored "Like very much" and "Like" for all three products using the 5-point facial hedonic ordinal scale.

From the results of the present study it can be concluded that stunting in the study group is of greatest concern, as was confirmed by results of the NFCS (1999) and SAVACG (1995). This health problem could be addressed by means of nutritional supplementation. The aim of nutritional supplementation should be to supplement the existing diet and in doing so ensuring a more ideal nutrient intake closer to what is recommended by the recommended dietary allowance (RDA). Nutritional deficiencies should, however, not only be addressed by means of nutritional supplementation, but should also include education of the parent/guardian to help them to make informed nutritional choices and in doing so providing their children with the nutrients necessary for optimal mental and physical development.

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