DEVELOPMENT OF A FOOD MULTIMIX TO ADDRESS MALNUTRITION AMONGST THE ELDERLY

By

N B Matiwane

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Supervisor: Prof W.H. Oldewage-Theron

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DECLARATION

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

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DEDICATION

This dissertation is dedicated to my parents Ernest Mncedsi and Phentoria Nomjoli for their great contribution towards my education and many of my achievements.

ABSTRACT

Introduction and purpose – The study was conducted in order to determine the nutritional status of the elderly attending a care centre in Sharpeville in order to develop a novel food item, to address malnutrition and to test and analyse the novel food item for acceptability (sensory analysis) and shelf life.

Methodology – A randomly selected sample of 170 elderly, including males and females, aged sixty and above participated in the research. A cross-sectional survey included socio-demographic, health and twenty-four hour recall questionnaires as well as anthropometric and biochemical measurements. Trained fieldworkers assisted with data collection dietary intake and food measurements consumption data were captured and analysed with assistance of a qualified dietician using a Food Finder ® version 3.0 program in to determine the frequency, mean and standard deviations. The socio-demographic and health data, biochemical and anthropometric measurements were analysed for means and SDs.

Results - Although 100percent of the elderly received a monthly pension, the majority (72percent) were bread winners in the households. The majority of households (65,8 percent) had a monthly income of R 501-1 000. Eighty two percent of the respondents indicated that they bought food once a month and the food was bought mostly from local supermarkets (68,2percent) which are generally very expensive. Most households (63,1percent) spent less than R200 on food per week. Taking into consideration that the average household size was 4,9, it was calculated to be less than R5,80 per person per day. The Top 20 food consumption list indicated that the majority of food items consumed were carbohydrate-based.

Dietary intake results confirmed that these households consumed mainly a carbohydrate-based diet and although the daily protein intake was sufficient, the diet was also deficient in total energy and dietary fibre, as well as a number of micronutrients including calcium, magnesium, zinc, selenium, iodine, thiamine, riboflavin, vitamins B6, C, D, E, biotin, pantothenate and folate. These findings indicated the prevalence of undernutrition.

The biochemical data showed that 73,1percent of the elderly had low serum zinc levels. A large percentage of men and women had sub-optimal haemoglobin levels. Most of the biochemical

variables were within the normal range, however the mean cholesterol level was 5,4 ±1,4mmol/l which was higher than the normal range of 5,2mmol/l.

The majority of the females were overweight and obese, signifying overnutrition in the sample of elderly people. The health status of the respondents was also compromised. A large number of subjects were taking chronic medication (55,9percent) and suffered from a number of disorders including painful joints (70,6percent), enteral infections (72,4percent) and chronic headaches (48,2percent). Forty one percent received chronic hypertension medication.

A food multimix was formulated, which involved the blending of locally available, affordable, culturally acceptable and commonly consumed food commodities mixed proportionally, drawing on the 'nutrient strengths' of each component of the mix in order to optimise the nutritive value of the end-product without the need for fortification. The initial estimates of energy and nutrient content of the ingredients needed the appropriate food databases. The nutrient content was calculated using the SA food composition data and Food Finder/Dietary Manager®. At least 30 percent target ratio of the RDA was met in most nutrients in the food multimix. Proximate analysis was carried out to determine macronutrients such as energy, protein, carbohydrate and micronutrients such as zinc and iron content of multimixes. Carbohydrate and energy content were derived using data gained from the analytical procedures. Sub-samples of formulated FMM recipes were taken and prepared for analysis and shelf life testing of the FMM, soup and spinach muffin was also carried. The end products of multimix formulated were two recipes namely cream spinach soup and low sodium spinach muffins. Eighty percent accepted the soup colour and 50percent liked the flavour, 55percent of the elderly accepted the appearance, 75percent accepted the smell of the product. The dried spinach was mixed with the apple blended well and regarding taste, only 15percent disliked the taste.

Conclusions: The results of this study confirmed that a novel food item such as FMM can be developed to meet certain criteria.

Recommendations: Further research is required where long-term effects of the implementation of the multimix in the diet of the elderly can be investigated.

Keywords: novel foods, food multimix, elderly, malnutrition, shelf life, sensory analysis.

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GLOSSARY OF TERMS

AAS	atomic absorbance
ADA	American Dietetic Association
AIDS	acquired immune deficiency syndrome
AOAC	association of official analytical chemists
approx	approximately
ARC	Agricultural Research Council
ASTM	American Society for Testing and Materials
aw	water activity
BMI	body mass index
Ca	calcium
CCK	cholecytokinin
Cfu/g	colony forming units per gram of sample
cm	centimeter
CRM	certified reference material
$CuSO_4$	copper sulphate
dl	deciliter
DNA	deoxyribonucleic acid
DOH	Department of Health
DON	Department of Nutrition
DRI	dietary reference intake
EAR	estimated average requirement
EC	European Commission
EDTA	ethylene diaminetetra acetic acid
EFA	essential fatty acids
EHRM	European health risk monitoring
Etc.	etcetera
EU	Europian Union
FAO	Food and Agriculture Organization of the United Nations
FCC	food chemicals codex
FDC	Food Development Centre.
Fe	iron
FE	folate equivalents
FMM	food multimix
FNRI	food and nutrition research institute
Fol	folate
G	gram
GAIN	Global Alliance for Improved Nutrition
GMO	genetically modified organisms
GIT	gastro intestinal tract
GRAIN	genetic resource action international
H	hour
HAI	Help Age International
Hb	heamoglobin
Hct	haemocrit

HCL	hydrogen chloride
Hg	mercury
HIV	human immunodeficiency virus
H_2O	water
H_2SO_4	sulphuric acid
ICP-MS	inductively coupled plasma-mass spectrometry
IDs	international units
IDASA	INSTITUTE for DEMOCRACY in SOUTH AFRICA
ILSI	international life science institute
INP	integrated nutrition programme
INQ	index of nutritional quality
kg	kilogram
kJ	kilojoules
Ltd	limited
m^2	square meter
mg	milligrams
MJ	megajoules
ml	milliliter
mm	millimeter
mol	SI base unit that measures an amount of substance.
MRC	medical research council
MUAC	mid-upper arm circumference
MUFA	mono unsaturated fatty acid
MVC	microvessel count
n	number
Na	sodium
NADP	nicotinamide adenine dinucleotide phosphate
NaOH	sodium hydroxide
NE	niacin equivalents
NEP	nutrition education programme
NFCS	national food consumption survey
NGO	non-governmental organisation
NHANES	national health and nutrition examination survey
NIRU	nutrition intervention research unit
nm	nanometer
NSDSHS	Nutrition Services Department of State Health Services
NSI	nutrition screening initiative
NUT	nutrition
P/S	polyunsaturated/saturated
PEM	protein energy malnutrition
pH	hydrogen ion concentration (relative acidity or alkality)
PLP	plasma pyridoxal 5¢-phosphate
Plt	platelets
ppm	parts per million
PTH	parathyroid hormone
Pty	proprietary

PUFA	polyunsaturated fatty acid
QFFQ	quantitative food frequency questionnaire
RAE	retinol activity equivalents
RBC	red blood cell
RBC	red blood cell count
RBP	serum retinol binding protein
RE	retinol equivalents
RNA	ribonucleic acid
RNI	reference nutrient intakes
SA	South Africa
SADHS	South African demographic health survey
SAMRC	South African Medical Research Council
SAVACG	South African Vitamin a Consultancy Group
SD	standard deviation
SENECA	survey in Europe on nutrition and the elderly: a concerted action
SPSS	statistical package for social sciences
SRBP	serum retinol-biding protein
THUSA	transition and health during urbanisation of South Africans
UI	international unit
UK	United Kingdom
UV	ultra violet
UNICEF	United Nations Children's Fund
USA	United State of America
USAID	United States Agency for International Development
VAD	vitamin A deficiency
Vit	vitamin
W	weight
WBC	white blood cell
WHO	World Health Organisation
WHR	waist-to-hip ratio
Zn	zinc

LIST OF SYMBOLS

≤	less than and equals to
≥	greater than and equals to
&	and
percent	percent
±	plus or minus
°C	degrees celcius
(v/v)	volume
µ	microgram
>	greater than
(v/v)	volume by volume
ß	beta
percent E	energy percentage
25-OH-D	concentration of 25hydrxyvitamin D

CHAPTER 1: THE PROBLEM AND ITS SETTING

1.1 INTRODUCTION

Even though good nutrition has been accepted universally as a basic human right, it is estimated that more than 800 million people suffer from malnutrition globally and that more than 20 percent of the population are hungry in the developing countries (Vorster, Oosthuizen, Jerling, Veldman & Burger, 1997:1). The number and proportion of older persons are growing world wide. The estimate of 540 million older persons will almost be doubled by 2020 and about 71 percent of the elderly will be staying in the developing countries (Morley, 1998:1). About 270 million people over 60 live in countries where the average income is less than R 12,58 a day in the year 2000. Older people live on a third to a half of average incomes. Over a quarter of a billion older people are currently living on much less than a dollar a day. Even in the poorest countries, life expectancy is increasing and the number of older people is growing. By 2050, over a billion people over 60, or more than half of the world's older people will live in what are now low income countries where the average income is less than R13,97 a day (Hickson, 2006:2). According to Help Age International (HAI) (2002:21), in study in the year 2000, there were 374 million people over the age of 60 in developing countries (62percent of the world's older people). Therefore, in just eight years will be 493 million older people in developing countries (65percent of the world's older people) (refer figure 1). In 2030, there will be over a billion older people in developing countries which are three quarters of the entire world's older people. In comparison, the number of older people in industrialised countries will increase from 218 million in 1996 to 362 million in 2050 which is a 65 percent increase over the period compared with a 200 percent increase in developing countries (refer figure 2) (HAI, 2002:21).

Africa is blessed with huge agricultural land masses, mineral resources, including precious metals, crude oil and waterways. Despite these facts African nations remain saddled with poverty, malnutrition and slow economic development (Amuna, Zotor & Tewfik, 2004:3). The

population of the Sub-Saharan Africa (SSA) over the last six years has increased by 61 million (from 6 270 million in 1996 to 6 880 million in 2002) although there was a drop in annual growth rate from 2,6 to 2,2 percent over the same period (World Bank, 2003; Food and Agriculture Organisation /World Health Organisation, 2003).

In SA the population aged 65 and over is expected to reach 7,4 million by the year 2035, which will be 6,4 percent in total. The composition of the aged population is 2 percent Asian, 8 percent Coloured, 35 percent White and 55 percent African. The proportions are expected to increase by 18 percent for Africans, one percent for both Coloureds and Asians, and for Whites to decrease by 20 percent in 2035 (Ferreira & Charlton, 2006: 1).

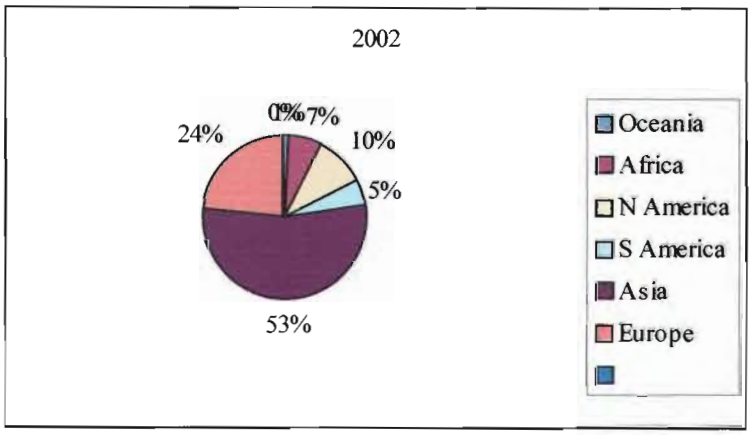

Figure 1 Distribution of the worlds populations over the age of 60 by 2002 (HAI, 2002:21)

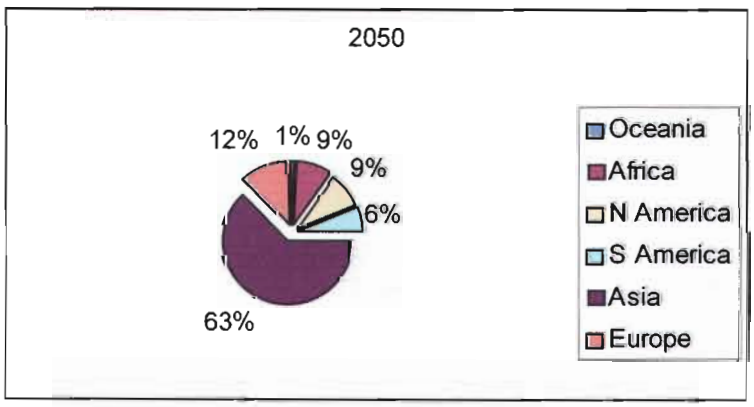

Figure 2 Distribution of the worlds populations over the age of 60 by 2050 (HAI, 2002:21)

1.2 THE GLOBAL NUTRITION PROBLEM AMONGST THE ELDERLY

The global crisis is set to increase amongst the older people, since the population of the world is ageing and undernourished (Visvanathan, 2003:2). Malnutrition is the condition that develops when the body does not get enough amounts of macro- and micronutrients it requires to maintain the healthy body. Therefore, malnutrition can be described in two categories that are undernutrition and overnutrition (Visvanathan, 2003:2). The most common nutritional shortfall amongst the elderly population is global malnutrition (reduced intake or increased requirements for protein and calories). About 65percent of elderly people admitted to hospital are malnourished, and undernourishment amongst elderly patients is linked with significant adverse clinical outcomes. Various studies indicate that both institutionalised and community-dwelling elderly individuals are prone to depression, medication, oral disorders (e.g., ill-fitting dentures), dementia and concomitant illness (e.g., poorly controlled diabetes) resulting to the list of reversible causes (High, 2001:1893).

Environmental and social factors may play a role in malnutrition risk and it can thus not be assumed that the elderly living in a community always experience independence from and control over food and other choices. Maturing or aging bodies and physiological systems function with nutrient requirements quite distinct from the younger. Decreased nutritional needs among the aging are associated with changes in economic conditions, self-treatment of health conditions or low nutrient intake in adults and aging adults (Watson, 1993:1; Schlenker, 1993:7-9; Azad, 2002:8). This has led to decreased mobility, the need for help during meal times and eating problems as factors related to malnutrition (Christensson, Unosson, & Ek 2001: 492). Thomas, Verdery, Gardner, Kant and Lindsay (1991:335) indicated that health professionals working with elderly people needed to be aware of their requirements as older people have totally different dietary and health considerations compared to younger people. One nutrient deficiency may result in a different clinical picture from that caused by a combination of multi-nutrient deficiencies (Thomas *et al.*, 1991: 335).

Sibai, Zard, Adra, Baydoun and Hwalla (2003:222) further showed that 100percent of elderly people are at high risk of osteoporosis, due to a grossly deficient intake of vitamin D. A lack of

vitamin D could result in bone tenderness, muscle weakness and osteoporosis or osteomalacia (Williams, 1994; Sibai *et al.*, 2003: 223).

Although Britain is one of the world's richest nations, according to a report one in seven elderly Britons are suffering from malnutrition. In Northern and Northwest England elderly are most likely to suffer from malnutrition, where up to 20percent of people aged 65 and over are thought to be at risk (Novis, 2004:1).

In a study carried out in Switzerland the prevalence of malnutrition in the developing world has been identified as a major cause of death affecting millions of people. The findings of the study showed that 1percent of the elderly were community-healthy, 4-5percent patients receive home help, 20percent are in hospital and 37percent are institutionalised (Guigoz, Lauque & Vellas, 2002:737-57).

A study by the Urban Institute estimated that about 5 million elderly Americans were experiencing food insecurity which led to malnutrition. The strong factors that are linked to food insecurity according to Cohen, Burt and Schulte (1993) were:

- Income less than 150percent of the poverty level.
- Poor health conditions.
- Minority race or ethnicity(Cohen *et al.*,1993)

The very same concerted efforts used to address child malnutrition, are likely to combat under-nutrition amongst the elderly. Protein energy malnutrition in an older person comes as a significant cost to the individual, families, communities and the health care system (Visvanathan, 2003:1).

Deficiency of vitamins or minerals could be described as the micronutrient malnutrition. More than 2 billion people in the world today may be affected by micronutrient malnutrition. Most common forms of micronutrient malnutrition are vitamin A deficiency, iron deficiency anaemia and iodine deficiency disorders. In table 1 the three main forms of micronutrients malnutrition are futher discussed. People of all population groups in all regions of the world can be affected by micronutrient malnutrition (FAO, 1997b; Borwankar, Sanghvi & Houston, 2007:176-177).

Table 1: Estimated numbers of all people (in millions) at risk and affected by the three main forms of micronutrient malnutrition (FAO, 1997b and Borwankar *et al.*, 2007:176-177)

	Iodine Deficiency Disorders		Vitamin A Deficiency		
Region	At Risk	Affected (Goitre)	At Risk	Affected (Xerophthalmia)	Iron deficient or Anaemic
Africa	181	86	52	1,0	206
Americas	168	63	16	0,1	94
South-East Asia	486	176	125	1,5	616
Europe	141	97	-	-	27
Eastern Mediterranean	173	93	16	0,1	149
West Pacific	423	141	42	0,1	1058
TOTAL	1572	655	251	2,8	2150

1.2.1 Undernourishment amongst the elderly globally

Undernutrition is a situation when a person consumes less essential nutrients and using or excreting them more frequently than they can be replaced. This type of malnutrition is the condition of inadequate intake of calories from protein, vitamins and minerals (Fyke, 2002:1; Andersen, Jean & Deskins, 2003:1-2). Undernutrition is prevalent amongst elderly populations resulting in inevitable consequences of ageing (Collier, 2006:1).

The etiology of malnutrition is a risk of under-nutrition in the elderly. Surveys have found a prevalence of 41percent undernourished, due to factors such as poor nutritional status that have a crucial effect on health. Low body mass index (BMI) and unintentional weight loss are also associated with an increased risk of death among the elderly (Whitney & Rolfes, 1996:618).

The world-wide diversity in the older adult population indicates life-style differences during the lifespan, environmental influences that affect the genetic potential and health status (Kuczmarsk, Kuczmarsk & Najjar, 2000:59). The nutrition screening initiative (NSI) indicating a basic

metabolic rate (BMI) of less than (<) 22, shows underweight in the elderly (NSI, 1991). This study is further substantiated by results of epidemiological studies on relationships between BMI and mortality and also indicated an increased mortality risk for the elderly, with BMI < 25 (Dey, Rotenberg, Sundh, Bosaaeus & Steen, 2001:55). The cut off point indicates that institutionalized elderly were five times more at risk of being underweight than those elderly people at home (NSI, 1991).

Research studies carried out on malnutrition among elderly American women and men showed protein deficiencies to be the problem (Schlenker, 1993:251). This was shown by anthropometric and biochemical markers which occurred mostly among the elderly men above 75 years. Epidemiological studies have also shown that nutritional deficiencies among the elderly groups, who are at risk of malnutrition, were caused by medical, physiological or socio-economic conditions (Buchowski & Sun, 1996:184; Christensson *et al.*, 2001:492).

1.2.1.1 Protein-energy malnutrition

Protein-energy malnutrition (PEM) is a common disorder in the elderly and may result from inadequate energy and protein intakes, a hypercatabolic state, or both. PEM accentuates the physiologic loss of fat that occurs with advancing age, and muscle mass particularly is affected. Depletion of protein may result in physical frailty and immune depression such that elderly may be exposed to falls, infections and a decrease in functional ability (Bos, Benamouzig, Bruhat, Roux, Mahé, Valensi, Gaudichon, Ferrière, Rautureau & Tomé, 2000:1129; Short, Vittone, Bigelow, Proctor & Nair, 2003:E92). Protein energy malnutrition (PEM) among elderly persons has been shown to occur in up to 59percent of the nursing home residents in the United State of America, thus malnutrition, with or without a contributing disease, is common among the elderly persons living in a community (Williams, 1994:261).

As indicated by Rubin and Holmes, undernourishment is a serious, potentially life-threatening situation in the elderly. The figures, range from 5percent to 12percent of the community dwelling elderly, 30percent to 61percent of hospitalized elderly, and 40percent to 85percent in those living in long-term care institutions (Rubin, 2005:1; Holmes, 2005:1).

In Scotland undernourishment amongst elderly people has been found to have a diversity of harmful effects ranging from the formation of pressure sores to the incidence of cracked femurs. Surveys amongst hospitalised elderly patients have shown that the elderly are often admitted from their homes in a condition of malnutrition, which would indicate nutritional shortage in at least some populations (McCormack, 1997:857).

1.2.1.2 Micronutrient deficiencies

Most severe problems of micronutrient malnutrition are found in developing countries. People in developed countries also suffer from various forms of these nutritional problems (FAO, 1997b). The most prevalent micronutrient deficiencies in developed countries are mainly iron, iodine, and vitamin A and can have effect on the growth, development and immunity of children (Van Stuijvenberg, Dhansay, Smuts, Lombard, Jogessar & Benadé, 2001:1). Over the past ten years show that FAO's most recent estimates about reductions in undernourishment, in 1997-99, there were 815 million undernourished people in the world: 777 million in the developing countries, 27 million in transition countries and 11 million in the industrialized countries. A decrease of 39 million since 1990-92 (the benchmark period used at the World Food Summit), presented the latest figure for which the revised figure was 816 million undernourished. Thus the average annual decrease stands at about 6 million people (SOFI, 2001;2; Kinsella, 1997:1).

Insufficient protein and calcium as well as micronutrients can lead to permanent adverse effects on growth, physical and mental potential. In most developing nations iodine deficiency in children aged 6 to 24 months impairs working capacity and brain development. Insufficient protein and calcium as well as micronutrients can lead to permanent adverse effects on growth, physical and mental potential. Iodine deficiency is estimated to have lowered the intellectual capacity of children by 10 to 15 percent. Iron deficiency in children aged 6-24 months impairs working capacity and brain development of approximately 40percent to 60percent of the developing world. Approximately 250 000 severe birth defects are caused by folate deficiency and vital fatty acids deficiencies affect intelligence and vision. Calcium and vitamin D deficiency cause rickets in small children (Kleinman, Murphy, Little, Pagano, Wehler, Regal & Jellinek, 1998: 9; Venkatesh Mannar & Sankar, 2004:999).

Micronutrient insufficiency is "hidden hunger" in that most people who experience these deficiencies are not aware they are suffering from them. They lead to poor growth, anemia, developmental delays, blindness and even death (GRAIN 2000:8, Etcheverry, Griffin & Abrams, 2005:77, Faber & Wenhold, 2007:394).

Vitamin and mineral deficiency disorders are commonly referred as micronutrient malnutrition. Vitamins and minerals are named as micronutrients because the body requires them only in minute amounts to maintain normal health and functioning. Lack of these micronutrients results in serious health problems (DoH, 2005:2). There are several problems that could lead to malnutrition. The series of illustrations in Figure 3 indicate important reasons why a person, family or community can be malnourished (FAO, 2004). As can be seen in this figure, many causes can contribute to malnutrition, disability and death.

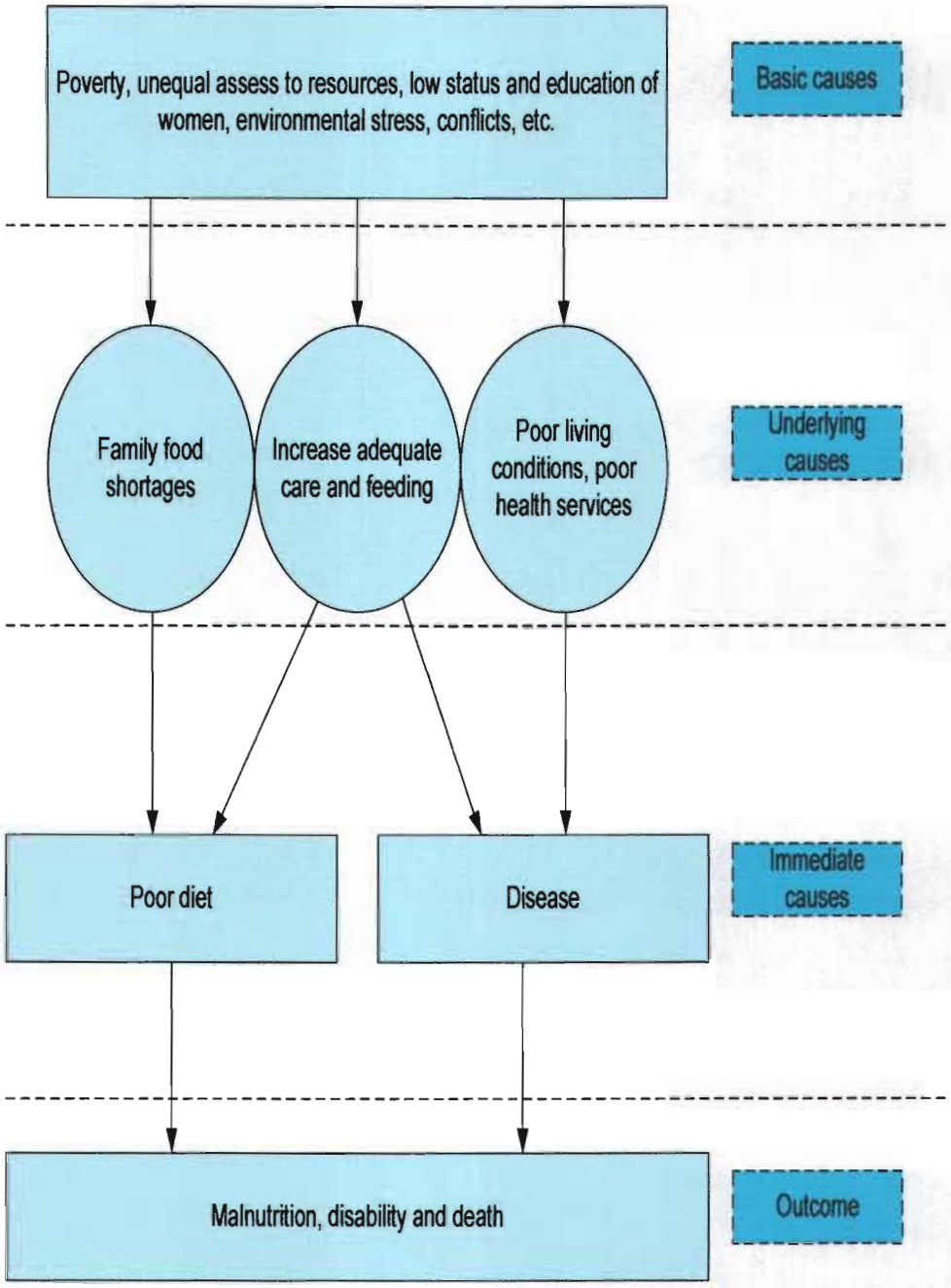

Figure 3 Framework of underlying causes of malnutrition and mortality (adopted from the FAO, 2004)

As cited by the American Dietetic Association (ADA,2001), the best strategy for optimal nourishment is to rely on foods. Studies carried on the relationship between the diet and diseases indicated that both macro and micronutrients are essential and have documented the necessity to avoid dietary excesses and imbalances as well as inadequate nutrient intake (DoH, 2005:1; ADA,

2001:2). Food components such as dietary fibres have potential health benefits but are not easily included in supplements. Health benefits are also contained in the complex matrix of natural foods that are unidentified (ADA, 2001:2). Most people who have access to a balanced diet can usually get all the nutrients they need from their normal diet. People should, therefore, be encouraged to select a balanced diet from food before considering any vitamin and mineral supplement, because foods contain many substances that promote good health (Codex Alimentarius Commission, 2005).

There has been a slowdown in the reduction of undernourished in the world. As a consequence, to achieve the World Food Summit goal of halving the number of undernourished in developing countries by 2015, the average annual decrease required is no longer 20 million but 22 million - well above the current level of performance (FAO, 1997a; Holmes, 2005:1). There is a need for appropriate intervention to offer the potential to stop further health decline and identify vulnerable individuals (Holmes, 2005:1).

There was an overall decrease in the number of undernourished in the developing regions hiding contrasting trends in different countries. There were only 32 out of the 99 developing countries that studied recorded a decline of undernourished between 1990-92 and 1997-99. About 116 million people achieved total reduction, as compared with a total increase of 77 million recorded for the countries in which the number of undernourished rose. The first group includes a number of large countries, such as China, Indonesia and Thailand in Asia and Nigeria in Africa, the total decrease achieved outweighed the total increase in the second, numerically larger group of countries. There was net reduction of 39 million as indicated in Figure 4. Thus the number of the undernourished has creased considerably in the majority of developing countries. This analysis excludes Ethiopia and Eritrea, nine developing countries in which less than 2,5 percent of the population was undernourished in 1990-92 were also excluded (SOFI, 2001:2).

South African studies carried out in the Western Cape and Free State indicated that in both males and females the dietary reference intakes (DRI's) of vitamin D, calcium, zinc, and vitamin B 6 were below the recommended daily intake levels for the elderly (Charlton, 2001:33).

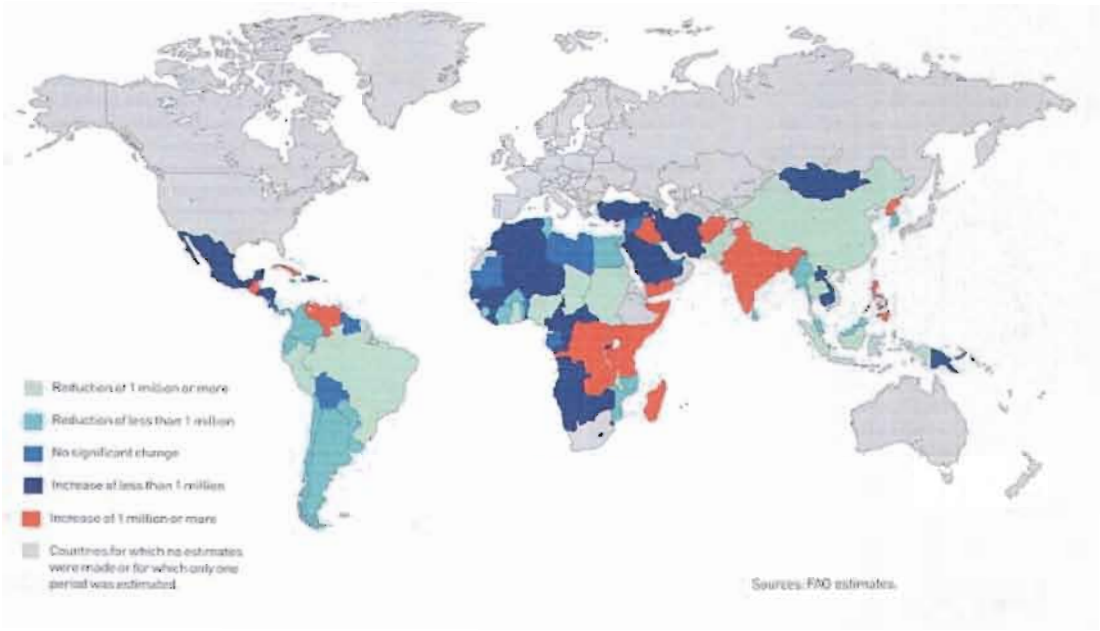

Figure 4 Degree of food deprivation changes in the number of undernourished between 1990-92 and 1997-99 (SOFI, 2001:3).

1.2.2 Overnutrition

There are more than 1 billion overweight adults worldwide. Overweight and obesity results in a major risk for chronic diseases such as diabetes mellitus two, cardiovascular disease, hypertension, stroke and several types of cancer (WHO, 2006:1). Overnutrition can be defined as dietary imbalances or excesses associated with many of the leading causes of death and disability. Overnutrition results from eating too much, eating too many of the wrong food, not exercising enough, or taking too many vitamins or other dietary replacements (DON, 2000:80-81; Schlenker, 1993:258and Fyke, 2002:1)

Obesity is a form of energy overnutrition from fat, carbohydrates, protein, or alcohol sources resulting in excess of body fat (Schlenker, 1993:258). Proper diet and exercise is required to correct the problem. Briefly, the food in the diet should be low in fat and high in fibre. Diets high in protein are no more effectual than any other diet except that there is rapid water loss. Surplus protein is dangerous to the body in several ways; at times it weakens the kidneys, heart, bones, and immune system. It is better to follow a regular, balanced diet that is low in fat and

sugar and high in fibre (DON, 2000:87-89). The risk of malnutrition is also elevated by being 20percent over weight, exposure to diet with high fat and salt and taking high doses of:

- Nicotin acid (niacin) to lower the cholesterol levels,
- Vitamin A to cure skin problems (DON, 2000:82-84; Fyke, 2002:1).

Low energy, macronutrient and cholesterol intakes were found to be prevelent among the elderly people of Cape Town (Charlton, 2001:32). Mean energy intakes fell below the DRI's for both women and men. Twenty seven percent of males and 36percent of females had energy intakes below 67percent of the DRI's. The low intakes of minerals and vitamins of the elderly people in Cape Town, as compared with the data from other studies in South Africa indicate that elderly people could not meet the required intake except vitamin B6 for men only (Charlton, 2001:33; DoH, 2002a).

1.3 NUTRITION PROBLEMS AMONGST AFRICAN ELDERLY

In Africa hunger and malnutrition have been on the increase since the 1960's reaching a peak in the 1980's as over 150 million people were affected. In 1983-84 Mozambique experienced famine and about 100 000 people perished. In Ethiopia, Sudan, Somalia, Liberia and Angola war also caused the problem experienced in Mozambique. Ethiopia alone in 1983 had 9 million famine victims. The protein energy deficiency is the most common form of malnutrition in Africa and it affects over 100 million people (Maletnlema, 1992:424).

The older population in Africa is increasing in line with global trends. The numbers of people over 60 in sub-Saharan Africa are currently estimated to be over 35 million. In Africa older people continue to face many challenges and poverty remains a fundamental problem. Older people have also been hard hit by the effects of HIV/AIDS (HAI, 2007:1).

Labadarios and Steyn (2005a) indicate that the African continent as a whole is known to be the only one in the world with a continuous high prevalence of malnutrition. There is little meaningful evidence or consistent improvement in nutritional status. The African continent is experiencing a triple burden which is that of poverty and food security, the epidemic of the

immunodeficiency virus (HIV) and the acquired immunodeficiency syndrome (AIDS) that continues to devastate the Sub-Sahara and malnourished hospitalised patients in Africa. This results in the elderly sharing their food with younger children and may exacerbate their frequently compromised nutritional status (Labadarios & Steyn, 2005a:2-3).

In the study carried out by Clausen, Sandberg, Ingstad and Hjortdahl (2000) on elderly people of Mmankgodi village in Botswana, the nutritional status was measured by BMI and showed that respondents 7percent were identified with a BMI less than 16 which indicated severe malnutrition and 71percent had a normal BMI between 18,5 and 29,9. An additional 14percent were moderately malnourished with BMI between 16 and 18,5. Seven percent, of the elderly were obese with a BMI of 30 or more, out of which 84 percent were women (Clausen *et al.*, 2000:60).

In 1993-94 a study was carried out to identify the diet and nutritional status of a group of healthy elderly Zimbabweans living in rural and urban environments. Most of the elderly people had a low protein intake compared to the study that was conducted in India (Allain *et al.*, 1997:467-468). Eating patterns of elderly Zimbabweans were influenced by both income and education which led to the frequent consumption of certain foodstuffs such as: meat, protein, bread, milk and fried food. Elderly that resided in the urban areas had low Vitamin B_{12}, and folate was higher in rural residents. Over one-quarter of the elderly people had low serum calcium concentrations and those who never drank milk had the lowest concentrations. Over one-third of the subjects had chewing problems and many had few teeth. Difficulty with chewing is a risk factor for malnutrition. The data indicate that particularly among urban women obesity is a problem and increased WHR predicted mortality from cardiovascular disease in older men and women. The cholesterol levels of <l60mg/dl indicated undernutrition amongst the elderly (Allain *et al.*, 1997:467-468; International Life Science Institute, 2005:4).

Pieterse, Manandhar and Ismail (1998) carried out a study on older Rwandan refugees in the in North-west of Tanzania. The findings indicated the prevalence of undernutrition and the proportion of the BMI cut off point of <18,5 was 19,5percent among men and 13percent among women. The data collected was further compared with that in young elderly aged (50-59) where 23,2percent of older men and 15,1percent of older women were malnourished compared with

15,0percent of younger men and 10,9percent of younger women, thus indicating a higher prevalence of malnutrition in the elderly Rwandan refugees (Pieterse *et al.*, 1998:261-262)

Information from Help Age International research indicates that most elderly have no access to basic needs such as food. Among elderly Malawians, 50 percent of men and 22percent elderly women were malnourished and about 38percent of men and 13percent of women were severely malnourished (HAI, 2002:24).

In Africa there have been few studies on diet or nutritional status in the elderly populations (Allain, Gomo, Adamchak & Matenga, 1997:643). The elderly are not considered a priority for targeting of nutrition interventions in Africa, and it is not surprising that different types of nutrition interventions have not been described nor published about this population. Only a few studies in African countries have been done and few nutritionists are working with older people (Charlton & Rose, 2001:2428s).

1.4 THE MALNUTRITION PROBLEM AMONGST THE ELDERLY IN SOUTH AFRICA

Data on the nutritional status of community-dwelling elderly South Africans is not abundant and is largely limited to information from four studies: a sample of urban elderly blacks in the Free State, a sample of urban blacks from the BRISK study in the peri-urban settlements of Cape Town a study of older coloured (mixed ancestry) subjects in Cape Town and a sample of white elderly in Potchefstroom. A study on the nutritional status of older non-urban South Africans, conducted in a sample of 100 subjects in Pankop, assessed biochemical parameters and anthropometrical measurements (dietary data were not collected) (see Table 2) was the only published study. Profiles of macronutrient intake and energy mean fell below the RDA for both black and coloured men and women) in urban Cape Town (see Table 3). Both men and women in these two groups, had energy intakes below 67percent of the RDA (Charlton, Bourne, Steyn & Laubscher, 2001:36).

The South Africa Demographic and Health Survey (SADHS) of 1998 found that 19,8percent of adult men and 26,1percent of adult women were overweight while 9,3percent of adult men and 30,1percent of adult women were obese. Obesity is regarded as a major risk factor for diabetes mellitus, hypertension and other chronic diseases of lifestyle. The same survey found that 16percent of adult women and 13percent of adult men were hypertensive in 1998. It is estimated that 8percent of the adult population have Type 2 diabetes (DoH, 2001:16-17).

In 1998 a study of both men and women aged greater than and equals to (≥) 15years carried out by Puoane Steyn, Bradshaw, Laubscher, Fourie, Lambert, and Mbananga in South Africa indicates that 29,2percent men were overweight (≥25 kg/m2) and 9,2percent had an abdominal obesity, while women were overweight by 56,6percent and 42percent had abdominal obesity (Puoane *et al.*, 2002:1).

Table 2: Dietary surveys of older South Africans (Charlton *et al.*, 2001:31)

Sample	N	Age range	Dietary method	Place
Urban blacks	400	65 - 116	24h recall FFQ*	Free State
Urban blacks	148	60 - 89	24h recall FFQ*	Cape Town
Coloured	200	65 - 92	24h recall FFQ*	Cape Town
White	100	65 - 85	24h recall Dietary history	Potchefstroom
Rural blacks	100	60 - 88	Anthropometry Biochemisty †	Pankop
* FFQ = food frequency questionnaire. † No dietary assessment was performed.				

Table 3: Comparison of the mean (SD) energy distribution, P/S ratio, cholesterol and fibre intakes of older South Africans (Charlton *et al.*, 2001:34)

	Recommended	Black urban Cape Town	Black urban Free State	Coloured Cape Town	White Potchefstroom
N		148	400	200	100
Men		74	182	104	48
Women		74	218	96	52
Age group (years)		60 - 89	65 - 116	65 - 92	65 - 84
percent E protein	13				
Men		15,7 (5,2)	11,5	14,3 (2,5)	15,4 (1,9)
Women		14,2 (4,5)	12,1	14,7 (3,3)	15,5 (2,5)
percent Animal/total protein					
Men		57,6 (21,9)		64 (10)	
Women		52,4 (22,5)		63 (10)	
percent E Fat	< 30				
Men		25,9 (10,4)	25,1	31,8 (5,1)	38,6 (5,2)
Women		24,1 (10,8)	27,7	33,1 (5,6)	36,8 (5,7)
P/S ratio	>1				
Men		0,69 (0,47)	0,67	0,83 (0,24)	0,5 (0,3)
Women		0,68 (0,48)	0,59	0,84 (0,24)	0,6 (0,3)
percent E Carbohydrate	> 57				
Men		57,9 (15,8)	59,9	56,3 (7,2)	43,2 (7,3)
Women		64,8 (14,4)	58,5	55,9 (7,3)	45,9 (6,2)
percent E sugar	< 10				
Men		12,1 (9,4)		18,9 (8,0)	12,2 (5,7)
Women		15,9 (10,5)		16,2 (9,2)	10,7 (6,9)
Dietary fibre	30 g				
Men		16 (11)	31 (38)	17 (8)	22 (8)
Women		11 (7)	28 (19)	16 (8)	23 (7)
Cholesterol	< 300 mg				
Men		300 (344)	356 (348)	285 (168)	412 (193)
Women		175 (162)	334 (318)	225 (114)	308 (108)
P/S = polyunsaturated/saturated fat					

Micronutrient intake of all groups in the studies did not meet the RDA for the following micronutrients: vitamin D, calcium and zinc (Table 4). In general the black Cape Town sample had the lowest mean micronutrient intakes compared with the other samples, which is in line with their lower energy intakes (Charlton, 2001:34).

Table 4: Comparison of the mean (SD) energy distribution, P/S ratio, cholesterol and fibre intakes of older South Africans (Charlton 2001:34)

		Men				Women			
Vitamins	RDA Men/Women	Black (Cape Town)	Black (Free State)	Coloured (Cape Town)	White (Potch)	Black (Cape Town)	Black (Free State)	Coloured (Cape Town)	White (Potch)
Vitamin A (RE)	1 000/800	1214 (4456)	3458 (5523)	1185 (971)	2142 (632)	379 (425)	2 866 (3197)	987 (759)	1 922 (761)
Thiamin (mg)	1,2/1,0	0,90 (0,63)	1,70 (1,55)	0,95 (0,47)	1,4 (0,4)	0,65 (0,42)	1,48 (0,93)	0,86 (0,36)	1,2 (0,3)
Riboflavin (mg)	1,4/1,2	1,29 (2,52)	1,66 (1,32)	1,4 (0,9)	1,8 (0,7)	0,69 (0,44)	1,56 (1,58)	1,3 (0,7)	1,7 (0,5)
Niacin (mg)	15/13	14,8 (10,6)	15,5 (11,0)	16,3 (8,5)	20,7 (4,9)	9,1 (6,0)	14,4 (9,5)	14,4 (6,2)	18,6 (3,7)
Vitamin B6 (mg)	2/1,6	1,11 (0,73)	1,06 (0,86)	1,3 (0,7)	1,6 (0,3)	0,76 (0,50)	1,1 (1,0)	1,3 (0,6)	1,6 (0,3)
Folate (µg)	200/180	210 (250)	171 (124)	236 (129)	212 (84)	125 (90)	159 (122)	210 (92)	209 (69)
Vitamin B12 (µg)	2,0	9,2 (47,6)	6,92 (14,0)	8,9 (8,3)	5,9 (3,1)	2,2 (3,2)	6,3 (1,4)	6,8 (6,2)	4,9 (2,1)
Vitamin C (mg)	60	49 (108)	57,4 (60,7)	61 (62)	58,7 (23,6)	23,5 (32,5)	64,9 (154)	65 (84)	75,7 (49,5)
Vitamin D (µg)	5	2,0 (3,2)	1,47 (1,47)	3,6 (2,7)	2,8 (2,3)	1,6 (3,2)	1,45 (1,95)	2,8 (1,7)	2,3 (1,9)
Vitamin E (mg)	10/8	6,2 (6,6)	9,91 (8,91)	14,7 (7,3)	18,6 (7,1)	2,6 (3,7)	8,2 (6,5)	13,2 (6,6)	13,2 (4,7)
Minerals									
Calcium (mg)	800	424 (234)	513 (412)	499 (263)	819 (357)	319 (237)	631 (1401)	482 (216)	734 (357)
Iron (mg)	10	8,7 (6,8)	14,8 (12,6)	9,5 (4,8)	13,3 (3,5)	5,4 (3,0)	12,8 (7,2)	8,6 (3,8)	11,4 (2,4)
Magnesium (mg)	350/280	253 (122)	423 (314)	260 (109)	341 (108)	181 (75)	376 (234)	235 (85)	290 (69)
Phosphorus (mg)	800	917 (401)	1207 (798)	1030 (458)	1367 (477)	629 (288)	1185 (1271)	915 (327)	1201 (285)
Zinc (mg)	15/12	9,2 (6,6)	10,6 (7,4)	9,3 (4,4)	12,2 (3,1)	6,5 (4,4)	9,8 (6,8)	8,0 (3,1)	10,1 (2,5)
Copper (mg)	-	1,8 (5,4)	1,47 (1,67)	1,5 (0,9)	1,5 (0,5)	0,7 (0,4)	1,28 (1,07)	1,5 (0,9)	1,3

1.5 CAUSES OF MALNUTRITION

The Severity of deficiencies depends on the nutrients and the consequences of malnutrition that may include growth, stunting, anorexia and susceptibility to infections, behavioural changes and learning disabilities. The latter may have lifelong effects and it was found that iodine deficiency and iron deficiency anaemia during infancy can cause mental retardation or inferior psychomotor function in childhood, even after the deficiencies have been corrected. The problems are caused by multifactors and include poverty, ignorance, faulty feeding practices, infections and infestations, food scarcity, consumption of foods of low nutrient density and low bio-availability of food nutrients (Zailah, Taylor, Nan & Johnson, 2000:70-76). There are several factors contributing to malnutrition in the elderly people, namely the inadequate intake, attributed to lack of appetite or difficulty in preparing foods as well as psychological factors, (depression), social factors, (isolation and low income) and physiological factors (reduced sense of smell taste and taste, drug-nutrient interactions and reduction in nutrient absorptions) (Drozdowski & Thomson, 2006:7580). Factors contributing to malnutrition in elderly may be divided into primary and secondary as indicated in the table below.

Table 5: Factors contributing to malnutrition in elderly (2005:2), Fyke, 2002:2 & DoH, 2001:13-14).

Primary: Social and Environmental	**Secondary:** Physical and Mental
Ignorance	Impaired appetite(due to disease or depression)
Poverty	Poor dentition
Social Isolation and loneliness	Reduced absorption
Mental Disturbance	Increased requirements (e.g. disease trauma, surgery, burns, pressure and sores)
Physical disability	Alcohol Intake
Chronic disease states	Drug therapy
Iatrogenic (e.g. low fat diet for gallstones, problem if patient is underweight)	

Lean body mass decreases with age, while the proportion of fat increases. Aging may also result in a decreased level of activity, leading to few energy body needs. After the

ages of 50, daily energy needs decrease by ten percent for each decade (Chernoff, 2001:49)

1.5.1 Poverty driven hunger

Poverty may be defined as a lack of income required to satisfy important non-food needs, including clothing, energy and shelter. Throughout the developing world older people experience lack of income to provide in these needs as their key problems. Human poverty could be estimated by constraints on quality of life. Older people are disproportionately likely to be uneducated or illiterate, to face chronic illness and often experience physical remoteness from services. Experiences of poverty in older people may result to social isolation and a sense of powerlessness (HAI, 2002:4). According to HAI, Kenya's older people suffer from social exclusion because they are unwanted and receive no respect from their supportive families and communities (HAI, 2002:6). Inadequate income may result in a limited number of meals consumed and dietary variety, hunting for inexpensive foods and bargains (Holmes, 2005:3). In South Africa it is related to being without a job, inability to pay for food, health care and basic services, disintegration of families, susceptibility, risk of homelessness and despair(IDASA:2008:2). Compared to the past, todays world is a world of abundance. Increased agricultural productivity and improved health in the 20th Century have catalyzed the unprecedented social and economic transformation (WHO/NUT, 2003:1). The problem is that the food is neither produced nor distributed equitably. Hunger is a question of maldistribution and inequity but not lack of food (WHO/NUT, 2003:1).

Malnutrition is a risk factor for disease. A downward spiral, which may end in death, is the result when poverty is added to the picture. Poor people are prone to diseases because they may consume and absorb too little nutritious food. Insufficient food leads to stunted development and premature death. Malnutrition increases vulnerability to diseases. People's inability to plough or purchase nutritious food could result in diseases, poverty and illness which could lead to death. The turning tide of malnutrition indicates that the major entry point to fight malnutrition is better nutrition. Better health could result in stronger immune systems, which could result in reduced illness. Healthy people feel

stronger, can work better and earn more. Slowly poverty and malnutrition will be eradicated (WHO/NUT, 2003:1-2).

1.5.2 Urbanisation and Education

Urbanisation and migration have phased out the traditional family support, resulting in abuse and neglect by family members (HAI, 2002:35). In Southern Africa the elderly are more likely to reside in the rural areas. This observation is the norm in the most, if not all regions of the world, resulting from the migration of young adults to the cities and return of elderly from urban areas (Kinsella, 1997:4). This could result in disruption of family units and family life as the contributing cause of malnutrition. Furthermore, urbanisation could lead to increased demand for available money and there is a possibility of extreme poverty (Vorster *et al*, 1997:26).

In the 1990s educational levels among older South Africans remained fairly low, but should improve as better-educated cohorts reach old age. The census carried out 1991 revealed that more than one-third of the 65and over population had no formal education experience (compared with 12percent of persons aged 25-34), while 18percent had completed less than 7 years of schooling (Kinsella, 1997:4). Lack of education could result in insufficient nutritional knowledge, poor nutritional practices and therefore consumption of inadequate nutrients leading to malnutrition (Voster *et al.*, 1997:26).

1.5.3 Marital status and living arrangements

The gender difference is striking (see figure 5) and women live longer on average than men do and tend to marry men older than themselves. Only 12percent of elderly men were widowed compared to women aged 60 and above. South Africa has a relatively high rate of elderly who were never married or divorced (9percent and 8percent for women and men respectively) (Kinsella, 1997:4-5; Charlton, 2000:2). The patriarchal inheritance laws can lead to widows losing their property including their homes. They also experience lowered social status after losing a husband (HAI, 2002:8).

Lee, Cho, Grodstein, Kawachi, Hu and Colditz (2005) indicated that marital disruption was also strongly linked with loss of weight. Women may skip regular meals after losing

In the mid-1980's and early 1990's participation in the formal labour market fell slightly among men in South Africa. South Africa is an exception among African countries in its formal economic support for older citizens (Kinsella, 1997:5). Women aged 60 and over and men aged 65 and over are eligible for a means–tested general social pension of R 870.00 in the year 2007.

1.5.5 Expenditure

A study in South Africa carried out by Mohatle (1999) showed that older people's pensions were utilised to support their families basic requirements such as food, clothing and school fees for children(refer figure 6). Elderly men spent about 38percent whilst elderly women spent 32percent on school expenses, 30percent was utilised for food by elderly men and 24percent by women, clothing expenses were much less at 12percent for elderly women and 20percent for elderly men. The lesser percentages of expenditure were on other life support facilities such as electricity, church and clubs, transport and funeral benefits (HAI, 2002:15).

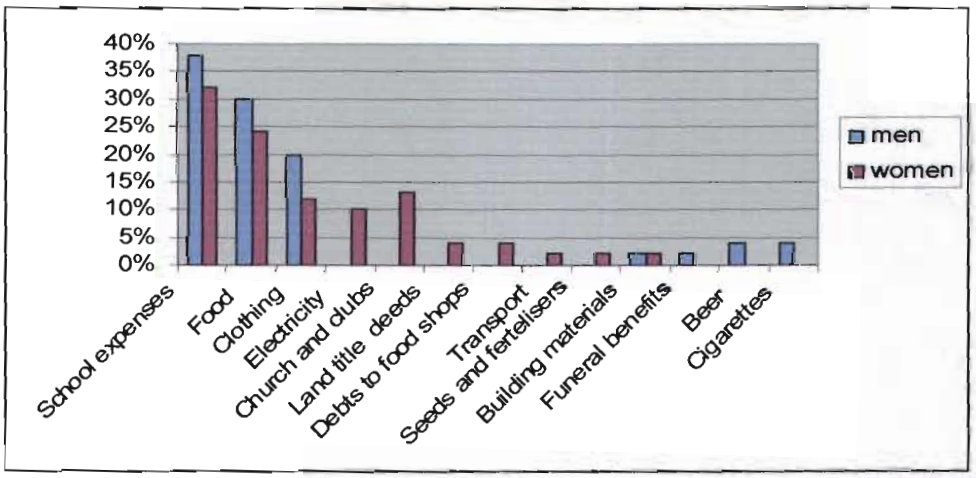

Figure 6 Elderly people's pension expenditure in South Africa (HAI, 2002:15)

1.5.6 Unequal access among household

The inequality of access to food is due to major differences in income or purchasing power among households. The best method to assess the inequality is to look at data on food consumption for households in different income levels. However, there are less data

sets that exist, and those that exist are mostly one-off snapshots rather than data series showing changes over time. In the developing countries there are important data on the distribution of household income and expenditure. In addition, these data are also available in time series of Gini coefficients. The unequal access to food among households is influenced more by the income inequalities and changes in this can serve as an alternative for changes in household access to food (SOFI, 2001:10).

1.6 RATIONAL AND MOTIVATION

To the detriment of already underprivileged groups, micronutrient malnutrition is a major barrier to socio-economic development and contributes to a vicious circle of underdevelopment. It has long-ranging effects on health, learning ability and productivity. High social and public costs, reduced work capacity in populations due to high rates of illness and disability, and tragic loss of human potential may be the results of micronutrient malnutrition. Overcoming micronutrient malnutrition is a precondition for ensuring rapid and appropriate development (FAO, 1997b).

Infectious diseases are some of the factors which lead to micronutrient malnutrition due to inability to access a variety of foods, knowledge of optimal dietary practices and poverty. Micronutrient malnutrition usually occurs when diets lack variety. Whereas short-term interventions have a task in providing specific target groups with vitamin and mineral supplements at certain times, only food-based approaches can prevent micronutrient deficiencies in a sustainable manner for most of the population (FAO, 1997b).

Furthermore, the South Africa's Constitution has established sound nutrition as a guaranteed basic human right through the Bill of Rights. The Department of Health has as one of its obligations, to ensure that nutrition security is respected, protected, facilitated and provided for the people of South Africa. Nutrition security includes food security, health security and care security where security refers to sustainability, having food and good nutrition on an ongoing basis. Therefore, sound nutrition involves more

than just the availability of food or the consumption of a certain amount of nutrients per day (DoH, 2001:11).

An introduction of energy-dense, high protein and nutrient-enriched foods to the diets of the elderly would assist in addressing the nutritional status (over and undernourished) of the elderly people. The high rate of malnutrition among the elderly, as indicated in the literature, (Schlenker, 1993:258) motivated this research. The maintenance of the nutritional status of the elderly improves their well-being, prevents comorbidity, increases their contribution to society and decreases the costs of clinical care (Sibai *et al*, 2003: 216). This study will be undertaken to determine the nutritional status amongst the elderly people in a care centre in Sharpeville, in order to develop a nutrient-dense multimix food product that will address specific micronutrient deficiencies in this elderly community.

1.7 MOTIVATION FOR THIS STUDY

The findings of the South African studies that were carried out in the Western Cape and Free State indicated that in both males and females the dietary reference intakes (DRI's) of vitamin D, calcium, zinc, and vitamin B 6 were below the recommended daily intake levels for the elderly (Charlton, 2001:33).

Due to little research on elderly malnutrition in South Africa, it was deemed necessary to do this study on consumption patterns and nutritional status of the elderly in the care centre in Sharpeville.

The centre for elderly is situated in a township called Sharpeville. It's a centre that was developed by the pensioners and retired elderly people. The centre is run by the board of directors from different stake holders. Low-income elderly take part in activities offered at the centre five days a week and they are also provided with breakfast and lunch. Participation and attendance is voluntary at the care centre in Sharpeville (n=300). The

Vaal University of Technology was invited by the board of directors to evaluate the service rendered by the care centre and this project was undertaken as a result.

1.8 PROJECT OBJECTIVES

The main objective of this study was to develop a cost-effective and nutrient-dense food multimix for elderly people aged ≥ 60 attending the care centre in Sharpeville by using locally grown and cheap and affordable food items in order to address malnutrition problems found, and improve the nutritional and health status of elderly people. The rationale for formulation of FMM product was directly related to the clinical need of particularly vulnerable target groups on the basis of their metabolic requirements and maintenance of good health requirements in ageing.

The specific objectives were to:

- determine the nutritional status of the elderly in the Sharpeville Care of the Aged by using a socio-demographic and health questionnaires, a quantitative food frequency questionnaire (QFFQ), twenty-four hour recall, biochemical and anthropometric measurements;
- develop a novel food item, FMM, to address malnutrition problems found in objective (1); and
- test and analyse the novel food item for acceptability (sensory analysis) and shelf life.

The conceptual framework for this study is represented in Figure 7. Phase one was the baseline survey and the researcher was assisted by Prof Oldewage-Theron. Phase two was the sole responsibility of the researcher.

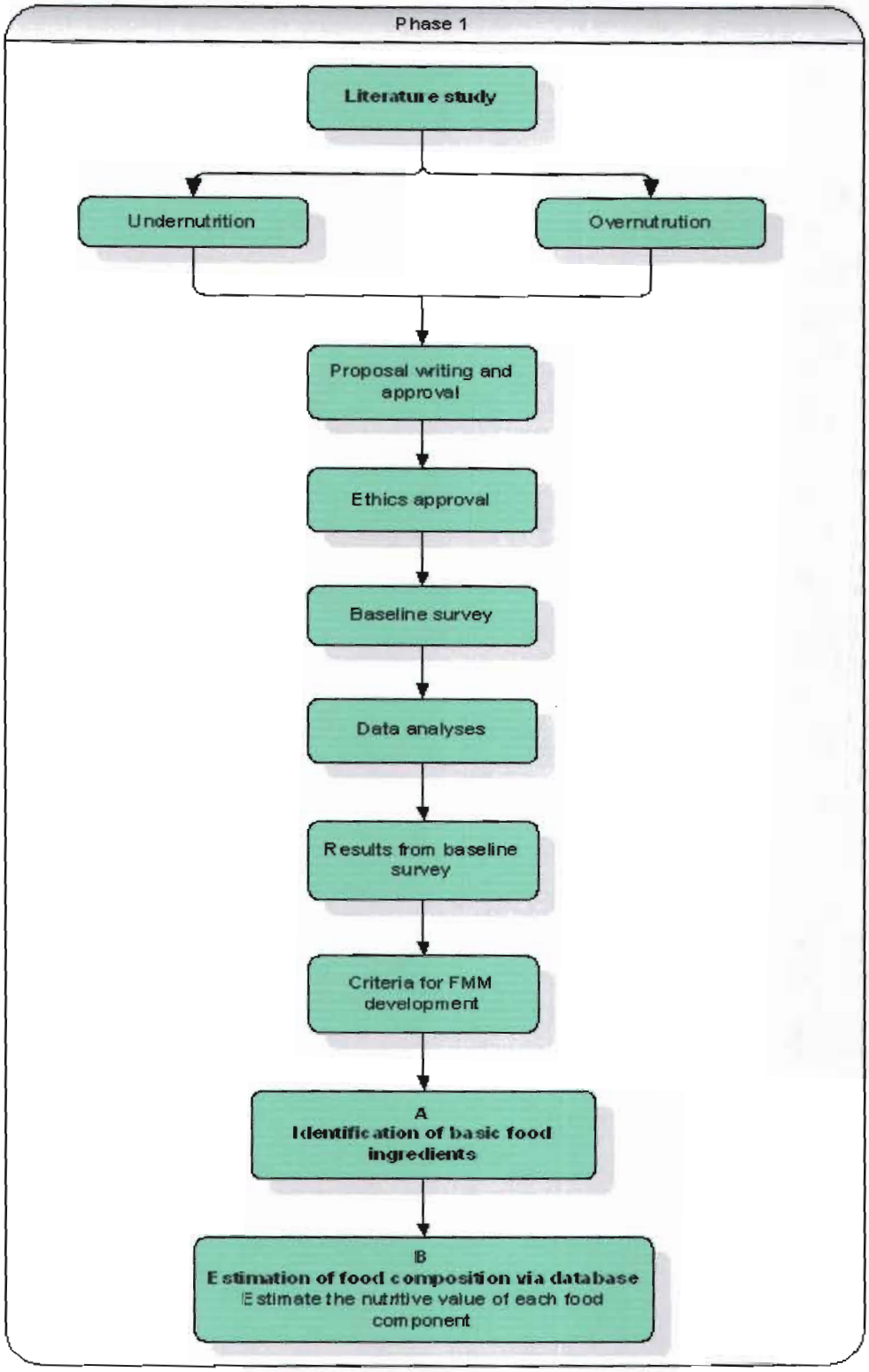

Figure 7 Conceptual Framework of the study

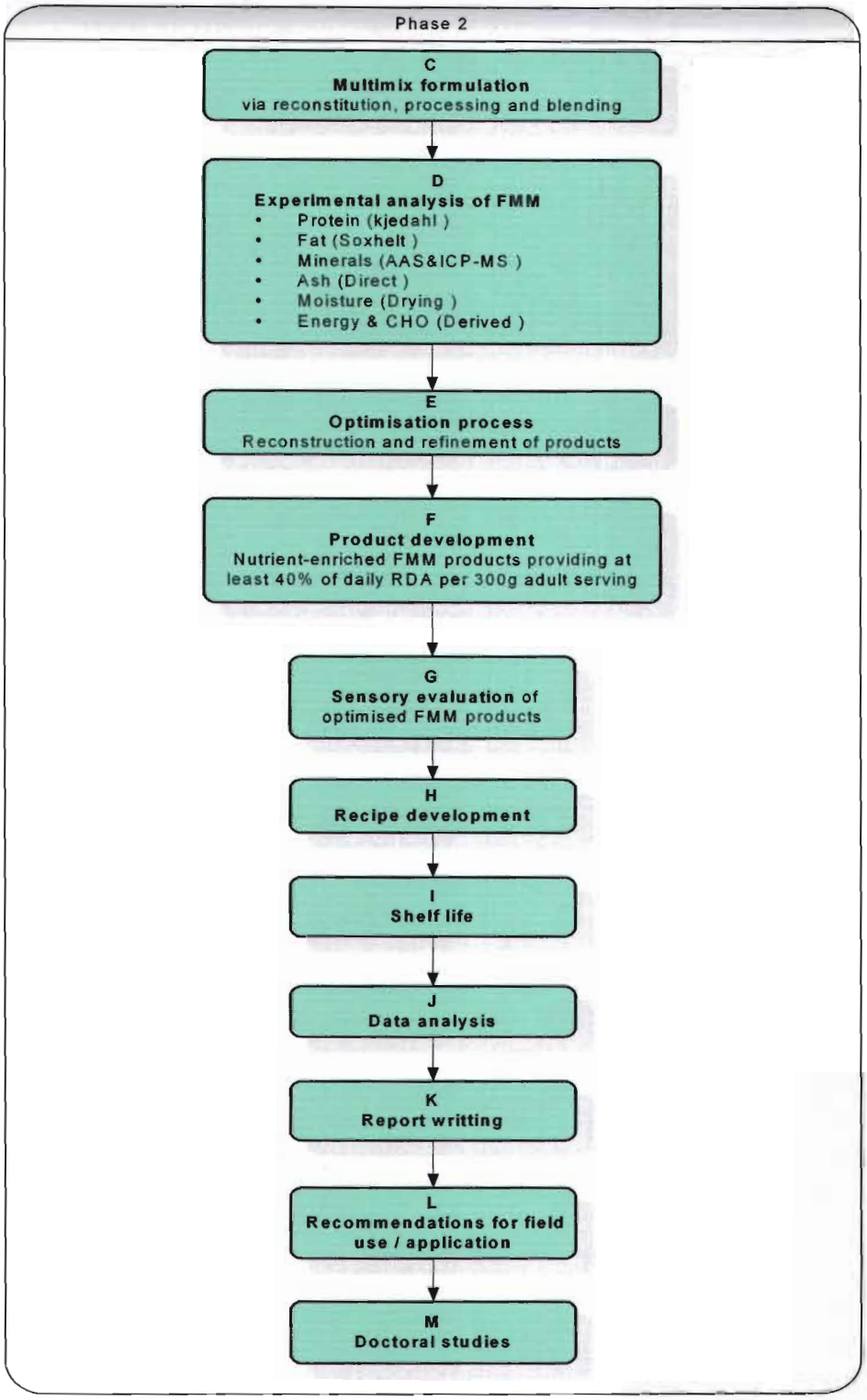

Figure 7: Conceptual framework of the study (continued)

1.9 STRUCTURE OF THE DISSERTATION

The dissertation consists of five chapters. In Chapter One the motivation for this study is discussed. Chapter Two discusses the literarature synthesis that could influence food intake in elderly as well as feeding practises in the care centres, the anthropometric indices and weight-for-height. In Chapter Three malnutrition treatments are discussed. The methodology and methods used in this study are discussed in Chapter Four. In Chapter Five the results are given and discussed. Chapter Six consist of the conclusions and recommendations.

CHAPTER 2: LITERATURE SYNTHESIS ON AGING

2.1 INTRODUCTION

The personality changes linked with aging have been debated almost since the beginning of modern psychology. Aging refers to the time-sequential decline that occurs in most humans including weakness, increased vulnerability to disease and adverse environmental conditions, loss of mobility and agility and age-related physiological changes. An understanding of aging usually includes reductions in reproductive capacity (Goldsmith, 2004:9).

2.2 CONCEPTUALISATION OF AGING

In biology aging is a cumulative change in an organism, organ, tissue or cell resulting in a reduced functional capacity. In humans, aging is linked to degenerative changes in the skin, bones, heart, blood vessels, lungs, nerves and other organs and tissues (The Columbia Encyclopedia, 2005:1; Dhar, 1998:1; Abdulraheem, 2003:1).

Aging has been related to reduction of function and exercise performance. Decreased exercise performance has been associated with decreased oxidative capacity and reduced muscle mass. Vascular changes in structure and function as the result of aging could also contribute to decreased exercise performance through impaired blood flow. Reduced capillary density and a thickening of vascular walls are present with aging (Olive, Devan & Mccully, 2003:1). It is, further, the progressive accumulation of changes with time that are associated with or responsible for the ever-increasing susceptibility to disease and death which accompanies advancing age (Harris, 2004:321).

In humans aging is characterized by a complex phenotype. Aging is a progressive deterioration of physiological function, an intrinsic age-related process of loss of viability and increase in vulnerability (Cutler & Mattson, 2006:221).

In broad terms the definition of aging includes all structural and functional changes that occur throughout the life span from the embryonic development through maturation and senescence (Shlenker, 1996:9; Bozzetti, 2003:114).

Aging is accompanied by numerous functional and phenotypic changes in T cells, B cells and monocytes/macrophages; moreover, increases in autoimmunity, infections and occurrence of cancer have been reported in aged people. Healthy elderly persons, defined according to the criteria of the SENIEUR protocol, show various alterations in immunocompetent cells (Kudlacek, Willvenseder, Statlawetz, Harn, & Pietschmann 2000:1).

The aging process may result in functional sequelae connected to the loss of muscle tissue include insulin resistance, leading to Type 2 diabetes mellitus and impairments in muscle strength, maximal aerobic capacity, resting metabolic rate, immune response and physical function and mobility. The loss of alpha-motor neurons is also associated with aging which contributes to this muscle atrophy. Increased sedentary behaviour, catabolic illness, medication, and undernutrition also play essential roles (Dipietro & Dzuira, 2000:1).

The maturing or aging body and physiological systems function with nutrient requirements quite distinctly from the younger. Decreased nutritional needs among the aging is associated with changes in economic conditions, self-treatment of health conditions or low nutrient intake in adults and aging adults (Watson, 1993:1; Schlenker, 1993:7-9; Azad, 2002:8). This leads to decreased mobility, the need for help during meal times and eating problems as factors related to malnutrition (Christensson, *et al.*, 2001:492). Thomas *et al.* (1991:335) indicated that health professionals working with elderly people needed to be aware of their requirements as older people have total different dietary and health considerations compared to younger people. One nutrient deficiency may result in a different clinical picture from that caused by a combination of multi-nutrient deficiencies (Thomas *et al.*, 1991: 335).

2.3 THE EXTENT OF AGING

Ageing is a victory of times, a product of improved public health, sanitation and development. Many of the world's older people live in poverty. About 270 million people over 60 lived in countries where the average income was less than R12,58 a day in the year 2000. Older people live on a third to a half of average incomes. Over a quarter of a billion older people are currently living on much less than a dollar a day. Even in the poorest countries, life expectancy is increasing and the number of older people is rising. By 2050, over a billion people over 60 – more than half of the world's older people - will live in what are now Low Income Countries where the average income is less than R13.00 a day. According to (HAI, 2002:21), in the year 2000, there were 374 million people over 60 in developing countries (62 percent of the world's older people). Therefore, in just eight years there will be 493 million older people in developing countries (65 percent of the world's older people). In 2050, there will be over a billion older people in developing countries forming three quarters of the entire world's older people. In comparison, the number of older people in industrialised countries will increase from 218 million in 1996 to 362 million in 2030, a 65 percent increase over the period compared with a 200 percent increase in developing countries (HAI, 2002:21). By 2020, the number of the population aged 60 and over is anticipated to reach 23percent in North America, 17percent in East Asia, 12percent in Latin America, 10percent in South Asia and 25percent of Europe (Karst, 2003:1).

2.4 FACTORS AFFECTING AGING PROCESS

There are two types of factors that affect the aging process namely the intrinsic factors and extrinsic factors. The intrinsic factors involve the life span of an individual, the genetic material combined at the moment of fertilization along with environmental influences and determines the rate of aging and ultimate life span (Schlenker, 1993:10; De Malgahaes, 2005:2). Extrinsic factors include environmental factors that can change the genetic programme in humans and animals. Chronic exposure to sunlight accelerates the rate of change in skin collagen that leads to skin wrinkling. The greatest potential for

positive alteration of genetic programmes is through qualitative and quantitative nutrient intake (Schlenker, 1993:10).

It's no secret that bodies changes due to age. Some changes are obvious, while others are more subtle. Numerous people age comfortably and remain active, alert and vibrant throughout their lives and their physiologic age may be younger than their chronological age. However, others may experience the effects of osteoporosis and osteoarthritis, which can slowly reduce their abilities to participate fully in activities (Hocking, 2005:42; De Malgahaes, 2005:2).

2.4.1 Aging body composition changes

The first metabolic response to ageing is decreased metabolic rate where the body initially breaks down adipose tissue and is unable to supply energy. Later the visceral organs and muscle also are broken down and a decrease in weight is experienced. Organ weight loss is the greatest in the liver and intestine, intermediate in the heart and kidneys, and smallest in the nervous system (The Merck Manuals, 2005).

Approximately 2percent to 3percent loss of lean body mass per decade indicates the aging process. Age related loss of skeletal muscle resulting in less muscle strength, changes in gait, balance and increased risk for chronic diseases may indicate sarcopenia. Energy requirement changes due to the individual decrease of lean muscle, increased body fat and less active life style. In elderly people over the age of 75 physical activity levels often become drastically low (Harris, 2004:323; Bozzetti, 2003:115).

Decreased body metabolic rate may lead to obesity and an increase in "bad" cholesterol levels (AAOS, 2000:2).

In older adults the senses of taste, touch, smell, sight and hearing diminish at individual's rate (AAOS, 2000:2). Sensory loss may affect appetite, particularly in the taste buds that affects perception of salty and sweet tastes. More than 70percent of the elderly suffer from xerostomia (Richards, 2006:2).

The muscle may begin to shrink and lose muscle mass. It happens naturally and it can be accelerated by a sedentary lifestyle. The water content of tendons, the cord-like tissues that attach muscles to bones, decreases as one ages. This may result to the stiff tissues and decreased ability to tolerate stress. It becomes more difficult to accomplish routine activities such as opening a jar or turning a key due to decreased strength on handgrip. The heart muscle becomes less able to pump large quantities of blood quickly to the body (AAOS, 2000:2). Only 15percent of body weight remains as muscle by the age of 75. Most of the muscle weight is replaced by fat. The muscle fibres also decrease number and size. Thus, it takes muscles longer to respond when 50 years compared to 20 years olds (AAOS, 2000:2). The endurance activities of the elderly are maintained. In 1989 Rosenberg coined the word *sarcopenia* from the Greek word that means "poverty of flesh". The poverty of flesh refers to decrease in muscle mass and strength that may occur with healthy ageing and is thought to be a process and the outcome (Thomas, 2005:132). These could result decrease in anabolic hormones, physical activity, impaired oral intake and changes in cytokine system (Visvanathan, 2003:4). The causes of sarcopenia include:

- Inactivity.
- Decreased protein synthesis.
- Neural, hormonal, and nutritional factors (Hocking, 2005:56).

The weakening of fat-free mass is generally due to lowered muscle mass named sarcopenia, which is a main cause of frailty, disability and loss of independence in the elderly. An essential characteristic of sarcopenia is that it seems to affect primarily type II muscle fibres, the anaerobic (white) ones that are responsible for strength-requiring actions such as rising from a chair, whereas type I oxidative (red) fibres are spared in normal elderly subjects. Involuntary loss of skeletal mass is observed even in generally healthy people in the absence of weight loss or in the presence of obesity and weight loss exacerbates sarcopenia (Bozzetti, 2003:115).

The aging cardiovascular system may lead to lipid accumulation, myoclonal muscle thickening, thrombogenesis and inflammation (Hocking, 2005:55). Major causes of

death and disability among both ageing women and men are caused by coronary heart disease and stroke. Cardiovascular diseases account for close to 60percent of all adult female deaths in a typical high-income country and are also the major cause of death among women aged 50 and above in low-income countries. Typically women are ten years older than men when symptoms of heart disease are experienced and they may be up to 20 years older before the first heart attack is experienced. Heart disease and stroke are, however, still commonly considered men's health problems (WHO, 2002:8).

2.4.2 Nervous system

Normal aging of the nervous system consists of a selective neuronal loss accompanied by gliosis. There are specific changes in energy metabolism in mitochondria where lipofuscin accumulates in mitochondria in the brain and in many other cells which do not divide rapidly (Hocking, 2005:42).

Testosterone has essential anabolic effects on muscle and thus increasing age in men causes the circulating androgen concentrations to decline. There is high evidence that this may contribute to development of sarcopenia and decrease in functional status that may occur with ageing (Visvanathan, 2003:5).

2.4.3 Aging bones

All through life, bones gradually change through a process of absorption and formation called "remodeling''. The balance between bone absorption and bone formation changes due to aging, resulting in a loss of bone tissue. Decreased mineral content of bones may be experienced and the bones become fragile and less dense. Osteoporosis develops as a result of loss of bone mass and affects both women and men. Osteoporosis can lead to crush fractures of the vertebrae, resulting in a "dowager's hump in the spine. Older men and women may suffer from hip fractures as a result of osteoporosis. The chemistry of cartilage changes shows less water content and cartilage becomes more susceptible to stress. Degeneration of cartilage and arthritis can develop. Ligaments, the connective tissues between bones become less elastic, reducing flexibility (AAOS, 2000:2). The movement of joints becomes more restricted and flexibility decreases with age resulting

from changes in the tendons and ligaments. The breakdown of the cushioning cartilage may lead to inflamed and arthritic joints (AAOS, 2000:2; Center for Aging, 2003:1).

2.4.4 The endocrine system

The endocrine system is responsible for the production of hormones and directly effects most cell activity in the body. Hormones that weaken with age include insulin, growth hormones, thyroid hormones, DHEA, melatonin, testosterone, estrogen, androgens and aldosterone. This may lead to the need for hormone replacement as well as dietary changes that can help this decrease (Center for Aging, 2003:1).

2.4.5 The immune system

The thymus gland functions in T-cells and shrinks as aging continues and the implications can be severe. When the immune system begins to detoriate diseases such as lupus, rheumatoid arthritis and multiple sclerosis can occur. The ultimate weakening of the body becomes a tremendous burden for the immune system to bear (Center for Aging, 2003:1; WHO, 2002:27). The dysregulation of immune function with ageing is well recognized. It can contribute to higher occurrence of increased morbidity and mortality from cancer and infectious autoimmune and neoplastic diseases (WHO, 2002:27).

2.4.6 The skin and hair

In the elderly wrinkles and dryness of skin is caused by exposure to the sun and from free radicals. This results in a loss in collagen and an increase of elastin. Elderly people perspire less as a result of sweat glands that may also become damaged over time. Less sensitivity to pain and the fact that wounds take longer to heal may be the effect of loss of nerve cells in an elderly person (Center for Aging, 2003:1; Haines, 2005:1; Shuman, 2006:1).

Aging may also cause rougher skin and the development of lesions that could become tumors. The skin may become transparent caused by thinning of the epidermis and the skin becomes more fragile and easily bruised. Most body hair decreases with age.

However, many experience unwanted hair growth such as in the nostrils, ears and thickening eyebrows. Hair also loses its natural colour, turning grey or white (Haines, 2005:1; Shuman, 2006:1).

The gravity, facial movement and sleep position are the secondary factors that contribute to changes in the skin. The drooping of the eyebrows and eyelids, looseness and fullness under the cheeks and jaw are caused by gravity when skin losses its elasticity. The smoking elderly tend to have more wrinkles than nonsmokers of the same age, complexion, and history of sun exposure (Haines, 2005:2; Shuman, 2006:2.)

2.4.7 Urinary system

The kidney function is to filter, remove waste and maintain of proper blood composition. Even though kidney function declines with age, it does not have major problems unless it is severely restricted in the amount of blood it receives because of heart problems (Harris, 2004:323). Further complications involving kidney functions can result from dehydration, hemorrhage, cardiac failure and systematic infection, improper use of diuretics or toxic antibiotics (Harris, 2004:323).

2.4.8 Digestive system

The digestive system includes the mouth, esophagus, stomach, intestines and rectum. Nutrition affects the digestive system, as seniors often do not eat properly because of periodontal disease, have no teeth or dentures, or have bad dentures which make it hard to chew. The significant chemosensory loss and decreased ability to identify odours and tastes is associated with aging (Bozzetti, 2003:116). Xerostomia or the dryness of the mouth is a common problem amongst the elderly people. Seventy percent of elderly people suffer from xerostomia and this automatically affects the nutrient intake. Elderly people affected by xerostomia tend to have difficulty in swallowing and chewing, this may lead to omission of crunchy, dry and sticky foods. Loss of teeth in the elderly could result from untreated dental caries, which may lead to reduced eating of meat, fresh fruit and vegetables (Schlenker, 1993:80).

Taste buds sensitivity decreases with age, particularly in men. The first tastes to decline are sweet and salty and more slowly bitter and sour, resulting in nutritional alteration. Loss of appetite may result from changes in taste, which could result in nutritional deficiencies (Harris, 2004:323).

- **Gastro intestinal tract**

Elderly people are often incapable of adjusting their food consumption following the periods of over or underfeeding. Elderly people compensate less precisely for oral preloads and develop early satiation, making it difficult for them to swallow large amounts of energy at any single meal (Morley, 1998:587). Early satiation is associated with the rate of gastric emptying and is the result of the fundus inability to undergo suitable adaptive relaxation in response to food arriving in the stomach. The lowered fundus relaxation may lead to more rapid filling of the antrum (Morley, 1998:587, Hajjar, Kamel & Denson, 2004:5).

Gastric mortality may be impaired with aging but the small intestine is unaffected. The signal transduction pathways and cellular mechanisms controlling smooth muscle contraction may be affected by aging. This may influence the colonic motility and thereby contribute to the development of constipation (Drozdowski *et al.*, 2006:7580).

- **Stomach disturbances**

The essential regulators of satiety are gastrointestinal sensory and motor function and these are mediated by vagal mechanisms from mechanoreceptors that are situated in the wall of the stomach. The increased sensations of fullness are related to distention of the distal stomach (antrum) and are likely to be more essential than the proximal stomach (fundus). The impairment of the relaxation of the gastric fundus with ageing may result in rapid antral filling, distention and earlier satiety (Visvanathan, 2003:3-4).

Satiation in the elderly people has been associated with a decline in the gastric emptying of large meals. Elderly people experience early satiety which makes it difficult for the elderly to ingest large amounts of energy at any single meal. There is a lowered adaptive

relaxation of the fundus of the stomach resulting in more antral filling due to this early satiety (Hajjar *et al.*, 2004:5, Morley, 1998: 587). Decreased appetite, food intake and prolonging antral distenstion may be as a result of slow gastric emptying and could have a prolonging effect of small intestinal satiety signals (Visvanathan, 2003: 4).

Cholecytokinin (CCK) is a small intestinal hormone in response to fat and protein in the gut. It causes the secretion of bile into the duodenum and pancreatic secretions. The satiating effects of CCK increase with age and healthy elderly people have high plasma CCK concentrations (Visvanathan, 2003: 4).

The nutritional alterations observed in the elderly digestive system might explain the anatomic and functional changes in the gastrointestinal system. The most common changes are decreased sensitivity to sweet, sour, salty and bitter compounds as well as amino acids. Alterations in taste may be exacerbated in elderly subjects resulting from the intake of medication. The most frequent anatomic and functional alterations in gastrointestinal apparatus are summarized in Table 6 below (Bozzetti, 2003:115).

Table 6: The pathological and functional alteration of the GI tract during aging (Bozzetti, 2003:115)

	Pathology	**Functional consequence**
Stomach	Atrophic gastritis Slow emptying time	Hypochlorhydria, bacterial overgrowth, Vitamin B12 deficiency; iron deficiency Early satiety and hypoorexia
Pancreas	Atrophy/fibrosis	Decline in cell function, decline in exocrine secretion and possible steatorrhea
Colon	Motor dysfunction	Delayed colonic transit

2.4.9 Respiratory system

After age 20 there is a decrease in the alveoli surfaces of 3 square foot/year. There is a decline in blood flow which results in less exchange of oxygen and carbon dioxide in the lungs as one grows older. It becomes difficult to cough with 40percent less air moving in

and out of the lungs and one is more susceptible to bronchial infections and pneumonia. Major disease is chronic obstructive pulmonary disease (COPD) which includes chronic bronchitis, emphysema and asthma. COPD is the fourth leading cause of death for elderly. Other acute respiratory disorders would be tuberculosis, flu and pneumonia (Center for Aging, 2003:1).

2.4.10 Factors that are additional to aging

There are several factors that are additional to aging with different consequences and may affect the nutritional status of the elderly. Factors contributing to poor food intake in the elderly are shown in the table below (Barasi, 2003:220).

Table 7: Factors contributing to poor food intake (Barasi, 2003:220)

Physical /Medical Factors	Social Factors	Psychological factors
Mobility	Money available	Depression
Selection of foods bought	Food storage/preparation facilities	Bereavement
Food preparation	Education /knowledge of nutrition	Mental illness
Dentition	Social isolation	Alcoholism
Appetite		
Disease		
Drugs		

- **Poor Appetite**

Changes that occur in the physiological regulations of appetite and satiety may result to anorexia which is a physiological response to aging. In elderly people appetite regulation is affected by illness, drugs, dementia and mood disorders (Thomas, 2005:131; Hajjar *et al.*, 2004:5 & FAO, 2004a)

The physiological decrease in appetite and food intake that accompanies normal aging and which may result in desirable weight loss is described as anorexia of ageing. In the study carried by SENECA (Survey in Europe on Nutrition and the Elderly, a Concerted Action) over the period 4 years as the follow up, the findings were the average energy intake in men decreased by 0,6MJ/day and 0,4MJ/day in women (Visvanathan, 2003:2).

In the same study, over the period of 10 years findings were that 23percent of men and 27percent of women had lost 5kg of their first body weight. In the other follow up over the period of 4 years, there was another weight loss of more than 5kg. Therefore, the evidence was strong enough that older people were at increased risk of reduced energy and nutrient intake (Visvanathan, 2003:2).

The major cause of malnutrition is probably poor appetite or anorexia and is mediated by various factors. The energy intake decreases with age and micronutrient deficiencies are more likely to occur with lowered energy intake (Charlton, 2002:s608, Thomas, 2005:131; Hickson, 2006:4). Older people indicate multiple changes in taste sensation. Gustatory papillae atrophy has been confirmed to take place in humans from middle age onward (Hajjar *et al.*, 2004:5).

There are various peptide hormones released by the gut that includes: gherlin, CCK, glucagon-like peptide1 and pancreatic polypeptide that play a role in regulating appetite. Cytokines are also thought to be involved in the regulation of appetite (Hickson, 2006:4).The ghrelin, an endogenous ligand for the growth hormone secretgogoue receptor, has been found to release more growth hormone and is found in a human stomach. Ghrelin has been found to modulate the energy balance via the influence on glucose metabolism and insulin secretion. It also regulates the gastric motality and acid secretion though the vagal mediation (Muccioli, Tschöp, Papotti, Deghenghi, Heiman & Ghigo, 2002:236; Arvat, Maccario, di Vito Broglio, Benso, Gottero, Papotti, Mucciolli, Dieguez, Casanueva, Deghenghi, Camanni, Ghigo, 2001: 1169; Takaya, Riyasu, Kanamoto, Iwakura, Yoshimoto, Mori, Komatsu, Usui, Shimatsu, Ogawa, Hosoda, Akamuzi, Kojima, Kangawa, & Nako, 2000:4909). Decreased levels of Ghrelin with ageing would lead to weight loss and undernourishment (Visvanathan, 2003:3).

Appetite, food and fluid intake could be increased when the endogenous epioids are acting directly on structures such as hypothalamus and nucleus accumbens. The oestrogen deficiency that occurs in post–menopausal years may result in feeding by the endogenous opioids (Visvanathan, 2003:3).

- **Oral health and dental status**

Problems of chewing may be present due to loss of teeth, poorly fitting dentures and atrophy of oral muscles (Litchford, 2004:2). Oral health and dentition have indicated a significant effect on food consumption. Elderly people using dentures have greater difficulty with eating a variety of foods, more chewing problems are experienced and the dryness of the mouth more common. Elderly people are likely to prefer textures that make it easy to chew and swallow (Hickson, 2006:5 & Popper *et al.*, 2003:35). Lack of interest in consumption may be due to factors such as changes in dentition and can result in painful teeth and gums or chewing muscles and painful sensitivity to hot and cold foods (Litchford, 2004:2).

- **Dyphagia**

Amongst the elderly people swallowing dysfunction is a common problem and may be due to the increased prevalence with age of neurological conditions (Sitoh, Lee, Phua, Lieu, & Chan, 2000:376). There are three basic types of dyphagia i.e. the oral, pharyngeal and the esophageal. Oral dyphagia is the result of weak tongue and lip muscles, which makes it difficult to propel food in throat and initiate swallowing by the elderly. Pharyngeal dyphagia is due to delayed swallowing reflex, the swallow does not clear the bolus from the throat. Aspiration may occur when the food go through the larynx. The structural blockages, stenosis, may result from esophageal dysphagia and strictures may result from esophageal dysmotility (Litchford, 2004:2). Therefore, swallowing is a complex motor reflex requiring harmonization among the neurologic system, the oropharynx and the esophagus. Dysphagia when untreated can result in dehydration, malnutrition, respiratory infections and death (Wilkins, Gillies, Thomas, & Wagner, 2007:144).

- **Changes in muscle**

The central development of sarcopenia is thought to be the qualitative and quantitative changes in the muscle. Lowered muscle mass, muscle strength and muscle efficiency may be seen with increasing age. The increasing age may also affect the muscle fibres,

decrease in total muscle fitness, low muscle protein synthesis and decreased functional units (Visvanathan, 2003:5).

Cytokines are thought to be the essential mediator of enhancing anorexia and muscle mass loss as well as decreasing albumin levels when disease develops in older people. Ageing is a form of stress and is associated with elevated levels of cortisol, catecholamine manufacturing and decreased sex and growth hormones (Visvanathan, 2003:4; Thomas, 2005:132). Cytokines may play an essential role in the formulation of sarcopenia. An increased risk of developing mobility disability and impairment of activities of daily living in an older woman may be the result of higher IL-6 levels (Visvanathan, 2003:5).

- **Physical Activity**

Decreased physical activity in elderly people may lead to less strength and lean mass and decreased mortality rate than in active elderly individuals. Less use of muscles may cause a large decline in muscle size and strength, even with adequate protein and energy intake (Visvanathan, 2003:5).

- **Nutrition**

Sarcopenia may be developed due to impaired nutritional intake. A study carried by Castaneda and colleagues as cited by Visvanathan (2003:5) has shown that consuming half the recommended daily allowance (RDA) of protein 0,8g/kg/d causes significant decrease in strength and body cell mass in post-menopausal females (Visvanathan 2003:5).

- **Fat Stores**

The leptin that is produced predominantly in the adipose tissues and circulates in amounts directly related to the size of fat, stores is thought to play a role decreasing the food intake. The reduced food intake in post-menopausal women has been associated with increased levels of leptin. The rise in serum leptin is seen with ageing, but it is being

destroyed by fat mass adjustment in women. In ageing men it is not destroyed by the adjustment of fat mass and may be mediated by the fall in testorone concentrations (Visvanathan, 2003:4).

2.5 Nutritional Requirements

Every elderly person has a unique nutritional requirement, thus dietary recommendations should be individualised. The DRI's are established to optimise the health of individuals and groups in order to provide a guideline for assessing intake and estimating needs (Harris, 2004:326). Nutrient needs of the elderly are distinctive and complex. Deteriorating lean body mass and decreased physical activity levels reduce energy needs. Meanwhile, the requirements for certain nutrients are higher than for younger adults (Van Grenvenhof & Funderburg, 2003:1).

The rising number of elderly people above 65 years of age is very diverse with regard to sickness and health. The nutritional requirements and food consumption also varies. Anorexia of aging results in nutritional deficiencies and is a common syndrome in the elderly people and may be either caused by or result in loss of functions and accelerated aging (Van Staveren & De Groot, 2003:1). Inadequate nutritional status is a common problem in the elderly, related to aging and diseases, but also environmental factors in this growing part of the population. Factors such as loneliness play a major role (Ferry, 2005:1).

2.5.1 Macronutrients

Macronutrients are generally defined as those food mechanisms which are present in quantities of one gram or more in the daily diet and which provide energy. Therefore, they include protein, fat, carbohydrates, and most dietary fibres and alcohol. Water is also considered a macronutrient although unable to provide energy (FAO, 1996).

2.5.1.1 Energy

Energy requirements for elderly people are generally reduced resulting in body composition changes, lowered metabolic rate and reduced physical activity. An

assessment of energy needs can be determined on actual or desired body weight basal energy expenditure, resting energy expenditure or total body weight. Although energy requirements of elderly people decrease, most needs for protein, vitamins and minerals remains the same or more. Therefore meeting the nutritional requirements may be difficult. Dietary Reference Intakes (DRIs) and Estimated Energy Requirement (EER) for energy by active individuals is 12 881kJ/day for older men and 6 720kJ/day for women (IOM, 2005:108). While energy intake in young men and women of 11 340 and 6 720kJ respectively, declined to 7 560and 5 460kJ over the age of 65 years in NHANES III (Bozzetti, 2003:116). Deficiencies may arise when the intakes are below 6 300kJ/day leading to supplementation (Bozzetti, 2003:116; Harris, 2004:326). About 1,4-1,8 multiples of the basal metabolic rate (BMR) are required to maintain body weight at different levels of physical activity (WHO, 2002:9).

The Baltimore Longitudinal Aging Study has indicated that there is a decrease in the mean kilojoules intake from11, 340 kJ per day at 20–30 years to about 8 820 kJ per day at 75–79 years, which results from reduced basal metabolic rate by one-third, and through decreased physical activity as regards the remaining 1680 kJ (Bozzetti, 2003:116).

2.5 1.2 Protein

The rate of protein yield and synthesis is moderately reduced on a weight basis, but protein synthesis and degradation increase when expressed in units of body cell mass. The RDA for protein of 0,8 g/kg per day assumes consumption of mostly first class protein and an energy intake of 168 kJ/kg per day. Protein intakes of 0,9–1,1 g/kg per day are beneficial for healthy older persons and 1–1,5 g/kg per day to meet the needs of ill health (WHO, 2002:10; Bozzetti, 2003:116). The recommended intake of amino acids in normal conditions should be at least 1–1,2g/kg per day (Bozzetti, 2003:116). The food sources of animal protein are meat, milk, and plant protein bread and cereals (Barasi, 2003:61). Older people experience a loss in skeletal tissue mass and protein stores in the skeletal muscle may be insufficient to meet requirements for protein synthesis, making dietary protein intake more essential (WHO, 2002:10). Protein energy malnutrition

(PEM) may be experienced by elderly who consume inadequate protein and minerals (Harris, 2004:327).

2.5.1.3 Water

There are three standards of fluid intake that have been documented for the elderly. Firstly, corresponding to a fluid intake of 30 ml/kg body weight for elderly >65 years and secondly, corresponding to 1 ml/kJ energy consumed and thirdly, to 100 ml/kg for the first 10 kg, 50 ml for the next 10 kg and 15 ml for the remaining kilograms. In a population of institutionalised elderly residents the intake of fluid was adequate by the 30 ml/kg body weight standard, but it resulted to be low for underweight residents. On the contrary, the second formula was resulted more than adequate, and the third standard was found inadequate (FAO, 2004:4).

2.5.1.4 Carbohydrates

The recommended daily intake of carbohydrates is 130 g/day (IOM, 2005:265). Large quantities of carbohydrates are required to protect proteins from being utilised as the energy source. Approximately 45percent to 65percent of the total daily calories comes from the carbohydrates and is currently recommended by dietary guidelines. Increased consumption of complex carbohydrates, essential vitamins and minerals must be emphasised (Harris, 2004:327; Lin, 1999:36).

2.5.1.5 Lipids

The recommended total lipid caloric intake must not be more than 25percent to 35percent. The intake of saturated fat must be reduced or used in moderation and by choosing more monounsaturated or polyunsaturated fat (Harris, 2004:327; WHO, 2002:9).

There is a significant increase in fat percentage for female volunteers between the ages of 20-50 years and a continuous increase for males. Two recent investigations using bioelectrical impedance methodology have shown that fat mass index rose by an average of 55percent in males and 62percent in females from young to elderly age categories and

total body fat increased till approximately 60 years of age after which it decreased (Bozzetti, 2003:115)

2.5.2 Micro-nutrients

Micronutrients, both vitamins and minerals play an essential role in the growth and health of the human beings (Spear, 2004: 290).

2.5.2.1 Vitamin A

Vitamin A (retinol) is an important nutrient required in minute amounts by humans for the normal functioning of the visual system, growth and development. It is also responsible for the maintenance of epithelial cellular integrity, immune function and reproduction (WHO, 2004:17; Chernoff, 2005:1241s). The functions of Vitamin A are at two levels in the body namely in the visual cycle in the retina of the eye and in all body tissues where it systemically maintains the growth and soundness of cells (WHO, 2004:19). There is no indication that the vitamin A requirements of healthy elderly individuals differ from those of other adults. It should be remembered, however, that diseases that impede vitamin A absorption, storage and transport might be more common in the elderly than in other age groups (WHO, 2004:34).

Recommendations for Vitamin A have been lowered for older adults from previous editions of the RDAs. The present suggested levels are 700μg/day for women and 900μg/day for men (IOM, 2006:61). A number of researchers have suggested that these recommendations be set at even lower levels even though the vitamin A intake for many older adults is below current recommendations and vitamin A levels remain normal (Chernoff, 2005:1242s). The dietary requirements for vitamin A are usually provided for as preformed retinol (mainly as retinyl ester) and provitamin A carotenoids (WHO, 2004:17). According to WHO (2004) Vitamin A Deficiency (VAD) is when tissue concentrations of vitamin A decrease enough to have undesirable health consequences even in the absentia of clinical xerophthalmia. VAD is more prevalent among the children, pregnant and lactating women (WHO, 2004:21).

High vitamin A consumption may lead to higher risk for fractures and over long periods of time may create serious bone health problems since the Vitamin A is a vitamin D and calcium antagonist. It has been recommended that dietary vitamin A be obtained from high intake of carotenoids, including ß-carotene, lycopene, zeaxanthine, and lutein (Chernoff, 2005:1242s).

Vitamin A is found naturally in animal products such as human milk, glandular meats, liver and fish liver oils (especially), egg yolk, whole milk and other dairy products. Preformed vitamin A is also utilised to fortify processed foods, which may comprise sugar, cereals, condiments, fats and oils (WHO, 2004:27). Provitamin A carotenoids are found in green leafy vegetables (e.g. spinach, amaranth, and young leaves from various sources), yellow vegetables (e.g. pumpkins, squash and carrots), and yellow and orange non-citrus fruits (Gallagher, 2004:81; WHO, 2004:27).

The cheapest way to meet vitamin A requirements in older adults is by eating a diet rich in fruits and vegetables as well as providing a good source of dietary fibre (Chernoff, 2005:1242s).

2.5.2.2 Thiamin (Vitamin B_1)

Thiamin as part of carboxylase helps in removal of carbon dioxide from alpha-keto acid during oxidation of carbohydrates. It is essential for growth, normal appetite, digestion and healthy nerves (Anderson, 2004:144). Thiamine deficiency has been classically considered to exist in dry (paralytic) and wet forms and results in the disease called beriberi. Nursing mothers that are thiamine deficient with breast fed infants may have beriberi may occur. It also occurs in adults with high carbohydrate consumption (mainly from milled rice) and with intakes of anti-thiamine factors such as the bacterial thiaminases that are in certain ingested raw fish (WHO, 2004:165-166).

The physiological concentrations of thiamin are absorbed by an energy-requiring carrier-mediated process. In older people there is little verification that thiamin absorption is impaired unless related to the use of alcohol. The RDA thiamin for males is 1,2 mg/day and for females is 1,1 mg/day (Lin, 1999:38, Anderson, 2004:144 & IOM, 2006:35). The

vitamin B1 food sources are pork, organ meats, whole grains, and legumes (WHO, 2004:186; Anderson, 2004:144).

2.5.2.3 Riboflavin

Riboflavin is important for the metabolism of carbohydrates, amino acids and lipids and supports antioxidant protection. It functions as a co-enzyme for (Gallegher, 2004:94).

Riboflavin (vitamin B_2) deficiency may experienced in conditions of hypo-oral riboflavinosis with sore throat, oedema of the pharyngeal and oral mucous membranes, cheilosis, angular stomatitis, glossitis, seborrheic dermatitis and normochromic, normocytic anaemia associated with pure red cell cytoplasia of the bone marrow. Riboflavin deficiency occurs in combination with a deficiency of other B-complex vitamins. The main source of hyporiboflavinosis is insufficient dietary intake as a result of limited food supply, which sometimes is exacerbated by poor food storage or processing (WHO,2004:169). The RDA for the 19–70 age range is 1,3 mg/day for men and 1,1 mg/day for women. There is no evidence that older people have diminished riboflavin needs (WHO, 2002:58; Gallagher, 2004:97, IOM, 2006:37). The dietary sources of vitamin B_2 are milk and dairy products, meats and green vegetables (WHO, 2004:186; Anderson, 2004:144). About 20percent to 27percent of older people in America and European countries who are commonly suffering from riboflavin deficiency do not meet the RDA. There are even more frequent low intakes of riboflavin in developing countries where dairy products are not commonly consumed (Lin, 1999:39).

2.5.2.4 Niacin

Niacin, the collective term for nicotinic acid and nicotinamide is an element of the coenzymes nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP) (Lin, 1999:40; WHO, 2004:173; Gallagher, 2004:98). Initial symptoms of niacin deficiency include muscular weakness, anorexia, indigestion and skin eruptions (Gallagher, 2004:99). Severe niacin (nicotinic acid) deficiency characteristically results in pellagra, which is a chronic wasting disease linked with a characteristic erythematous dermatitis that is bilateral and symmetrical, a dementia after

mental changes including insomnia and apathy preceding an evident encephalopathy, and diarrhoea resulting from swelling of the intestinal mucous surfaces (WHO, 2002:58; Gallagher, 2004:99-100). The food sources of niacin nicotinic acid are liver, lean meats, poultry, fish, grains, legumes and can be formed as nicotinamide from tryptophan (WHO, 2004:186; Gallagher, 2004:99). The requirements for niacin are expressed as niacin equivalents (NE), while the amino acid tryptophan can be converted to niacin. The RDA for niacin is the same as for young adults, 16 mg NE/day for males and 14 mg NE/ day for females (Lin, 1999:40; Gallagher, 2004:99; IOM, 2006:38).

2.5.2.5 Vitamin B_6

Vitamin B6 deficiency alone is rare as it usually occurs in association with a deficit in other B-complex vitamins. Biochemical changes that occur at earlier stages include decreased levels of plasma pyridoxal 5¢-phosphate (PLP) and urinary 4-pyridoxic acid (WHO, 2004:175).

Vitamin B_6 deficiencies in humans show symptoms of weakness, sleeplessness, peripheral neuropathies, cheilosis, glossitis, stomatitis and impaired cell-mediated immunity (Gallagher, 2004:103). The RDA of vitamins B_6 for elderly men is 1,7 (mg/day) and for women is 1,5 (mg/day) (WHO, 2004:180; Gallagher, 2004:103, IOM, 2006:40).

The dietary sources of vitamin B6 are pyridoxine, meats, vegetables and whole-grain cereals pyridoxamine, and pyridoxal (WHO, 2004:186; Gallagher, 2004:103).

2.5.2.6 Folate

Folate functions as an enzyme cosubstrate in many chemical reactions during the metabolism of amino acid and nucleotides by donating or accepting single carbon units. The essential role for folate is the formation of red and white cells in the bone marrow and for their maturation. Folate is a single-carbon carrier in the development of heme (Gallagher, 2004:105). Folate deficiency results in impaired biosynthesis of DNA and RNA. The first signs of folate are the nuclear hypersegmentation of circulating polymorphonucear leukocytes followed by megaloblastic anemia and then general

weakness, depression and polyneuropathy (Gallagher, 2004:106). The RDA for folate in the elderly is 400g and is the same for elderly women and men (WHO, 2004:294; Lin, 1999:40; IOM, 2006:42). Dietary sources that are rich in folate are liver, mushroom and green leafy vegetables. Other food sources that are good in folate are lean beef, potatoes, whole wheat bread, orange juice and dried beans (Gallagher, 2004:105).

Folate is needed for the creation of nucleic acids (FAO/WHO, 2003). Nutritional deficiency of folate occurs in people eating an inadequate diet (WHO, 2004:293). Folate deficiency can arise from malabsorption conditions resulting from gastrointestinal disorders and secondary deficiencies of B6 and B12 (WHO, 2004:293; FAO, 2003). Increased folate intake could be a possible advantage for the elderly because of its inverse association with metabolite homocysteine as a marker for coronary artery and cerebral vascular disease (Lin, 1999:40). Diets that contain adequate amounts of fresh green vegetables (i.e. in excess of three servings per day) will be good folate sources (WHO, 2004:293).

2.5.2.7 Vitamin B_{12}

Vitamin B_{12} functions in forms of two coenzymes that are the adenosylcobalamin and methylcoalamin. The vitamin plays an essential role in the metabolism of the vitamin propionate, amino acids and single carbons respectively (Gallagher, 2004:107). Vitamin B_{12} deficiency results in impaired cell division especially in rapidly dividing cells of the bone marrow and intestinal mucosa (Gallagher, 2004:108-109). Low serum vitamin B_{12} levels have been found in elderly people. Aging is accompanied by a higher risk of vitamin B_{12} deficiency. In harmful anemia, for an example there is failure of the stomach to secret the intrinsic factor which is a needed for vitaminB_{12} absorption. Other important contributors that reduce vitamin B_{12} are the decreased digestion of vitamin B_{12} from food and bacterial overgrowth in the small bowel absorption. High levels of methylmalonic acid are a sensitive and specific sign of vitamin B_{12} deficiency. The RDA for vitamin B_{12} for elderly women is 2,4g/day and is also the same for elderly men. The food sources of vitamin B_{12} are liver, kidney, milk, eggs, fish, cheese and muscle meats (Gallagher, 2004:108; Lin, 1999:41; IOM, 2006:44).

2.5.2.8 Vitamin C

This essential nutrient not only participates in intermediary and oxidative metabolism but also improves iron absorption. In addition, ascorbic acid has been shown to be necessary for a normal immune response (WHO, 1997; WHO, 2004:130; Gallagher, 2004:110).

The RDA for vitamin C is 90 mg/d for males and 75 mg/d for females over age 50 (Chernoff, 2004:6; Gallagher, 2004:113, IOM, 2006:50). About 800–1200 mg/day (in the presence of adequate vitamin D nutrition) is helpful for bone mineral density of the femur, neck and lumbar spine and reduction of fractures (WHO, 2002:2). The most well known feature of vitamin C deficiency is anemia. Insufficient vitamin C in human beings results in scurvy (WHO, 2004:130; Gallagher, 2004:112). Decreased consumption of vitamin C is associated with illness, hospitalization, and institutionalization. Chronic disease including atherosclerosis, cancer, senile cataracts, lung diseases, cognitive decline and organ degenerative diseases may be as a result of lowered intake (Chernoff, 2004:6). Vitamin C is widely abundant in many foods (Lin, 1999:39). Many fruits and vegetables are the main sources of vitamin C. Particularly citrus fruits and juices are rich sources of vitamin C but other fruits such as cantaloupe and honeydew melons, cherries, kiwi fruits, mangoes, papaya, strawberries, tangelo, tomatoes and watermelon also contain variable amounts of vitamin C. Vegetables such as cabbage, broccoli, brussels sprouts, bean sprouts, cauliflower, kale, mustard greens, red and green peppers, peas and potatoes may be more essential sources of vitamin C than fruits, mainly because the vegetable supply often extends for longer periods during the year than the fruit supply does (WHO, 2004:135; Lin, 1999:39; Gallagher, 2004:111).

The ingestion of ascorbic acid amongst the elderly varies. Vitamin C status can be inhibited by conditions such as smoking, medication and emotional as well as environmental stress (Lin, 1999:39; WHO, 2004).

2.5.2.9 Vitamin D

Vitamin D is needed to maintain normal blood levels of calcium and phosphate, which in turn are required for the normal mineralization of bone, muscle contraction, nerve

conduction and general cellular function in all cells of the body (WHO, 2004:54). There is no RDA for vitamin D but the DRI is presented as the AI (Adequate Intake) is 10-15µg/day for both elderly men and women. Older women are at risk for insufficient vitamin D intake (Chernoff, 2001:52). The two major sources of Vitamin D are found in the diet and sun exposure. Dietary sources comprise of fatty fishes and fortified dairy products. Fortified dairy products consumption is variable among older women and especially in older adults, lactose intolerance is more prevalent (Chernoff, 2001:52).

The skin, through sun exposure, is also a source of the vitamin D precursor and may be essential for elderly who live in temperate climates, whereby old people can get outside daily. In winter where it is very cold during the winter months many elderly people do not get out at all. In elderly who reside in warmer areas there is a fear of skin cancer from too much sun exposure and an impediment to the activation of vitamin D precursors. The vitamin D precursor found in skin decreases with age. Ageing affects the ability of the kidney and liver to hydroxylate vitamin D precursors (Chernoff, 2001:52).

Vitamin D deficiency contributes to deteriorating bone mass and increases the incidence of hip fractures, due to low blood levels of 25-OH-D coupled with elevations in plasma PTH and alkaline phosphatase. The recommended vitamin D intake is 10 µg/day and should reduce the rate of bone loss and the incidence of hip fractures (WHO, 2004:49).

2.5.2.10 Vitamin K

Vitamin K plays an important role in blood clotting and bone formation. Vitamin K occurs naturally in the form of phlylloquinones which are synthesized by green plants and the menaquinones which are synthesized by bacteria (Gallagher, 2004:91).

Vitamin K deficiency is predominantly defined as hemorage and in severe cases causes fatal anemia. Although in human beings vitamin K deficiency is very uncommon but it is associated with lipid malabsorption, liver disease and destruction of intestinal flora in those using chronic antibiotic therapy (Gallagher, 2004:93). There is no RDA for vitamin K and it is given as AI's and not tolerable upper intakes. The AI's for elderly men is 120µg per day and 90µg per day for females. Vitamin K is found in bulky amounts in

green leafy vegetables particularly broccoli, turnip greens, cabbage and dark lettuce. Other food substances such as dairy products and meat contain vitamin K in minute micrograms (Gallagher, 2004:92).

2.5.2.11 Calcium

Calcium in the body makes up about 1,5percent to 2percent of the body weight and 39percent of total body mineral. About 99percent of calcium is found in the bones and teeth. One percent of calcium remains in the blood and extra cellular fluids. Calcium inside the cells of all tissues regulates the essential metabolic functions (Anderson, 2004:123; Barasi, 2003:195). Calcium is needed for nerve transmission and regulation of heart function. Proper balancing of calcium, sodium, potassium and magnesium ions maintains skeletal muscle tone and is responsible for nerve irritability. Calcium ions serve as necessary for cofactors for several enzymatic reactions including the conversion of prothrombin to thrombin which helps in the polymerisation of fibrinogen to fibrin and the final step in the blood clot formation (Anderson, 2004:125; Barasi, 2003:195).

The AI for calcium is the same for elderly men and women that is 1200mg per day (Anderson, 2004:126, IOM, 1997:73). Food sources of calcium are green leafy vegetables such as kale, collards, turnip greens, mustard greens, broccoli, the small bones of canned sardines and canned salmon, clams and oysters are good sources of calcium (Anderson, 2004:126; Barasi, 2003: 195-196).

2.5.2.12 Iron

Iron forms a component of the haemoglobin molecule in blood and accounts for two-thirds of the body's iron content. Iron is the carrier of oxygen from the lungs to the tissues and plays an important role in survival (Barasi, 2003:203). Some iron is found in myoglobin which is the pigment that is recognised in muscles that are high in affinity for oxygen. The rest of the iron is utilised in the enzymes that are important in oxidation-reduction reactions, stored in the body or in the blood and is carried between the body sites (Barasi, 2003:203; Anderson, 2004:136).

Iron is found in two forms in the diet, haem iron that includes foods of animal origin and non haem iron or inorganic iron that is mainly in plant foods. Iron is utilised mainly by the bone marrow for synthesis of red blood cells and by muscle cells for myoglobin synthesis. Iron also participates metabolically in active cells for the formation of cytochromes in the mitochondria, in the synthesis of hormones and nurotransmiters and immune system (Barasi, 2003:205; Anderson, 2004:140).

Iron deficiencies occur when the iron stores become depleted and the amount of iron in the blood falls. Anaemia is the most common iron deficiency (Barasi, 2003:207; Anderson, 2004:142). The RDA for elderly people is 8,0mg /day and is the same for both sexes (IOM, 2006:69). The richest food sources of iron are liver, sea foods, kidney, heart, lean meat and poultry. The best plant sources are dried beans and vegetables although availability of iron is far less than in animal sources. Milk and dairy products are devoid of iron and high consumption may be correlated to poor iron status (Barasi, 2003:204; Anderson, 2004:141).

2.5.2.13 Zinc

Zinc is available in all body tissues and fluids. Zinc content has been estimated to be 30mmol (2g) in the body. The total body content of the skeletal muscle is approximately 60percent and bone mass with a zinc concentration of 1, 5–3mmol/g (100–200mg/g), for approximately 30percent. Lean body mass has a zinc concentration of approximately 0.46mmol/g (30mg/g) (WHO, 2004:230). Zinc is an important component of a large number (>300) of enzymes taking part in the synthesis and degradation of carbohydrates, lipids, proteins and nucleic acids as well as in the metabolism of other micronutrients. Zinc also contributes to the maintenance of cell and organ integrity (WHO, 2004:230; Barasi, 2003:207).

Zinc deficiency in humans causes growth retardation, delayed sexual and bone maturation, skin lesions, diarrhoea, alopecia, impaired appetite, increased susceptibility to infections mediated via defects in the immune system, and the appearance of behavioural changes. The other effects of zinc deficiencies are impaired taste and wound healing,

which have been claimed to result from a low zinc intake and are less consistently observed (WHO, 2004:230; Barasi, 2003:208).

Dietary intake of zinc is linked to protein content of the diet due to zinc occurring complexed with proteins and their additives (Barasi, 2003:207). The RDA for the elderly men is 11mg/day and for elderly women is 8,0mg/day (IOM, 2006:72). Good sources are lean meat, sea foods, and dairy products. Moderate sources are pulses and grains but are essential for vegetarians. Leafy vegetables, fruits, fats, alcohol and refined cereals are the lowest group (Barasi, 2003:2047; Anderson, 2004:145).

2.5.2.14 Phosphorus

Approximately 700 g of phosphorus exists in the tissue cells of adults and it an important element. It rates second to calcium in abundance in the cells (Barasi, 2003:201, Anderson, 2004:129). Eighty five of phosphorus is present in the skeleton and teeth as calcium phosphate crystals. About 15percent of phosphorus exists in the extra cellular fluid compartment and in the metabolically active pool in every cell in the body (Anderson, 2004:128). The RDA for the elderly men is the same as for elderly women at 700mg /day (IOM, 1997:47). Excellent food sources of phosphorus are meat, poultry, fish and eggs. Milk products and milk are good sources and nuts, and legumes, cereals and grains are also sources (Anderson, 2004:129).

2.5.2.15 Magnesium

Magnesium is the third most plentiful intracellular cation in the body. The body of an adult has approximately 20 to 28 g of magnesium of which 60percent is found in the bone and 26percent in the muscle and the remainder is found in the soft tissues and body fluids (Anderson,, 2004:130; Barasi, 2003:202). The RDA for the elderly men is 420mg/day and for elderly women it is 320mg /day (IOM, 1997:17). Food sources of magnesium include whole grain cereal, nuts, legumes, seafoods, coffee, tea, cocoa and chocolate (Barasi, 2003:202; Anderson, 2004: 132). Magnesium deficiencies are very scarce although symptoms include tremors, muscle spasms, personality changes, anorexia, nausea and vomiting (Barasi, 2003:203; Anderson,, 2004:132).

2.5.2.16 Sodium

Sodium and chloride are considered together because these minerals occur together in foods as well as in the body. Sodium is a main cation of extracellular fluid, having over 90percent of the cations in the blood. About 40percent of the body's sodium is contained in bone as an essential part of the mineral lattice (Barasi, 2003:217; Whitmire, 2004:170). Sodium plays an important role in maintaining osmolality of body fluids. It maintains the extracellular fluid, hence the blood volume and acid-base balance. Electrochemical gradients across the cell membranes are maintained by sodium (Barasi, 2003:217; Whitmire, 2004:171). The RDA for sodium in elderly people is 500mg/day (Whitmire, 2004:171). The main source of sodium is common table salt because it has undergone some processing. Plant foods contain very little sodium, whereas animal foods contain low to moderate levels (Barasi, 2003:218; Whitmire, 2004:171).

2.5.2.17 Potassium

Potassium is the most important cation of intracellular fluid and is present in small amounts in extra cellular fluid (Barasi, 2003:220; Whitmire, 2004:172). Potassium is involved in maintaining water balance, osmotic equilibrium and the acid based balance. It also promotes cellular growth. An adequate supply of potassium is important and the potassium content of muscle is related to muscle mass and glycogen storage. Food sources of potassium are fruits, vegetables, fresh meat and dairy products. The estimated minimum requirement for adults is between 1600 to 2 000mg /day (Whitmire, 2004:172).

Table 8: A summmary of micronutrients and the RDA of the elderly people

Micronutrient	Unit of measurement	RDA male	RDA female	EAR male	EAR female
*Vitamin A	µg/day	900	700	625	500
*Thiamin	mg/day	1,2	1,1	1,0	0,9
*Riboflavin	mg/day	1,3	1,1	1,1	0,9
*Nicotinic Acid	mg NE/day	16	14	12	11
*Vitamin B_6	mg/day	1,7	1,5	1,4	1.3
*Folic Acid	µg dietary FE/day	400	400	320	320
*Vitamin B_{12}	µg/day	2.4	2.4	2.0	2.0
#Vitamin C	mg/day	90	75	75	60
#Phosphorus	mg/day	700	700	580	580
#Magnesium	mg/day	420	320	350	265
*Iron	mg/day	8,0	8,0	6,0	5,0
*Zinc	mg/day	11	8,0	9,4	6,8

#INSTITUTE OF MEDICINE. 1997. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride.

*INSTITUTE OF MEDICINE. 2006 Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silver, Vanadium, and Zinc

2.6 FOOD CHOICES AND NUTRITIONAL STATUS OF THE AGED

2.6.1 Models of food choices

The term 'food choice' refers to the set of conscious and or unconscious decisions made by an elderly person when purchasing food or in consumption. Older adults are much more likely to have significant health consequences related to the foods they eat or choose not to eat (Herne, 1995:13).

Models of food choices vary, but for the purpose of this research, personal, socio-economic, educational, biological, cultural, and extrinsic and intrinsic factors will be discussed.

- **Personal factors**

Choice of food among the elderly is a function of several interrelated aspects of personality and mental health (Herne, 1995:13). Changes in health, loss of spouse or close friends, financial status and lack of social support contribute to self perpetuating cycle of poor eating habits, despondency, which can result in malnutrition (Litchford,

2004:1). The priority given to food depends on the situation therefore food will be of a minor consideration. In these cases an elderly will more likely accept food of a lower palatability. Food choices are made based on palatability of foods. Older adults tend to eat smaller meals and eat more slowly than younger adults, and are more likely to consume food that they are familiar with (Litchford, 2004:1).

While lower intakes do not automatically confer malnutrition, they do pose greater risks of poor intakes among elderly people living on low incomes. Satiety changes in adults affect their food choices as they lack sensory specific satiety or their sense of taste and recognition of fullness is impaired. Attitude towards food and nutrition has been found to play an important role. Appetites, moods, emotions, depression, apathy, bereavement and isolation have a potential impact on the diet, food choice and consumption (Herne, 1995:13).

- **Socio-economic factors**

According to Herne (1995:16), social class and material resources can affect food choice both on a societal and individual level. The economic status of an individual determines various aspects of his/her lifestyle, including nutritional intake, physical activity and standards of health and hygiene (Evans, 2005:2). Elderly in the higher social class tend to consume more fresh fruit and vegetables, whole wheat bread, fruit juices and grilled meats and eat less high fat, fried and salty foods. They usually avoid additives in food and tend to seek healthy foods. Elderly in the lower social class live in the outskirts of town, a situation which makes it difficult for them to buy fresh produce and they, therefore, depend on local shops which are expensive with less fresh produce (Herne, 1995:16).

- **Educational factors**

Better educated elderly people move into higher status and more lucrative employment which pays them more money. When these educated elders retire, food habits are then a function of wealth and class. It is often believed that the higher the general educational attainment of an elderly, the greater his/her nutritional knowledge. The educated elderly

tend to seek more information, as they are more informed and use the information to purchase food (Herne, 1995:19, Wahlqvist, 2002a:912).

- **Biological factors**

Age-related sensory changes may result in poor food choices. Four senses that play a role in eating are sight, smell, touch (mouth feel) and taste. The taste, the smell and the appearance of food are not perceived the same way by the elderly. The importance of the senses of sight, smell and taste is that they interact to stimulate appetite. When the sense of smell is impaired the elderly can have decreased ability to detect food aromas, thereby losing the stimulation that these aromas provide which is salivation, gastric acid flow and secretions from various endocrine organs. The loss of sense of smell appears to be related to the decrease in the number of taste buds rather than the loss of gustatory sense structures. Older adults are less able to differentiate between food flavours, sweet foods may taste bitter, sour foods may taste metallic and salty foods may be tasteless. Changes in detention can result in painful teeth or chewing muscles or extreme and painful sensitivity to hot and cold foods (Herne, 1995:20, Wahlqvist, 2002a:912).

- **Cultural factors**

Culture has an enormous influence on all aspects of food consumption such as foods that are regarded as acceptable, when they may be eaten, person/s to prepare and cook them and cooking methods, slaughter and food etiquette (Herne, 1995:25, Wahlqvist, 2002a:912).

Religion and religious beliefs connected to food are a reflection of cultural values associated with people's country of origin and are often resistant to change even in migrant populations (Herne, 1995:26).

- **Extrinsic factors**

The quality expected of a food is a function of where it is eaten and the circumstances under which it has to be consumed. Furthermore, only certain foods are deemed fit for particular occasions such as celebrations (Herne, 1995:24).

Seasonal variations have an impact on food consumption patterns. In summer there is an abundance of cheaper fresh produce while in winter the vegetables are more expensive. The elderly, therefore, opt for cheaper foods with less nutritional value (Herne, 1995:24).

2.7. CONCLUSION

In this chapter aging has been analysed and explored. Factors affecting aging, nutritional requirements of the aged, their eating habits, food choices and nutritional status of the aged and pathological consequences of malnutrition among the aged were also discussed. It can be argued that aging is related to malnutrition as it affects GIT (such as the inability to swallow, less absorption of nutrients in the stomach and delayed emptying of fundus) and mobility (such as inability to absorb calcium and vitamin D and restricted diet). The next chapter deals with strategies to address malnutrition amongst elderly.

CHAPTER 3: STRATEGIES TO ADDRESS MALNUTRITION AMONGST ELDERLY

3.1 INTRODUCTION

There are various strategies that are used to correct malnutrition problems. Strategies are used such as food fortification which is the enhancing of food stuffs with vitamins and minerals that are absent from the food source and food supplementation which involves the provision of tablets and capsules to the targeted age groups. Food diversification is classified as a food based strategy aimed at reducing malnutrition in the long term, providing knowledge and assistance to communities to develop and successfully grow vegetable gardens and farming on a small scale. The role of nutrition education is also a form of a malnutrition strategy and another solution categorised under food based strategies includes the importance of novel foods and formulation of food multimix as part of functional foods. Furthermore a multimix can be used as one of the cheapest methods to combat malnutrition.

3.2 TREATMENT OF MALNUTRITION

The treatment of malnutrition is intended to provide sufficient proteins, calories and other nutrients for nutritional rehabilitation and maintenance. These are several ways to combat malnutrition and ways to improve nutritional status. These involve activities to prevent mineral and vitamin deficiencies in vulnerable populations through dietary diversification, micronutrient supplementation and fortification of commonly eaten foods and introduction of novel foods (Bowley, 2005:8).

Reasons for implementing food-based strategies to overcome micronutrient deficiencies are the following:

- preventive, cost-effective, sustainable and income generating;

- culturally acceptable and feasible to implement;
- promote self-reliance and community participation;
- take into account the crucial role of breastfeeding and the special needs of infants during critical weaning period;
- foster the development of environmentally sound food production systems; and
- build alliances among government, consumer groups, the food industry and other relevant organisations to achieve the shared goal of preventing micronutrient malnutrition.

Food fortification, one of the food-based strategies, has the potential for wide populations coverage and can involve a combination of micronutrients.

Adoption of food-based strategies can enable possible redirection of funds previously devoted to curative health care and social welfare to other developmental activities (FAO, 1997b).

3.2.1 Food fortification

Fortification is the addition of nutrients at levels higher than those found in the original or in comparable foods (FAO/International Life Science Institute (ILSI), 1997). Food fortification can be expensive, because it is not sustainable. Food fortification can also impose problems, especially if the vehicle utilised is not acceptable to the people, for example, an excessive intake of sugar can cause dental caries. Food fortification can result in an expansion of financial support from external resources, government as well as international and local non-government organisations (NGO's) (FAO/ILSI 1997).

Food fortification has been defined as the addition of one or more important nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups (FAO, 1996a; ADA, 2005:1301; DoH: 2003:1). Enrichment is the addition of supplemental amounts of nutrients already present in a food or the concentration of those nutrients already present is increased. For example the addition of thiamin, niacin or iron to wheat flour (Shamah, 2006:3). Enrichment is the same as

fortification and refers to the addition of micronutrients to a food irrespective of whether the nutrients were originally in the food before processing or not (WHO, 2006).

Food fortification is the process by which the quality of the diet is improved by the addition of nutrients to the commonly eaten foods. Further fortification is the addition of nutrients at levels greater than those found in the original or incomparable foods (FAO/ILSI, 1997).

Fortified and enriched foods are products whose original composition is modified through addition of vital nutrients to satisfy the identified specific nutritional needs of defined populations (Pantanelli, 2000:14-15). Micronutrient deficiencies were identified as major public health problems and in the early twentieth century, enrichment of basic foods promoted by the industrialized nations resulted in a drastic reduction of illnesses. Initially food fortification was aimed at guaranteeing a sufficient intake of such nutrients throughout the population. For example, rickets was brought under control by the incorporation of vitamin D in milk, and beriberi and pellagra by the addition of thiamin and niacin to wheat and cereals. Margarine is frequently enriched with vitamins A and D to avoid a low intake in cases where margarine is used as the sole source of fat (Shamah, 2006:3).

A fortification programme is usually implemented when there is a wide spread and regular nutritional insufficiency in the population's diet (FAO/ILSI, 1997). The National; Food Consumption Survey in South Africa 1999 carried out by Labadarios, Steyn, MacIntryre, Gericke, Swart, Huskisson, Dannhauser, Voster, Nesmvuni, Nel(2005:540) to determine the nutrient intakes and anthropometric status of children living in different cities, towns, informal settlements and farms. The findings include the following:

- The majority of children consumed less food and micronutrients in their daily meals than required.
- Many families had less income to buy food and often go hungry.
- A large amount of popular foods that they bought and consumed were maize meal, wheat, tea, whole milk and bread.

Therefore, the South African government decided to fortify the most commonly eaten foods, namely bread, flour and salt (Labadarios et al, 2005:540).

3.2.1.1 Food fortification in developing countries

In many developed countries food fortification continues to be a widely utilised mechanism. Lifestyles have rapidly changed by fortification and rising trust for more highly processed foods has been used to justify the addition of nutrients to an increasing range of foods in order to ensure nutritional sufficiency of the diet. It is essential to note that there is no general agreement regarding the extent to which food fortification should be practiced and the existing attitude towards it varies in the developed world. There is a restrictive legislation regarding the addition of micronutrients to foods in France, the Netherlands, Norway and Finland. However fortification has continued in these countries for certain processed foods. It is allowed in France and restoration takes place of vitamins to reimburse for processing losses to the extent of 80-200percent of naturally occurring levels. It is also legal to add nutrients to foods for special dietary uses. Addition of nutrients to certain foods for special dietary uses in the Netherlands is allowed as well. Fortification of margarine and iodine addition to salt are also practiced (FAO, 1997b).

Fortification of foods in North America is viewed positively. Many studies emphasise the responsibility of such nutrified foods in assuring nutritional adequacy in the North American diet. The increasing range of fortified foods can be justified by the fact that the RDA's for many nutrients are commonly not met. Other factors can complicate food fortification policies, however, as was shown by the USA National Dairy Council's request for monitoring of Ca fortification on the basis thus required element is readily available in dairy products. Fortification regulation is currently receiving more attention than the technologies involved in developed countries (FAO/ILSI, 1997).

Salgueiro, Zubillaga, Lysionek, Caro, Weill and Boccio (2002) determined that at the global level, different basic staples such as wheat flour, salt, sugar and other condiments have been enriched with iron, vitamin A, iodine, and other micronutrients, as the most cost-effective and sustainable option to eliminate micronutrient deficiencies (Salgueiro *et al.*, 2002:55).

Industrialized countries provide their populations with an abundant supply of vitamin A through enrichment of foods such as margarines and vegetable or canola oil. Many Central American countries, such as Guatemala and the Honduras, have successful programmes enriching sugar with vitamin A (Shamah & Villalpando., 2006:s75)

One of the most successful enrichment programmes for fortification is salt iodization. Since the 1970s salt iodization programmes were implemented in many countries and adopted worldwide in 1990. Iodized salt is now available for 1.5 billion consumers throughout the world, saving millions of small children from mental retardation each year (UNICEF, 1998). The first country to achieve certification for the elimination of illnesses associated with iodine deficiency as a public health problem was Bolivia in 1996. That achievement was the result of numerous coordinated actions, i.e. legislation which transformed the political decision into a public policy, and 13 years of coordinated work between salt producers, the government and international cooperation institutions (UNICEF, 1998).

In 1983 there was economic crisis in Venezuela; the low-income population (approximately 80 percent of Venezuelans) decreased its use of nutritious foods, which was reflected in an increased prevalence of Fe deficiency. In 1993 the Venezuelan Government responded through the Special Commission on Enriched Foods which started a fortification programme of wheat and corn flour with ferrous fumarate. Also thiamin, riboflavin and niacin were added. Both cereals represent 45percent of total energy consumption among the Venezuelan population. In school-aged children and adolescents, the fortification of these flours resulted in a decline in the prevalence of iron deficiency anemia IDA from 37 and 19percent respectively in 1992, to 15 and 10percent in 1994 (Shamah *et al.*, 2006: 75).

3.2.1.2 State of fortification in S.A

In 1994 South Africa's Integrated Nutrition Programme was derived from the recommendation of the Nutrition committee that was mandated by the Minister of Health to develop a nutrition strategy for the country. The recommendation made by the committee was to replace the fragmented food-based approach of the past with an

integrated nutrition approach. It includes a vision of optimal nutrition for all South Africans. The mission was to improve the nutritional status of all South Africans through the health care system by the implementation of integrated nutrition activities (Bowley, 2005:8).

South Africa has achieved many milestones in its efforts to combat malnutrition since 1994. The most recognized activities are as follows:

- Mandatory fortification of all maize meal and wheat flour (white and brown bread flour) with six vitamins and two minerals (vitamin A, thiamine, riboflavin, niacin, vitamin B6, folic acid, iron and zinc) and mandatory iodization of all table salt (Bowley, 2005:8).

There are a few adequately documented examples of successful fortified food items in South Africa that are presented in Table 9 below (Bowley, 2003:7).

Table 9: Cereal fortification in South Africa (Bowley 2003:7-8)

Country	Product	Mandate	Nutrient	Mandated level (IU/kg)	Mandated level (mg/kg)
South Africa	Maize meal (super)	Act 54, 1972, April 2003	Vitamin A	6250	6250
			Vitamin B1		3,09
			Vitamin B2		1,79
			Niacin		29,70
			Pyridoxine		3,89
			Folic acid		1,89
			Iron		37,35
			Zinc		18,90
South Africa	Maize meal (special)	Act 54, 1972, April 2003	Vitamin A	6250	6250
			Vitamin B1		3,86
			Vitamin B2		1,88
			Niacin		31,86
			Pyridoxine		4,25
			Folic acid		1,90
			Iron		40,14
			Zinc		22,55

Table 9 (Continue): Cereal fortification in South Africa (Bowley 2003:7-8)

Country	Product	Mandate	Nutrient	Mandated level(IU/kg)	Mandated level(mg/kg)
South Africa	Maize meal (sifted)	Act 54, 1972, April 2003	Vitamin A	6250	6250
			Vitamin B1		4,76
			Vitamin B2		1,97
			Niacin		34,65
			Pyridoxine		4,79
			Folic acid		1,95
			Iron		44,28
			Zinc		26,60
South Africa	Maize meal (unsifted)	Act 54, 1972, April 2003 Special permission may be granted for a lower iron content (34.65 mg/kg)	Vitamin A	6250	6250
			Vitamin B1		5,57
			Vitamin B2		2,06
			Niacin		38,25
			Pyridoxine		5,42
			Folic acid		1,20
			Iron		
			Zinc		
South Africa	Wheat flour (white)	Act 54, 1972, April 2003	Vitamin A	5360	**5360**
			Vitamin B1		**3,1**
			Vitamin B2		2,05
			Niacin		38,42
			Pyridoxine		2,82
			Folic acid		1,36
			Iron		43,65
			Zinc		20,70

The first initiative on fortification in South Africawas with the mandatory addition of iodine to table salt in 1995. In 1998 a follow-up National survey showed that about 89,4percent of primary school learners had sufficient levels of iodine. Similarly by enriching staple foods such as maize meal and wheat flour, and possibly sugar is expected to have a substantial reduction in micronutrient deficiencies, especially vitamin A, when the impact of fortification is evaluated within the next few years. This should result in considerable health benefits for children and the population at large (DoH, 2003 & Thom, 2000:1).

According to findings by the MRC (Medical Research Council, 2001), within one year of compulsory iodization of table salt in 1995, the iodine content of salt available in shops in three of the nine provinces more than doubled, from an average of 14 ppm to 33ppm. This average increased to 42 ppm over the next two years. Also 19,2percent of salt packages on retailers' shelves still had an iodine content of less than 20 ppm. The coverage of iodized salt improved from a situation before compulsory iodization where only 30percent of table salt was iodized, to a situation where 63percent of households in the country were using adequately iodized salt. Up to 20percent of people in vulnerable groups from three provinces (Mpumalanga, Limpopo and North West) were using poorly iodized salt and non-iodized salt meant for agricultural purposes in their food. Evidence of improved outcomes from the iodization of table salt was seen in primary school children. In four communities of the Western and Eastern Cape, iodine status improved dramatically within one year after the introduction of compulsory iodization, although the goiters in children take longer to recover (De Hoop, 2006:8; MRC, 2001:1-2).

The MRC (2001) has implemented another successful fortification whereby a short bread biscuit aimed at combating micro-nutrient deficiencies in primary school children aged 7-10 years old was developed to provide 50percent of the RDA. Three servings of the biscuit provided the child with 5mg of iron, 60μg of iodine and 2,1mg β-carotene. The absorption of iron was increased by provision of a 150ml cold drink fortified with vitamin C. As a result of utilising a red palm oil which is free of fatty acid in a biscuit, vitamin A deficiencies were considered as reduced (MRC, 2001:1; Van Stuijvenberg, Dhansay, Smuts, Lombard, Jogessar and Benade, 2001:1202). The shortening was

established through close collaboration between NIRU, the Malayisan Palm Oil Board and Carotino SDN BHD, Malaysia. The biscuit has been commercialized under the trade mark "Carotino Enriched Biscuit" on the South African market (MRC, 2001:1).

In April 2003 the South African milling industry started to fortify maize meal and bread in order to improve its nutritional values. The milling industry has made a substantial contribution towards the fortification programme in formulating this programme and consumers were also consulted to establish their views on fortification. Consumer research that was conducted in year 2002 indicated that 81percent of consumers in peri-urban, rural areas were positive about fortification. When asked about vitamins and the benefits of vitamins, 78percent mentioned health benefits and 88percent of the respondents indicated that they would buy fortified foods and 41percent mentioned that they had bought fortified maize meal with added vitamins. Seventy-eight percent of the consumers indicated no concerns about fortification (DoH, 2003). South Africa has a special logo for fortified food and some examples of fortified wheat flour and maize meal products are indicated in Figure 8 below (Bowley, 2005:8).

Figure 8 Fortified grains in South Africa (Bowley, 2005:8)

The DoH in South Africa has embarked on a complex programme to address undernourishment (nutrient deficiencies) that was widespread amongst children aged 6-13years old. The National Food Fortification Programme was recommended to strengthen wheat, maize, flour and retail sugar, three of the five most commonly consumed foods vehicles as reported by National Food Consumption Survey(Ref). All South African children as reported by the National Food Consumption Survey showed a dietary intake of

energy, calcium, iron, zinc, selenium, vitamin A, vitamin D, vitamin C, vitamin E, riboflavin, niacin and vitamin $B_{6\ that}$ was less than 67percent of the RDA and in many cases below 50percent of the Recommended Dietary Allowances (Klugman, 2002:1-2; Thom, 2000:1).

3.2.1.3 South African fortification standards

According to DoH (2003), the final, minimum levels of fortificants in the fortified foodstuff should be not less than the levels shown in Columns III, IV and V of the table below.

Table 10: Fortified food vehicle standards (DoH, 2003)

		III	IV	V
Fortificant	Unit	Wheat foodstuffs	Maize foodstuffs	Unsifted maize meal
Vitamin A	UI/kg	5400,00	6400,00	6400,00
Thiamin	UI/kg	3,60	3,85	3.85
Riboflavin	UI/kg	2,00	1,85	1,85
Niacin	UI/kg	31,000	28,50	28,50
Folic acid	UI/kg	1,50	1,50	1,50
Pryridoxine	UI/kg	3,20	3,20	3,20
Iron	UI/kg	43,00	37,00	14,00
Zinc	UI/kg	20,00	18,50	18.50

Table 11 shows the fortification micronutrient mix composition as prescribed by the DoH (DoH, 2003).

Table 11: Fortification micronutrient mix specification (DoH, 2003)

Fortificants	wheat flour (g/kg	Maize meal(g/kg)	Unsifted maize meal(g/kg)
Vitamin A Palmitate.25000 IU/g	119,04g	138,88g	138,88g
<SIZE= 1> Thiamin Mononitrate	12,34g	13,93g	13,93g
Riboflavin	8,90g	8,50g	8,50g
Nicotinamide	118,40g	125,00g	125,00g
Folic acid	7,15g	7.15g	17.5g
Pyridoxide HCL	16,24g	19,32g	19,32g
Electrolytic iron	178,57g	178,57g	89,28g
Zinc oxide(min 80percentactivity)	9,40g	93,40g	93,40g
Calcuim carbonate(min 40percent activity).as carrier	To complete 1000g	To complete 1000g	To complete 1 000g

Other fortification standards include that the dosage 200g of micronutrient mix per ton of wheat or maize foodstuffs is the dosage required to cover the minimum fortification levels. The quality standard for fortificants, independently or mixed with a diluents shall be the Food Grade Standard in accordance with the standards. As determined in the Food Chemicals Codex (FCC) and the SA fortification standards,there should be minimum levels in the dry wheat flour, dry maize meal when analysed at the point of manufacturing or importation should include the micronutrient levels naturally present (DoH, 2003).

South Africa has a policy that compels the millers to add six vitamins and two minerals to maize meal and wheat flour produced in S.A (i.e. vitamin A, thiamin, niacin, vitamin B_6, folic acid, iron and zinc). All fortified foods by law carry a logo written: "fortified for good health" which shows that the product is fortified. It makes it clear for the buyers to know that the product has health value (DoH, 2005).

3.2.1.4 Advantages of food fortification

Where fortification is being implemented fewer children become ill or die at an early age and there is improvement in children's growth resulting in better performance at school. Increased strength is experienced by adults who can work longer and harder. Therefore, a healthier population results in increased work being completed (DoH, 2005:3). Fortification is essential because it does not need change in the dietary habits of the population. In the appropriate food industry infrastructure, fortification can be implemented relatively quickly and can be sustained over a long period of time. A food fortification approach is based on population and food fortification is defensive and cost-effective (FAO/ILSI, 1997; ADA, 2005:1304).

3.2.1.5 Disadvantages of food fortification

The shelf life of fortified milled cereals is decreased as compared to unfortified unmilled cereals. Regular quality control is vital. When fortified food is cooked too long, especially vitamin C loss can be as much as 90percent (Desenclos, Berry, Padt, Farah, Segala & Nabil. 1989). Food fortification can be expensive because it is not sustainable. A fortified product is more expensive than an unfortified one. Food fortification can also impose problems, especially if the vehicle utilised is not acceptable to the people, for example an excessive intake of sugar can cause dental caries. Food fortification can result in a need for financial support from external resources, government as well as international and local non-government organisations (NGO's). Food fortification suits a few specific product categories, such as milk, cereals, and juice drinks (ADA, 2005:1306; FAO/ILSI, 1997).

3.2.1.6 Practical problems encountered in choosing fortification programmes

The requirements for fortification of food should be as follows:

- The food items must be commonly eaten by the target population and have a regular consumption pattern with low risk of surplus eating and a good stability during storage.
- The food items must be centrally processed with minimum stratification of the fortificant and have no contact between the fortificant and the carrier food.

- Fortification must be contained in most meals with availability unconnected to socio-economic status and related to energy intake for the particular group (FAO, 1996a).

- **When a nutrient is considered appropriate for fortification:**

Fortification is considered when the food vehicle is constant under normal conditions of storage, distribution and utilisation present at a level where there is a reasonable guarantee that consumption of the food contains the added nutrients and will not result in increased intake, considering cumulative amounts from other diet sources. The nutrients should be suitable for its intended purpose and in compliance with applicable provisions of the Republic Act and regulations governing safety of substances in food (FNRI, 2005; DoH, 2003).

3.2.2 Food supplementation

Food supplementation is the addition of nutrients not available or only available in minute quantities in the food (FAO/WHO, 1992; Ninh *et al.*, 2003). Most supplements are available in the form of tablets, capsules or injections, which could be expensive for socio-economically disadvantaged people. Supplementation programmes have an immediate impact on individual cases and they rely on contained external support for supply of supplements, which may make them difficult to sustain in the long term. Additionally, supplementation programmes frequently fail to reach the most severe cases of micronutrient deficiency (FAO, 1997b).

- **Food Supplements**

Dietary supplements are intended to supply nutrients that are expected, but missing from the diet (Ramberg, Vennum & Boyd, 2002:1). Vitamin and mineral food supplements are intended to supplement the diet, with at least one of these ingredients: vitamins, minerals, herbs or other botanicals, amino acids, metabolites, or combinations of these ingredients (Hemmelgarn, 2005: l; FDA, 2003:1).

3.2.2.1 Food Supplement Composition

Vitamin and mineral food supplements should contain vitamins/provitamins and minerals whose nutritional value for human beings has been proven by scientific information and whose status as vitamins and minerals is recognized by FAO and WHO (Codex Alimentarius Commission, 2005).

The sources of vitamins and minerals may be either natural or synthetic and their selection should be based on considerations such as safety and bioavailability. In addition, purity criteria should take into account FAO/WHO principles, or if FAO/WHO standards are not available, international Pharmacopoeias or recognized international standards. In the absence of criteria from these sources, national legislation may be used (Codex Alimentarius Commission, 2005).

3.2.2.2 Advantages of food supplements

Although outright vitamin deficiencies are rare, some people are at risk for marginal vitamin shortages. Supplements can be appropriate for:

- Dieters who restrict their food intake (to less than 5.040 Kj per day), anorexia nervosa sufferers and people who eat only certain types of food may omit important nutrients
- Lactose intolerant people commonly eliminate milk and other dairy foods from their diets due to the fact that are unable to digest milk sugar (lactose). This can result in a deficiency of riboflavin and calcium.
- People who have food allergies. If one cannot consume certain types of foods, such as wheat or fruit, one may experience problems in obtaining sufficient intakes of certain nutrients.
- Vegans eat no animal foods and may become deficient in vitamins B12, D, and riboflavin (as well as the minerals iron and zinc).
- Women who might become pregnant or are already pregnant. Before conceiving, women should eat a diet that is rich in folic acid. This means eating generous amounts of spinach, broccoli, oranges, and lentils, and also taking 400 micrograms of

folic acid daily. If taken at the time of conception, it helps to prevent neurologic problems in the fetus, and can reduce certain types of birth defects.

- Active people who are at risk for heart disease and cancer. Although the evidence is preliminary and controversial, 100 to 400 international units (IDs) of vitamin E is unlikely to cause harm, and its antioxidant properties may be beneficial (ADA, 2005:1307).

3.2.2.3 Disadvantages of dietary supplements

Dietary supplements can create problems related to nutrient excesses, nutrient imbalances, or adverse interactions with medical care (ADA, 2001).

Herbal product supplements have not been tested to determine their safety or effectiveness. Quality or purity of dietary supplements are not held to any set of federal standards. It is advisable to consult a doctor or another health care provider before starting to take supplements and keep them informed when continuing the use of the product. Supplements advertised as "natural" are not necessarily safe. In fact, herbs, like other so-called natural products, can have powerful drug-like effects. Some of these effects can be fatal for people who take other medicines or have certain medical conditions. Counterfeit promoters often fall back on the same claims to trick consumers into buying their products (Kurtzwiel-Walter, 2000:4).

3.2.3 Nutrition education

Nutrition education can be defined as a curricula, courses, lesson plans and units, and activities designed to provide instruction with regard to the nutritional value of foods and the relationship between food and human health (Celebuski & Farris 2000:1).

Nutrition education is individual or group sessions with the provision of materials that are intended to improve health status and to attain positive changes in dietary and physical activity habits, and the emphasis is on the relationship between nutrition, physical activity, and health, all in keeping with the personal and cultural preferences of the individual (NSDSHS, 2005:1).

Nutrition education consist of health issues for students, professionals, policy makers, and the public the study of education strategies, behaviour, and communication to develop and disseminate nutrition education and communicate information on food and nutrition (DoNDFS, 2006:1).

The goal of nutrition education is to strengthen specific nutrition-related practices or behaviours to alter the lifestyle that contributes to poor health; this is achieved by establishing a motivation for change among people and creating desirable food and nutrition behaviour to encourage and protection of good health. People are given assistance to learn new information about nutrition and to develop the attitudes, skills and confidence that they require to enhance their nutrition practices. Nutrition education provides people with correct information on the nutritional value of foods, food quality and safety, methods of preservation, processing and handling, food preparation and consumption to help them make the best choice of foods for an adequate diet (FAO, 1997).

There are two distinct situations in nutrition education, namely, patient education and public education. Personal contact that occurs between the health worker and his patient is called patient education. This is a person-to-person communication during which the health worker communicates with an individual in order to improve the parents' or their child's nutritional status (FAO, 2004).

Public education consists of the interventions for recuperating the health of the general public. Nutrition education is concerned with modifying social communication to bring about middle or long-term changes in the common behaviour of the population. When interpersonal communication forms part of the proposed strategy, it has a complementary role, reinforcing other activities aimed at changing the behaviour of an entire social group (FAO, 2004b).

3.2.3.1 Planning a community nutrition education programme

All programmes require a proper planning and it is crucial for the success of a nutrition education programme. Nutrition education is efficient only when it is based on sufficient

analysis of the nutritional problems, clear and brief definition of the objectives and the methods of communications (FAO, 1997b).

As promoted by FAO, the social communication approach to nutrition education combines elements of the social marketing and the community-based approaches. Participation of the community is highly recommended in programme planning and implementation and the use of multimedia strategies, i.e. several channels of communication, to influence undesirable behaviour patterns related to nutrition is recommended. A schema has been developed which divides programme planning into four phases: problem identification, formulation, implementation and evaluation (FAO, 2000).

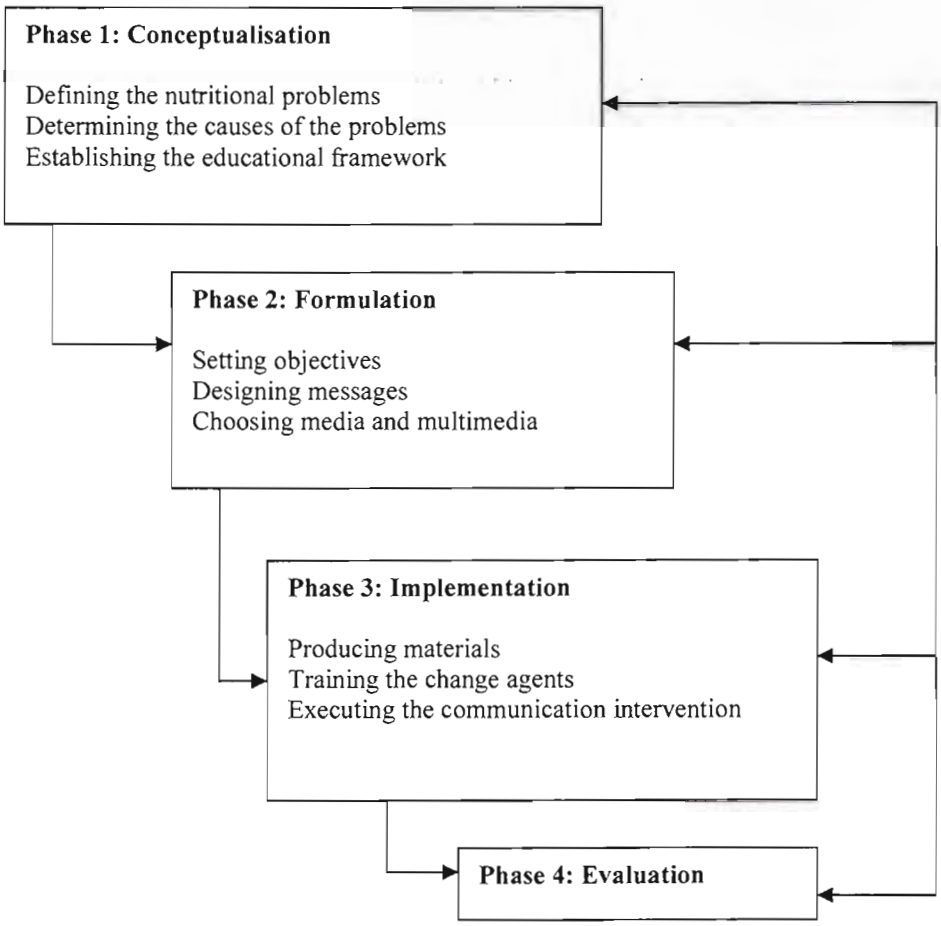

Figure 9 Phases of programme planning for nutrition education (FAO, 2000).

Major aims of nutrition education are to offer people adequate information, skills and motivation to obtain and to consume appropriate foods. Education programmes can focus on strategies to improve family food supplies and competent utilization of available food and economic resources to provide well balanced diets and better care for susceptible groups.

Nutrition education programmes should comprise at least three components, which are directed at various social groups:

- Escalating nutrition information and awareness of the public and policy makers.
- Promoting acceptable healthy food choices and nutritional practices.
- Enhance variety and quantities food supplies in the family (FAO, 2004).

In 1997 the FAO, indicated that by incorporating these three components into nutrition education and training programmes in departments of agriculture, education and health it can facilitate improvement in local food and nutrition conditions. Traditional and new methods are required to reach large part of the population, including children, youth, men and women in the workplace and at home (FAO, 2004).

3.2.3.2 The importance of nutrition education

The nutrition education is essential in the following ways:

- To generate the best of the available food supply.
- To ensure that energy intake is enough (food groups with an emphasis on staples).
- To prevent diseases of important nutrients (RDA's).
- To lower the development of chronic non–communicable diseases (Wahlqvist, 2003:3).

3.2.3.3 Guidelines for nutrition education

Nutrition education contains the following information: four broad programme areas of food security, food safety, dietary guidance and a description of proposed nutrition education activities (USFDA, 2005:4).

- **Dietary guidance**

Dietary guidance is the use of principles found in the dietary guidance to develop non-formal nutrition education services for youth and adults (USFDA, 2005:1). The guidance is based on the existing consumption patterns of readily available foods and intends to address recognized nutrition-related public health problems. The Food Based Dietary guidelines consist of 10 short, easy to follow and simple messages which have been evaluated for understanding, suitability and applicability in consumer groups of diverse rainbow nation backgrounds in both rural and urban areas (Vorster, Love & Browne, 2001:1). The South African dietary guidelines are as follows:

- Enjoy a variety of foods.
- Be active.
- Make starchy foods the basis of most meals.
- Eat plenty of fruit and vegetables.
- Eat dry beans, peas, lentils and soya often.
- Meat, fish, chicken, milk, and eggs can be eaten every day.
- Eat fats sparingly.
- Use salt sparingly.
- Drink lots of clean, safe water.
- Drink alcohol sparingly (Vorster *et al.,* 2001:1).

Groups with special dietary needs will have to adopt these guidelines. Therefore, it is compulsory that the guidelines could and should be used in the Integrated Nutrition Programme and that they could form the basis of nutrition education in South Africa (Vorster *et al.*, 2001:1).

3.2.3.4 Nutrition education programmes

The Nutrition Committee appointed in 1994 by the Minister of Health made recommendations to develop a nutrition strategy that is the Integrated Nutrition Programme (INP) for South Africa. An integrated approach to nutrition to replace the

fragmented food-based approach of the past was recommended the Committee (Kloka, 2003:1).

The task of the Nutrition Education Programme (NEP) is to supply individuals, families and communities with the information and skills that allow them to make knowledgeable choices about healthy diets, to reduce risks of foodborne illness and chronic disease, and to manage food resources economically that support their physiological health and economic and social well-being (Anlinker, 2004:1).

3.2.3.5 Advantages of nutrition education

Advantages of nutrition education are:

- To make the best use of the available food supply.
- To ensure enough energy intake (food groups with an emphasis on staples).
- To prevent deficiencies of important nutrients (RDAs).
- To decrease the development of non-communicable disease with the use of dietary guidelines (FAO, 2004).

3.2.4 Food diversification

Food diversification is the accessibility and use of micronutrient-rich foods through social marketing of micronutrient-rich foods; increasing consumption of dark green leafy vegetable; small-scale and community gardening; and solar drying technology for preserving micronutrient-rich foods, as well as developing novel food items for specific nutritional needs. Dietary diversification is vital to improve the consumption of critical nutrients (FAO, 1997a; USAID, 2005:1).

Dietary diversification is essential to enhance the consumption of critical nutrients. How this can be achieved is illustrated below with reference to five micronutrients, which are considered to be of public health relevance or serve as markers for overall micronutrient intake. The nutrients selected for discussion include those that are among the most difficult to obtain in cereal- and tuber-based diets (i.e. diets based on rice, corn, wheat,

potato or cassava). Moreover, nutrient deficiencies of vitamin A, iron and zinc are widespread (GRAIN, 2000:9).

Improving dietary diversity by stimulating the production and consumption of micronutrient-rich foods is the only normal and sustainable approach to overcoming micronutrient deficiencies. There is a great range for improving direct household supplies to such foods in rural and urban areas. Diversity is the foundation of balanced nutrition. Agricultural and nutritional policies should encourage the availability of micronutrient-rich foods and targeted nutrition education programmes should help increase their consumption. "Only by providing a diversity of food sources in the field and by increasing awareness of food's relevance not just to fill the bowl with food but to improve nutritional well-being, can one break away from the cruel cycle of hunger and malnutrition" (GRAIN, 2000:9).

Food diversification includes all dietary improvement approaches focusing on food systems, from production to consumption. Food-based strategies other than food fortification are often narrowed down to community-based gardening and nutrition education. It is important that food systems as a whole be considered in order to address not only nutritionally relevant food production and consumption, but also processing, marketing, and distribution potential and constraints (FAO, 1997a). Strategies for food and dietary diversification at the community and household levels include a variety of food-based activities that can increase the availability of sufficient amounts and better variety of nutritious foods. These activities include:

- Promotion of mixed cropping and integrated farming systems.
- Introduction of new crops (such as soybean).
- Promotion of underexploited traditional foods and home gardens.
- Small livestock raising.
- Promotion of fishery and forestry products for household consumption.
- Promotion of improved preservation and storage of fruits and vegetables to reduce waste, post-harvest losses and effects of seasonality.

- Strengthening of small-scale agro-processing and food industries and income generation.
- Nutrition education to encourage the consumption of a healthy and nutritious diet year round (FAO, 1997a).

Other types of food diversification are mixed cropping and gardening for food and farming. Food diversification is the blending of locally available, affordable, culturally acceptable and commonly consumed foods (FAO/WHO, 1992). Dietary diversification could result in a high production and consumption of micronutrient-rich food at household level (FAO, 1997b).

Dark green leafy vegetables are the least costly source of vitamin A in many countries according to findings of the market surveys. Programme managers should, however, include other sources, such as fruits and vegetables to address micronutrient deficiencies (FAO, 1997a).

Figure 10 Singaporean woman having access to a variety of micronutrient-rich fruits and vegetables with which to feed her family (FAO, 1997b)

3.2.4.1 Mixed farming

Mixed farming exists in many forms depending on external and internal factors. External factors are "weather patterns, market prices, political stability, and technological developments" (FAO, 2001a). Internal factors may be defined as the local soil characteristics, composition of the family and farmers originality. It is the farmers' decision

to select for mixed enterprises. It occurs when the need to save resources by interchanging them on the farm because these permit wider crop rotations and thus reduce dependence on chemicals, because they consider mixed systems closer to nature, or because they allow diversification for better risk management (FAO, 2001a). Growing more than one species on the same piece of land at the same time, or with only a short interval between is also known as mixed cropping (Huxley & Van Houten, 1997:2).

3.2.4.1.1 Forms of mixed farming

Categorisation of mixed farming systems can be done in many ways depending on land size, type of crops and animals, geographical distribution, market and orientation. There are three major categories in four different modes:

- On-farm versus between-farm mixing.
- Mixing within crops and/or animal systems.
- Diversified versus integrated systems (FAO, 2001a).

The different degrees of availability of land, labour and inputs, ranging from plenty of land to a shortage of land refer to the modes of farming. There are two types of farm mixing i.e. the on farm mixing and between farm mixing. The on farm mixing may be defined as the mixing on the same farm and between farm mixing refers to exchange of resources between different farms (FAO, 2001a).

Mixing within crop and/or within animal systems refers to conditions where several cropping types are practiced, often over time, or where different types of animals are kept together, mostly on-farm. Both these systems occur regularly though they are not always apparent. Diversified systems have components such as crops and livestock that co-exist independently from each other (FAO, 2001a).

3.2.4.2 Accomplishment of food diversity in practice

It is important to work on strategies, which encourage and facilitate dietary diversification to achieve complementarity of cereal or tuber based diets with foods rich in micronutrients in populations with limited resources and access to food. These strategies are as follows:

- **Community or home vegetable and fruit gardens**

The home garden can be defined as a farming system on the area of land around the family home which combines different physical, social and economic functions. The home garden involves three vital aspects such as the most direct way of providing daily food, a source of income for the purchase of other foods and a way to produce non-food items such as medicinal herbs, spices, fuel wood and building materials (

These projects should result in greater production and consumption of micronutrient-rich foods at household level. The achievement of such projects requires good information and understanding of local conditions as well as the women involvement and community. Common constraints such as land availability and water supply may be experienced which requires the local government to intervene. The educational efforts should be implemented towards securing appropriate within the family distribution, considering the requirements of the vulnerable members of the family (FAO/ILSI, 1997).

A home garden that is well-developed has the potential, when access to land and water is not a major limitation, to provide most of the non-staple foods that a family requires every day of the year, including roots and tubers, vegetables and fruits, legumes, herbs and spices. Energy rich foods are roots and tubers and legumes are essential sources of protein, fat, iron and vitamins. Green leafy vegetables and yellow or orange-coloured fruits provide important vitamins and minerals, particularly folate, and vitamins A, E and C. Vegetables and fruits are a vital element of a healthy diet and should be eaten as part of every meal. Good sources of protein, fat and micronutrients, particularly iron and zinc are meat, chicken and fish. They are especially essential in small children's diets to ensure normal growth and intellectual development (FAO/ILSI, 1997)..

A study carried by a Nutrition Intervention Research Unit (NIRU) in a rural area in Kwa Zulu Natal, South Africa proved that a home garden programme promoting the production and eating of yellow vegetables and fruits drastically enhanced the vitamin status of the participants. In this case food consumption information was colleted by trained health care

workers and local women, the growth rate of the children was monitored and there was rapid assessment of health and nutritional status (SAMRC, 2001:2).

Another community based nutrition research project in Langebaan was transferred effectively to the local clinic, thereby extending the capacity of the health facility in monitoring growth and nutritional status of preschool children in the community. This project also created jobs for a few unemployed women in the community (SAMRC, 2001:2).

- **Production of fish, poultry and small animals (such as goats, rabbits.)**

These are best sources of highly bio-available important micronutrients. The production of animal foods at the local level may allow communities to access foods that otherwise may not be available due to high costs. These types of projects require support from the local governments or non-governmental organisations to overcome cost constraints for implementation (FAO, 2004).

- **Implementation of large commercial vegetable and fruit production**

The aim of this initiative is to offer micronutrient rich foods at affordable prices through efficient and competitive markets, which result in lower prices without reducing producer prices. This strategy will serve mostly in the urban and non-food producing rural areas (FAO, 2004).

- **Reduction of post-harvest losses of the nutritional value of micronutrient–rich foods**

Post harvest losses can be reduced by modification of storage and food-preservation facilities significantly reduce post-harvest losses. Promotion of effective cooking methods and practical ways of preserving foods at household level may drastically increase the access to bio-available micronutrient-rich foods (FAO, 2004).

- **Improvement of micronutrient levels in soils and plants**

The improvement of micronutrient levels in soils and plants improve the composition of plant foods and enhance yields. Modern agricultural practices can improve the micronutrient content of foods through correcting soil quality, pH and increasing soil mineral content depleted by soil erosion and poor soil conservation (FAO, 2004). There are several approaches that exist to prevent and treat micronutrient malnutrition and they are summarised in the Table 12 below.

Table 12 Several approaches that exist to prevent micronutrient malnutrition (Nutrition press, 1998:2)

Micronutrient deficiencies	Dietary diversification	Food fortification	Supplementation	Public health measures
Iron disorders	Seafoods, Reduce goitrogens	Water Salt Baby foods Milk	Iodised oil Potassium iodide tablets	Legislation Enforcement
		Condiments Flour		Salt monitoring Primary health care
Vitamin A	Green leafy vegetables Orange Fruits /vegetables Red palm oil Breast milk Animal foods	Sugar Salt Milk powder Baby foods Condiments	Capsules (oil) in massive or small doses	Prevention of infection immunisation antiparasitic environment health
Anemia	Green leafy Pulses Fruits/vegetables(vitamin C) Liver, red meat Avoid tea/ coffee with meals	Salt Cereals or cereal flour Condiments	Iron / folate tablets Parenteral iron	Prevention of infections -immunisation - antiparastic - environment health

3.3. PRODUCT DEVELOPMENT

The product development process is explained as a five to eight-step process involving ideas or concept and screening, research, development and product testing and marketing launch activities (Stewart-Knox & Mitchell, 2003:2). According to Marx, Van Rooyen and Bosch (2001), product development revolves around two characteristics which are:

- Specific product characteristics such as taste, recreation value, prestige, quality and price.
- Certain quantitative and qualitative characteristics of possible target market.

Therefore, the product concept is created by integrating unique product characteristics and certain consumer needs and actions in a specific fashion e.g. a nutritious multimix for adults older than 60 years suffering from malnutrition (Marx *et al.*, 2001:247).

As cited by Benner, Linnemann, Jongen and Folstar (2003), the product development process has to become more successful and capable of meeting or exceeding the customer's expectations to improve its success rate. There is a need for consumer orientation in the new development process. The starting point of the product development has to describe the requirements and demands of the consumer with a better understanding of consumers' requirements (Benner *et al.*, 2003:328).

3.3.1 Factors to consider in product development

There are several factors to consider when developing a product such as consumer survey, sensory analysis, sensory evaluation and shelf life of a product.

3.3.1.1 Consumer survey

It is essential that manufacturers address the changing needs and market research is often called on to collect information on trends. Market research simplistically attempts to predict the future. New technology becomes available that is critical to achieving a particular product, and suppliers are frequently asked to supply such information. The necessary information may be provided by the suppliers to assist food companies with designing or conducting customer focus groups. For example, it is possible to develop

reduced-calorie chocolate of acceptable quality with new fat replacers. Market research could also aid in predicting the consumer reaction to label changes dictated by a new or novel ingredient (Hood, Lundy, & Johnson, 1995:12-13).

3.3.1.2 Sensory analysis

Sensory analysis is the assessment of a product through organoleptic properties (five senses organs) by utilising humans as measurement instruments. The significance of sensory analysis is enormous in many domains to enhance the quality of products throughout the development process, to explain sensory properties of products, and to contrast products to competitors products (Meilgaard, Civille & Carr, 1991; Latreille, 2005:369; Piana, Oddo, Bentabol, Bruneau, Bogdanov, & Guyot Declerck, 2004:S26). Sensory analysis used in many fields to establish the organoleptic profile of diverse products (foods, cosmetics, pharmaceuticals, textiles, household products) and can be useful in knowing how they are perceived by the consumer (Meilgaard *et al.*, 1991; Piana *et al.*, 2004:S26).

In simple terms sensory evaluation is divided into two methods i.e subjective and objective testing. Subjective tests involve objective panelists, while objective testing implements the use of laboratory instruments with no involvement of the senses. Both tests are important in sensory evaluation and necessary in diverse conditions (Meilgaard *et al.*, 1991).

- **The hedonic scale as a means of testing**

One of the simplest forms of subjective testing is the use of the hedonic scale method. This rating scale method is utilised to measure the level of the liking of foods, or any other product where an affective tone is necessary (O'Mahony, 1986:12). The test depends on peoples' ability to communicate their feelings of like or dislike. Hedonic testing is popular because it may be used with unskilled people as well as with experienced panel members. A minimum amount of verbal ability is necessary for reliable results (Meilgaard *et al.*, 1991).

According to ASTM as cited by Meilgaard *et al.* (1991), in hedonic testing, samples are presented in succession and the subject is told to decide how much he likes or dislikes the product and to mark the scale accordingly. The nature of this test is its relative simplicity. The instructions to the panelist are restricted to procedures, and no attempt is made at direct response. The subject is allowed, however, to make his own inferences about the meaning of the scale categories and determine for himself how he will apply them to the samples. The hedonic scale is anchored verbally with nine different categories ranging from like extremely to dislike extremely. These phrases are placed on a line-graphic scale either horizontally or vertically. Many different forms of the scale may be used with success, however variations in the scale form are likely to cause marked changes in the distribution of responses and ultimately in statistical parameters such as means and variances (ASTM, 1968).

Hedonic ratings are converted to scores and treated by rank analysis or analysis of variance. As mentioned earlier, hedonic scales are used with both experts and untrained consumers, with the best results obtained with an untrained panel. The ratings labels obtained on a hedonic scale may be affected by many factors other than the quality of the test samples. Characteristics of the subjects, the test situation, attitudes or expectations of the subjects can all have a profound affect on results. A researcher needs to be cautious about making inferences on the bases of comparison of average ratings obtained in different experiments (Meilgaard *et al.*, 1991).

Many other tests besides hedonic scales are used in the sensory evaluation of a food product. Determining the type of research that is being done, and the type of evaluation that is needed is crucial in obtaining accurate results from a sensory project. Descriptive sensory analysis is one of the most comprehensive and informative tools used in sensory analysis. These techniques can provide complete sensory descriptions of products, determine how ingredient or process changes affect product characteristics, and identify key sensory attributes that promote product acceptance. Specific uses for descriptive sensory analysis include:

- Product "fingerprinting."

- Shelf-life determination.
- Competitive product comparison.
- Product development testing.
- Quality control monitoring.

Sensory evaluation carried by a trained sensory panelist is called objective testing. Sensory evaluation utilising consumer panelists is subjective testing (FDC, 2006:2).

3.3.1.3 Sensory evaluation

Sensory evaluation is the science of judging and evaluating the quality of a food by the use of the senses, i.e. taste, smell, sight, touch and hearing. It has been developed into an accurate, formal, structured methodology that is frequently being updated to refine existing techniques. The methods developed serve economic interests and can establish the worth or acceptance of a commodity. Sensory evaluation is used as a practical application in product development by aiding in product matching, improvements and grading which is another area where sensory evaluation is frequently used in research. Evaluation of a product may be required to establish the affects an experiment had on its subject. Quality control and marketing is yet another application of sensory testing. Sensory evaluation is divided into two methods, subjective and objective testing. Subjective tests involve objective panelists, while objective testing employs the use of laboratoty instruments with no involvement of the senses. Both tests are important in sensory evaluation and necessary in various conditions. A subjective test is the use of the hedonic scale method. This method is utilised to measure the level of liking of foods, or any other product. This test relies on people's ability to communicate their feelings of like or dislike (FDC, 2006:2). Hedonic testing is popular and it may be used with untrained people as well as with experienced panel members. A minimum amount of verbal ability is necessary for reliable results (Food Resource Nutrition and Food Management, 1998; Stone, 2006:1). Sensory evaluation carried out by trained sensory panelists is called objective testing. Sensory evaluation utilising consumer panelists is subjective testing (FDC, 2006:2).

3.3.1.4 Shelf life of a product

Shelf life testing is an investigation to verify the length of time that the food product will maintain its safety and quality. Shelf life differs according to the type of packaging and method and storage conditions (FDC, 2006:1). The better method to describe shelf life is to understand the changes that occur in a product quality over time. The change of quality over time is a purpose of storage temperature, humidity, package protection, product composition, water activity, processing conditions, and ingredient quality (FDC, 2006:1).

The key factor for determining the shelf life of many food products is by sensory evaluation. Survival analysis is a branch of statistics utilised widely in clinical studies, epidemiology, biology, sociology and reliability studies. Hough, Langohr, Go´mez and Curia (2003) applied survival analysis statistics to sensory shelf life of foods. Survival analysis was used to calculate acceptance limits for sensory defects by Hough, Garitta and Sa´nchez (2004) which can be applied to setting quality control specifications (Calle *et al.*,2006:307).

The useful storage life of food is represented by shelf life. Food develops characteristics such as changes in taste, aroma, texture or appearance that are intolerable or undesirable at the end of shelf life. The fundamental cause for the change may be microbial, chemical or physical. Rancidity and freezer burn are typical examples of chemical and physical deterioration. The determination of the microbial shelf life for many foods may be required during product development (Curiale, 1998:1). The components of life testing may comprise assessing the physical, microbial and sensory attributes of the products. The table 13 further shows the components of shelf life (FDC, 2006:1)

Table 13: The components of shelf life (FDC 2006:1)

Physical Attributes	Chemical Attributes	Microbial Analysis
Colour	Peroxide value(rancidity value)	Standard plate count
Moisture content	Free fatty acid content (rancidity indicator)	Testing for yeast and mould
Water activity	Vitamin retention or loss	Presence of coliforms
pH level		
Brix value		
Viscocity		

- **Testing the shelf life of a product**

The shelf testing of a product is essential to contrast the effects of processing and or formulation changes on the product safety and quality. Cost saving may be achieved by preventing product recalls and excessive waste. Products storage condition and packaging are highly selected. Unstable raw materials which inhibit the final product shelf life may be relatively identified. Safety and degeneration problems during the preliminary stages of the product development can be identified. Optimum storage conditions for costly or perishable raw materials can be established (FDC, 2006:2).

- **Spoilage susceptibility**

Microorganisms have specific growth requirements for temperature, moisture, acidity, nutrients and time. Microorganisms grow at a certain range and if minimum conditions are not satisfactory the growth will not occur. Generally microorganisms develop at temperatures between 4°C-65°C, at Ph values between 2 and 10, and water activity levels greater than 0,6 (Curiale, 1998:1; McSwane *et al.*, 2003).

Food processing techniques can be utilised to prevent, reduce or control microbial contamination. Pathogens can be eliminated by heat treatment (boiling, roasting, frying and baking). The most common and effective method to ensure microbial safety is heating food above the temperature of microbial viability for a sufficient time span.

Pathogenic microorganisms are destroyed at temperatures above 70°C. Heat treatment simultaneously enhances the shelf life, the organoleptic and nutritional characteristics of food (WHO/NUT, 1998:129).

- **Safety concerns of bakery products**

Bakery products are an important part of a balanced diet and, today, a wide variety of such products can be found on supermarket shelves. This includes unsweetened goods (bread, rolls, buns, bagels, crumpets and muffins), sweet goods (pancakes, doughnuts, waffles and cookies) and filled goods (fruits, meat pies, sausage rolls, pastries, sandwiches, cream cakes, pizza and quiche). However, bakery products, like many processed foods, are subjects to physical, chemical and microbiological spoilage (Smith, Daifas, El-Khoury, Koukoutsis & El-Khoury, 2004:19).

While physical and chemical spoilage limits the shelf life of low and intermediate moisture bakery products, microbiological spoilage of bacteria, yeast and moulds is the concern in high moisture products i.e., products with a water activity (a (w)) > 0.85. Furthermore, several products also have been implicated in foodborne illnesses involving *Salmonella spp.*, *Listeria monoctyogenes* and *Bacillus cereus*, while *Clostridium botulium* is a concern in high moisture bakery products packaged under modified atmosphere (Smith *et al.*, 2004:20).

3.3.1.4.1 Factors influencing shelf life

The three factors that are involved are microbiological changes, moisture and water vapour transfer and chemical or biochemical changes

- **Microbiological changes**

Unless a food has undergone a commercial sterilization process (e.g. canned foods) or has water activity, which will not permit microbial growth (e.g. sugar, breakfast cereals), the rate of growth of spoilage microorganisms is likely to be the major factor determining shelf-life. This rate is determined by a number of factors including, food properties (e.g. pH, total acidity, water activity, presence of preservatives either natural or added),

environmental factors (temperature, relative humidity, gaseous atmosphere), any process designed to kill or retard growth of microorganisms (thermal processing, freezing, packaging) and the type of microflora present on the food, and the initial population (Steele, 2004:2; Sewald & De Vries., 2003:3).

- **Moisture and water vapour transfer**

Not only is water (measured as water activity) a critical factor which determines which, if any, microorganisms will grow in a food. Many foods are sensitive to loss or gain of water. This in turn can be affected by the choice of packaging and in many instances will determine which packaging to be used. Many biscuits and savoury snacks, including nuts, suffer in quality as a result of moisture gain. Some baked foods such as cakes may suffer from moisture loss (Steele, 2004: 2; Sewald *et al.*, 2003:3).

- **Chemical or Biochemical Changes**

Numerous possible reactions which could limit shelf-life fall into this category. The most important are oxidation, non-enzymic browning, enzymic browning and, in some cases, food and packaging interaction (Steele, 2004: 2).

Oxidation of fats and oils leads to the development of rancidity marked by odour and flavour. This may limit the shelf-life of fats and oils but can also limit the shelf-life of many other foods containing fats and oils. Examples of foods stored at ambient temperatures that can develop rancid off flavours are nuts, potato crisps and biscuits. Storage of these foods in high oxygen atmosphere can sometimes be used to accelerate shelf-life studies but atmospheric oxygen is not the only initiator of oxidative spoilage. Many frozen foods can also have their shelf-life limited by fat oxidation. While freezing arrests microbial activity, chemical reactions precede at a much-reduced rate even at recommended storage temperatures (Steele, 2004:2; Sewald *et al.*, 2003:3).

A number of different vitamins are sensitive to oxygen including vitamin C (ascorbic acid) and vitamin B_1 (thiamin). When vitamins are added to fortified foods such as breakfast cereals or sports drinks and a label declaration made, then shelf-life

determinations will have to take account any vitamin degradation which will occur with time in addition to any other changes in quality (Steele, 2004:2).

3.4 Novel foods

Novel foods can be defined as foods and food ingredients that were not used to a significant degree or history of consumption (Food Standard Agency, 2000:1) by the European Union. Novel foods and novel food ingredients fall into particular categories.

Foods and food ingredients with a new or intentionally modified primary molecular structure:

(a) Foods and food ingredients containing or consisting of GMOs.

b) Foods and food ingredients produced from, but not containing GMOs.

c) Foods and food ingredients with a new or intentionally modified primary molecular structure.

d) Foods and food ingredients consisting of, or isolated from micro-organisms, fungi or algae.

e) Foods and food ingredients consisting of or isolated from plants and food ingredients isolated from animals.

The above category does not include foods and food ingredients obtained by traditional propagation or breeding practices and having a history of safe food use.

Foods and food ingredients to which has been applied a production process not currently used, where that process structure of the foods or food ingredients which affect their nutritional value, metabolism or level of undesirable substances (Foreign Agricultural Service US. Mission to the European Union, 2007:1; Food Standard Agency, 2000:1).

Novel foods are formulated in such way that it addresses newer interests in food taste and appreciation, convenience and utility, and health. This is accomplished by repositioning older better known and culturally rooted foods, or they may be the altogether new formulations or recipes with new meaning for the consumer (Wahlqvist, 2002b:s98). The novel foods regulation (EC) 258/97 stipulates that all novel foods are subject to a pre-market safety assessment (Food standard Agency, 2000:1).

The use of novel technology to produce foods could result in increased health benefits for the consumer and for the environment through minimising interbreeding of farmed and wild animals and through production efficiencies for the producer. Although these benefits will be only recognised if the products are willingly consumed by the general public (Evans &Cox, 2006:916; Mahoney, 2002:s212). Most novel foods are particularly marketed as contributing to the health and nutrition of the consumer. Novel foods discussed here include foods or food ingredients not previously consumed widely by a population. They may include foods with novel ingredients such asphytoestrogens, phytosterols, fat replacers that are not absorbed through the gut, new sweeteners and food fortified by micronutrients, amino acids, active compounds such as caffeine and so on. Novel foods can also be considered to include foods produced with new technologies such as foods produced with the use of biotechnology and irradiation (Mahoney, 2002:s212). The most recent and often quoted novel food is the golden rice that is potentially beneficial for developing countries and is genetically modified. Pro-vitamin A-enhanced rice varieties have the potential to help millions of people suffering from vitamin A deficiencies (Mahoney, 2002:s212).

3.4 1 Role and potential of novel foods

Considering the scope for sustainable and healthy human communities systematically, Wahlqvist (2002) arrived at an extensive list of general and particular possibilities and roles for foodstuffs. These range from how food may be eaten to maintain the future food supply, to food sufficiency for those with marginal intakes, to the reduction in the burden of diseases at all stages of economic development, and to the complex collection of

health problems that may shorten the lifespan and increase morbidity (Wahlqvist, 2002b:s99).

Table 14: Categorisation of food-health relationships for the purposes of food product development (Wahlqvist, 2002b:s99).

Health category	Food characteristics
Disease related to environmental degradation and methods of food production	Eco-sensitive foods (e.g. produced in sustainable ways; biodegradable or edible packaging; identifiable bio-security for animal-derived foods; nature of genetic material
Food shortage and PEM	Technologies that minimize post-harvest loss, increase shelf life and maintain palatability
Disease related to protein quality, fat quality and micronutrient status	Nutrient-dense foods; fish or its plant or microbial food surrogates
Physical inactivity and health (especially over fatness, also loss of lean mass particularly muscle	Food of low energy density and high nutrient density
Phytochemical deficiency disorders including menopause, macular degeneration, osteopenia	Greater emphases on plant-derived foods and their variety
Diseases of changing demography	Anti-ageing food, especially ones to delay body compositional change (bone, muscle and fat); loss of sensory function; decline in immune function; proneness to neoplastic disease; decline in cardio-respiratory function; and decline in cognitive function; and anti-inflammatory foods.
Ageing	
Rapid loss of traditional food culture and	
Acquisition of new food cultures	Maintenance of traditional foods in convenient, affordable and recognizable form
New psycho-social stressors and mood change	Food that favourably affects mood
Food that favourably affects mood of foods	Pre- and pro-biotic foods. Immune system enhancing foods
Illness related to the chemical safety of foods (e.g., pesticide residues)	Regional origin and certification of foods

3.4.2 Conceptualisation of a food multimix (FMM)

A study by Amuna *et al.* (2004) showed that in food-insecure environments, there was a possibility to improve the nutritive value of locally grown foods through a simple but scientific combination of food ingredients in the form of food multimixes.

Amuna *et al.* (2000) and Zotor *et al.* (2002) describe a food multimix as the blending of locally available, affordable, culturally acceptable and commonly eaten foodstuffs, mixed proportionally in order to meet nutritive values of the end-product, without the requirement for fortification food multimixes. The optimization process includes scientific approaches, principles and basic methods to be employed. Basic methods of food preparation include: roasting, boiling, grading and pureeing. These methods are more affordable than food fortification or supplementation, and can be easily implemented. Initiatives in developing countries to enhance the health and nutritional status through food fortification and supplementation programmes, have mixed outcomes in terms of their impact on the overall nutritional status and health of people (Ramakrishnan, 2002:s47; Amuna *et al.*, 2004:5).

In this study design basic methods of food preparation were utilised and blending of multimixes undertaken for smoother consistency. The target ratio percentage of energy from protein; carbohydrates: fat, was approximately 20,50 and 30 respectively (Amuna *et al.*, 2004:5)

A study by Amuna *et al.* (2000) showed that it is possible to advance the nutritive value of local foods through simple combinations of food ingredients in the form of food multimixes. The purpose of this study was to demonstrate the approach used in the development of the suitable FMM and how the products can provide sufficient nutrients in the daily complex diets of the poor, food-insecure communities as a nutrient intervention. There was also an attempt to make the FMM approach a medium to long-term adjunct to community-based rural integration projects intended to improve health and economic empowerment in Sub-Saharan Africa (Amuna *et al.*, 2004:5).

Food combinations have been in existence for centuries and maybe people were not aware when mixing different food groups to prepare a meal that they actually are formulating a multimix. There are several food items that were formulated using different names such as a basic mix and weaning mix (Cameron *et al,* 1983:117). Although this strategy was described in the literature in 1974 (Gopaldas) and 1983, it was not explored until in the 1990's when Zotor and Onofiok & Nanyelugo in Nigeria re-visited this. As a result few studies have published on this concept.

In this era there is a high rate of people suffering from HIV and malnutrition due to changing times, and there is a need for affordable high protein and nutrient dense food products using local food stuffs. Therefore, the food multimixes will be designed in a way that it provides nutritional support and improves the survival rates in the absence of drugs and supplements. Food multimix products have been designed in order to be reproduced in developing countries without utilising the scientific method and technology (University of Greenwhich Press Release: 2004:1).

In 1974 Gopaldas, searched for low-cost weaning and young toddler foods. The mixture of at least some of the preferred characteristics of high nutrient density, low bulk properties, utilization of low-cost and widely used cereals, pulses and oilseeds, and traditional processing methods that have the potential of being easily adopted at the home or village level were discovered (Gopaldas, 1974). In Gujarat formulations included low cost and widely used cereals, pulses and oil seeds. The inclusion or the exclusion of the oil seed in the ragigreen gram formulations shows its highest nutritive value in the weaning foods. The size of cereal to pulse or of cereal to pulse to oil seed were kept simple, as the vital purpose was to transfer the technology to the household and village level. The addition of oil seeds was to have a more nutrient-dense formulation whereas their omission was to reduce cost (Gopaldas, 1974).

The main steps of malting are steeping, germination, roasting and milling and were standardized on the basis of organoleptic acceptance, particularly for taste.

- Steeping means that all the seeds gave best results when soaked in an equal volume of water at room temperature (25° - 30° C) for 12 hours.
- Germination involves the wrapping of the seeds in damp muslin cloth for germination at room temperature, and arresting germination at 24 - 48 hours.
- Roasting and milling. Roasting was done in an electric oven at 110°C ± 3°C at different intervals for the variety of products (Gopaldas, 1974).

In Ghana low-cost, nutritious, well-balanced weaning foods rich in protein and energy were developed from locally available foods. One such weaning mix is a blend of legume (groundnut and/or cowpea) and cereal (maize) in the ratio of 1:4 w/w. Takyi *et al.*(1991:36) on the other hand suggested that alfalfa could be included in the weaning diet of infants. This legume was found to contain higher levels of protein, minerals, and β-carotene and could support child growth better the than weaning mix (Onofiok & Nanyelugo, 1998).

In Nigeria many researchers have worked extensively on cereal-legume combinations for example, a formulated nut-ogi (a mixture of corn gruel and peanut), soya-ogi (corn gruel plus soya bean), and the cerebabe (corn plus cowpea). Other useful combinations include ogi and melon protein (com gruel plus melon seed) and cowpea-ogi. Some of these combinations have been adopted by the food-processing industries and are available in the Nigerian market (Onofiok & Nanyelugo *et al.*, 1998).

3.4.2.1 General considerations

Several food items constitute a meal and each food item supplies some energy and different nutrients, all of which are combined in the meal. It is essential that foods be in the right amount so that there is an adequate balance between nutrients and energy. The foods chosen for the multimix should be easily available from the gardens or local markets, affordable in price, culturally acceptable and regularly utilised in most households. Local methods for food preparation and cooking are used which require less time and as little fuel as possible (i.e. to prepare) (Gopaldas, 1974; Cameron *et al.*, 1983:117). Operating principles in ingredient identification and FMM formulation are (Amuna *et al.*, 2000):

- **Stage one**

A: Identify the nutritional needs and/or limiting nutrients for target group or disease condition.

B: Make a list of foods from food composition tables that are major sources of these nutrients.

C: Determine whether foods are commonly available and affordable in the local community or if there are other sources at relatively low-cost.

D: Select at least one food ingredient from each of the major food groups and ensure a target total number of foods to no more than five per recipe.

E: Food selection should be based on 'nutrient strength' to be determined in stage two.

F: Use the food composition table and the Excel spreadsheet to arrive at the proportion of nutrient per weight selected.

- **Stage two**

Selection of ingredients from food composition table based on the following possible considerations:

A: Meeting energy and macronutrient needs.

A1: Selection of local staples which major carbohydrate sources e.g., millet, maize, sorghum and rice. (Relative fibre content was also considered in relation to target group requirement e.g. elderly people).

A2: Meeting protein needs: e.g., eggs, dried fish and legumes (helpful in body's enzyme production and proper function of immune system, relatively low cost, high biological value were considered).

A3: Meeting lipid/fat needs: (e.g. vegetable oils, nuts and pulses and other nutrients contained in nuts and pulses considered as rich sources of n-3, n-6 MUFA and PUFA, anti-oxidant minerals and as vehicle for absorbing important fat-soluble vitamins (antioxidant vitamins e.g. A and E); relatively available and at low cost.

To determine the total energy content for the food, apply the Atwater factors to calculate energy from protein (amount in grams X 4 kcal), carbohydrate (amount in grams X 3.75 kcal) and fat content (determined by amount in grams X 9 kcal).

B: Meeting mineral requirements: major sources e.g. spinach, tomatoes, carrot beans, which are rich in nutrients that will complement other ingredients of the multimix in bringing about a food-to-food fortification.

C: Meeting vitamin requirements: sources e.g. meats, eggs, tomatoes, carrots, citrus fruits which will improve nutrient strengths in the multimix.

- **Stage three**

A: Targeted energy density should be between (15,01–18,77kJ/g) so that relatively small packaged quantities can provide high energy. Further increases in energy density may be obtained by adding vegetable oil where appropriate.

B: Aim to achieve a targeted index of nutritional quality (INQ) score of 1,0 or higher to assure good quality of product.

C: Ensure adequacy of mineral and vitamin content of multimixes taking into account possible losses during processing and product development, but at the same time, avoid undue overloading with certain micronutrients e.g. iron which may have pro-oxidant properties in excessive amounts

D: Avoid excessive amounts of certain nutrients e.g. iron in malnutrition and high fibre in weanings. Ensure clinical or dietetic needs are met with possible minimal exposure to anti-nutritional factors.

E: Consider sensory factors e.g. coarseness, dryness of product, taste characteristics during recipe and product development stages.

3.4.2.2 Guidelines for planning a multimix

There are several steps that need to be followed when formulating a multimix. The flow diagram below indicates all the steps involved in the development and optimization of a food multimix (Amuna *et al*, 2004).

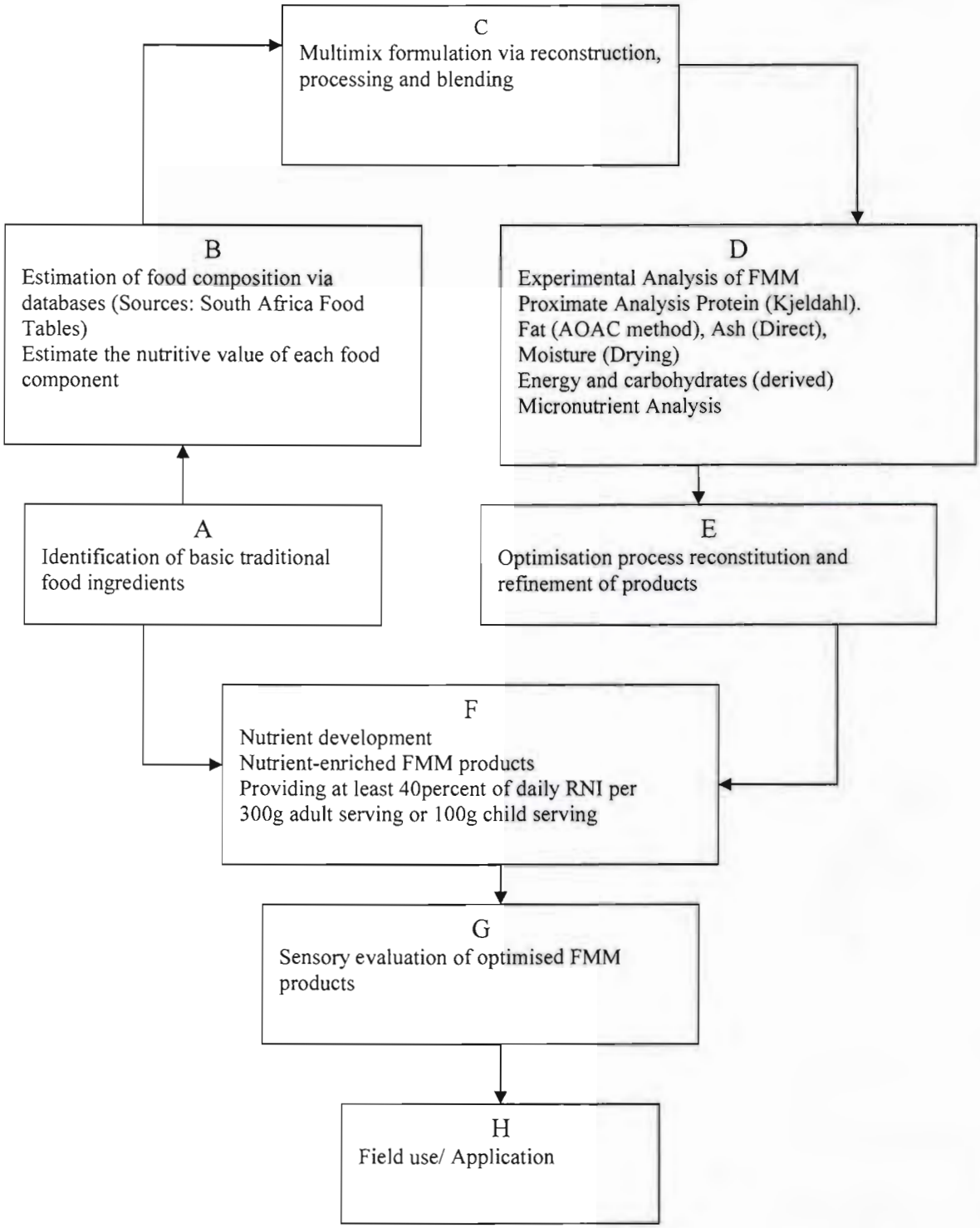

Figure 11 Steps involved in multimix formation (Amuna *et al.*, 2004)

3.4.3 Economic benefits of investing in nutrition

Investing in excellent nutrition can result in social and economic returns provided that it is strongly based on principles of effective community participation. Reimbursement includes good quality of life, high productivity cognitive and good economic returns. In children, the investment results in an increase in their capability attendance rate and intellectual performance in school. In addition adequate returns in investment made in the educational sector can be realized (see Figure 12 below) (FAO, 2004).

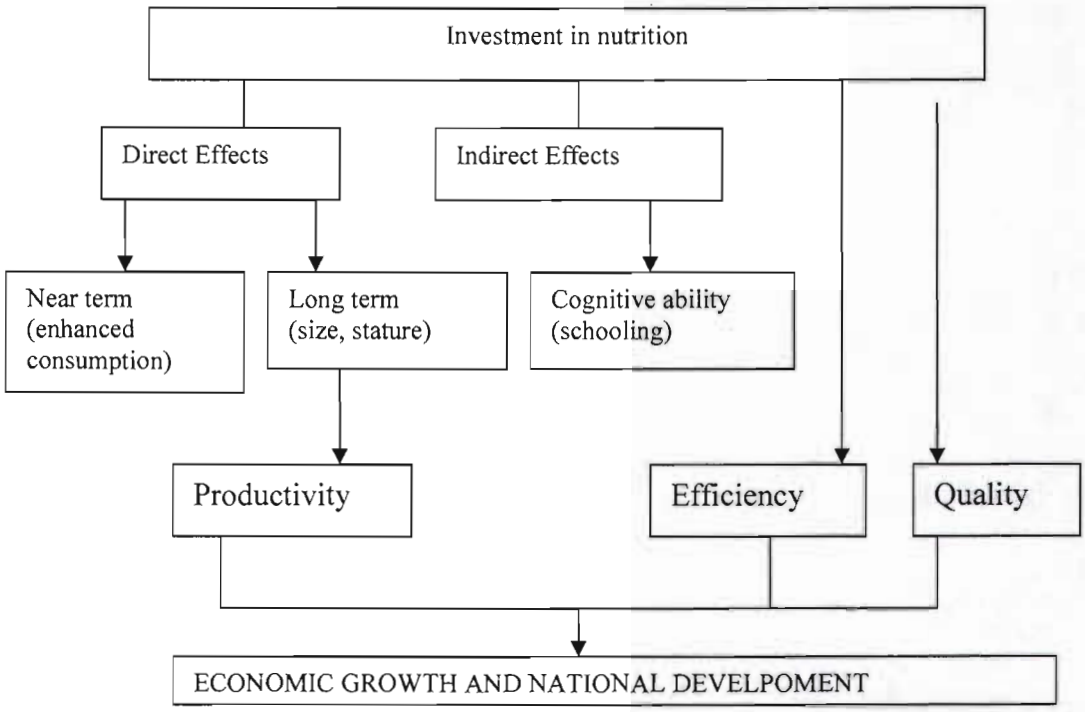

Figure 12 Economic growth and nutritional development (FAO 2004)

The development and implementation of a FMM can be an investment in nutrition as more nutrients can be consumed (direct effect) and thus assist with cognitive ability of children (indirect ability). Furthermore, this food product could be produced and marketed and contribute to income-generation and thus economic growth in the specific country of production.

3.5 CONCLUSION

Malnutrition is prevalent amongst the elderly and is linked to important adverse health outcomes, continuous disability and increased mortality. Appropriate nutrition may result in a longer life span and productive life. Understanding nutrient requirements is essential for health in the future. Helping to correct malnutrition problems nutrition intervention and dietary diversification may be implemented.

Strategies for addressing malnutrition that have been discussed in this chapter are supplementation, fortification, diversification, food novel products and nutrition education. Nutrition plays a major role in determining people's state of health and their susceptibility to diseases. By improving nutritional practices, especially of the elderly, many diseases could be potentially delayed. These diseases include arthritis, osteoporosis, cardiovascular disease and strokes, which are situations which can thus save money in annual health care costs. Nutrients such as multivitamins, B vitamins including folic acid, antioxidants including vitamin C and vitamin E, calcium and vitamin D and essential fatty acids (EFAs) have the potential for improving health and delaying the onset of many age related diseases. The FFM can be developed to address specific nutrient deficiencies or a combination of deficiencies. The FMM is the cheapest strategy to address malnutrition and all the ingredients used to formulate it are used by the target group. The FMM strategy can be also be used to strengthen the food intake through the combination of various, scant ingredients and providing maximum nutrition value with small quantities.

In the next chapter the methodology used in this research will be provided.

CHAPTER 4: METHODOLOGY

4.1 INTRODUCTION

Elderly people are becoming fast growing segment of the populations of developing countries. Although there is little data that exists, it is important to assess the nutritional status of elderly people because of its role in ensuring a better quality of life and its association with functional ability (HAI, 2002:21; Kikafunda & Luwango, 2005:1)

In a study carried out in SA as part of determining the prevalence of malnutrition amongst the elderly in developing countries, the research revealed there is poor nutritional status of elderly men and women (Charlton, 2001:33).

The purpose of this study was to determine the nutritional status and consumption patterns of elderly people at the care centre in Sharpeville in order to develop a nutrient dense, financially affordable and culturally acceptable novel food to address the possibleprevalence of malnutrition amongst the elderly.

The methods for each of these phases will be discussed in this chapter

4.2 ETHICAL CONSIDERATIONS

The ethics committee for research on human beings at the University of the Witwatersrand approved the study (R14/49). All volunteer participants were requested to sign the consent form. Prior to the study being implemented numbers were allocated to each subject in order to ensure confidentiality of information or the data collected from the elderly.

4.3 STUDY DESIGN

This study was carried out in four phases:

Phase 1: Planning the study design.

Phase 2: Baseline survey.

Phase3: The development of a multimix, calculation of composition, sensory evaluation and data analyses.

Phase 4: The report writing, recommendation for field use and doctoral studies in future.

4.3.1 Phase 1: Planning study design

4.3.1.1 Initial planning and administration

The planning procedure consisted of three steps:

- analysing the available scientific literature;
- writing the research proposal; and
- holding a planned participatory workshop with all the stakeholders.

The initial step was to visit the care centre in Sharpeville to obtain permission for conducting the research and prior evaluation. Prior to the data collection, the researcher explained the survey protocol to the staff and the elderly people at the care centre to gain their cooperation. The introductory visits were made to the care centre in Sharpeville for observation purposes prior to the base line survey, as to check on how many elderly people attended the centre and to recruit the elderly to form part of the study, and also to evaluate the kitchen and whether kitchen staff are able to prepare the menus. Adequate information was required about the nutritional status and dietary intake of the elderly people, specifically those living in a poor socio-economic background, as well as the food consumption patterns of these elderly people. The study and its benefits were explained the elderly. The consent from the elderly attending the care centre in Sharpeville was gained.

4.3.2 Phase 2: Baseline survey

A baseline survey was carried out in August 2004 to determine the prevalence, extent and underlying causes of malnutrition amongst the 300 elderly (≥ 60 years) people, receiving two meals per day at the in the care centre in Sharpeville from Mondays to Fridays.

4.3.2.1 Sampling strategy

One hundred and fifty subjects were randomly selected for the baseline survey which equals to 50 percent of the 300 elderly attending the care centre and should generate representative data. An extra 20 subjects were selected to make provision for possible dropouts throughout the duration of the project. Thus the sample size equated to 170. A cross-sectional survey (n=170), including males and females aged sixty and above attending the care centre in Sharpeville was conducted.

The inclusion and exclusion criteria included the following:

The inclusion criteria were elderly subjects regularly attending the care centre in Sharpeville, Vaal Triangle, ≥ 60 years old.

4.3.2.2 Fieldworkers

Eight fieldworkers were recruited from the third year and post graduate Vaal University of Technology students in the Department Hospitality and Tourism. All were able to speak the local languages in order to avoid the language barriers. The field workers were trained on how to approach the subjects, administer the QFFQ and how to take anthropometric measurements through demonstrations and role-play. The fieldworkers were trained by the researcher and Dr Salami, a nutritionist, on how to complete the QFFQ accurately with the use of food models to estimate the portion sizes accurately and to identify the unfamiliar foods. Various participatory facilitating methods were used in the training including case studies, role-plays and communication skills. English was the medium of instruction for the training sessions and fieldworker guidelines were also printed in English. The importance was cited on ensuring that the fieldworkers were aware of the objectives and importance of the project.

4.3.2.3 The study type and setting

The number and the proportion of the elderly persons was defined as those aged sixty and above for both men and women eligible for social pension (WHO, 2002 & Kinsella, 1997). The sample population consisted of 170 randomly selected elderly people in the care centre in Sharpeville, age ≥ 60 years.

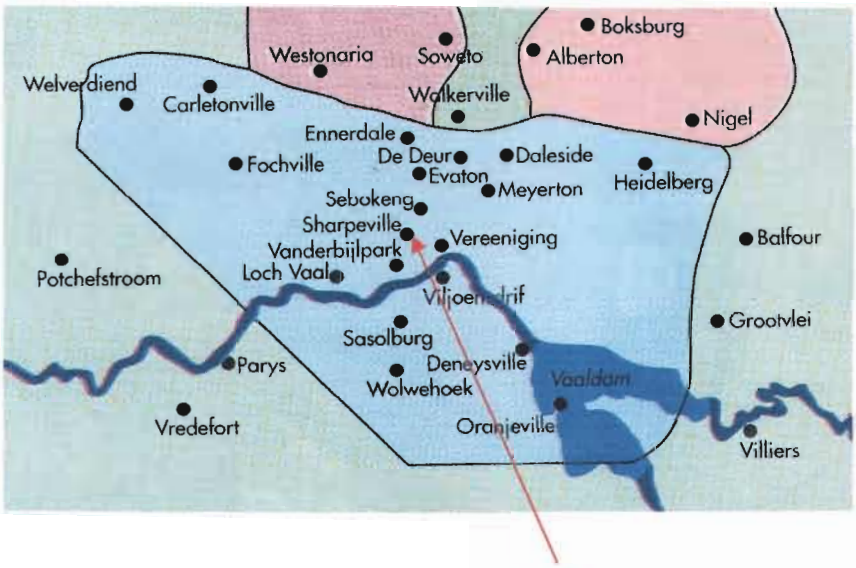

Figure 13 The map of Vaal Triangle

4.3.2.4 The measuring instruments

Different types of questionnaires were compiled and used in this study as follows:

- **Socio-demographic questionnaire**

A socio-demographic questionnaire was compiled in English and tested for reliability (see annexure B). The socio-demographic questionnaire included questions on age, the role of the elderly in the family, marital status, level of education, income level of the family, monthly income per household and number of people in the household. One hundred and seventy questionnaires were completed.

Demographic data such as age, gender of the subjects, home language, education, cooking activities and person responsible for preparing meals in the household were also obtained. Physical and infrastructure data such as the residence setting, number of

residents in a household, number of rooms, number of rooms used for sleeping, water storage, fuel usage, household pets. Socio-economic factors such as health, food, sources of livelihood, income generating activities, employment status, household assets, environmental sanitation and protection and education were recorded.

- Health questionnaire

The health questionnaire was also compiled in English and tested for reliability (see Annexure C). The health questionnaire focused on health conditions of the elderly. The health questionnaire included a detailed coverage of the nature and severity, as well as the duration of illness, description of appetite, loss of weight, the following of a special diet, the use of alcohol, and whether the respondents smoked.

- **Dietary intake data**

Dietary data such as dietary intake, food procurement behaviour and nutritional status was collected with the use of the 24-hour recall (see annexure D).

QFFQ was adapted from the validated QFFQ of the transition and health during urbanization in Southern Africa (THUSA) study (MacIntyre, 1998:2000) and used for this project in order to determine the usual food consumption patterns and dietary intake of subjects. The elderly people got tired when filling in the long questionnaire. Only ±10 questionnaires were completed. Therefore, the QFFQ's were discarded from the study, because the questionnaire was too long and time consuming, and elderly lost interest and fell asleep.

- **Twenty-four hour recall questionnaire**

A structured 24-hour recall questionnaire was drawn up and tested for reliability. The twenty-four hour recall questionnaire was used to determine the food items that were actually consumed and the portion sizes and mean daily nutrient intake by the elderly people. Food models were simultaneously used to determine portion sizes and field workers explained the food items to the subjects. The same subjects completed the twenty-four hour recall questionnaires four times at one-month intervals. This comprised

of one weekday, a weekend, especially a Sunday, end-of-the-month and middle-of-the-month in order to get clear information on food consumption. Then the top twenty food items consumed were determined. These were compared to determine the correlation and thus reliability of the data.

4.3.2.5 Blood sampling and biochemistry

A venous blood sample was drawn by a registered sister from a randomly selected sub-sample of 50 elderly people between 07H30-10H00 and analysed for full blood count, serum vitamin A, iron status (feritin, serum, iron, transferrin heamoglobin, heamocrit), zinc, folate, total cholesterol. A trained nursing sister measured blood pressure and a registered haematologist did blood analyses. Blood was separated (centrifuged at 1.500Xg for 20 min.) within 2 hours of blood collection. Separated plasma and serum were eliquoted in marked Eppendorf test tubes. Two qualified medical technologists continuously audited the separating procedure. Serum for the analyses of serum iron, transferrin, ferritin, total protein and albumin were stored at -10°C until analysis. Serum for serum retinol, vitamin E and zinc analysis was covered by aluminium foil and stored at -10°C until couriered to the Nutritional Intervention Research Unit of the MRC in Cape Town. The methods for blood analyses are shown in Table 15:

Table 15: Methods for blood analysis and summary for serum variable analysis

Variable	Method	Laboratory
Haemotacrit (Hct)	Numeric integration, Sysmex SF 300	Vaal University of Technology
Haemoglobin(Hb)	Cyanmethaemoglobin-colorimetric method, Sysmex SF 300	Vaal University of Technology
Mean cell volume (MCV)	Impulse generating Sysmex SF 300	Vaal University of Technology
Red blood cell count(RBC)	Direct current detection, Sysmex SF300	Vaal University of Technology
White blood cell count(WBC)	Flow cytometry with dual angle light care centre in Sharpevillettering analysis, Sysmex SF 300	Vaal University of Technology
Serum ferritin	Immunoturbidity;Roche	Vaal University of Technology
Total protein	Colormetric method, Konelab 20i	Vaal University of Technology
Albumin	Colormetric method, Konelab 20i	Vaal University of Technology
Serum iron	Colormetric method, Konelab 20i	Vaal University of Technology
Serum transferrin	Colormetric method, Konelab 20i	Vaal University of Technology
Zinc	Atomic absorption	Medical Research Council, Cape Town
Vitamin A,E	High performance liquid chromatography	Medical Research Council, Cape Town

4.3.2.6 Anthropometric measurements

Anthropometric measurements included weight, height, mid-upper arm circumference (MUAC) and waist circumference.

a) Weight

Two field workers were responsible for measuring weight and height and recording these results.

All the elderly people were measured for weight wearing light clothes without shoes. The body weight was determined to the nearest 0.1 kg using a standardised bathroom

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

The scale was placed on an uncarpeted area with the spirit level indication in the middle. The scale was switched on and waited until the zero indication (0,0) appeared as well as the stable indicator (^{o} in the top left-hand corner of the display panel). The subjects were weighed with light clothes, without shoes. They had to stand upright in the platform, facing the fieldworker and looking straight ahead. Their feet had to be flat and slightly apart. They had to stand still until the measurements were recorded in the space provided on the form. The subject had to step down from the scale and wait for zero reading to appear on the digital display. Then the procedure was repeated (SAVACG, 1995: 100-101, Whitney *et al*., 2005: E-6). The weight was determined to the nearest kg and the body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2).

b) Height

The height measurements were carried as follows:

- The subject had to remove his/her shoes.
- The subject was positioned as follows:
- Facing the fieldworker.
- shoulders relaxed, with shoulders, buttocks and heels touching each other against the wall,
- arms relaxed at the sides and legs straight and knees together,
- feet flat, heels touching.
- The subject had to look straight ahead before the headpiece.
- The fieldworker recorded the reading in mm in the anthropometric measurement space provided on the demographic questionnaire. The procedure was repeated twice. The two readings did not vary by more than 5mm and these measurements were taken to the nearest 0,5 cm by using a stadiometer (SAVACG, 1995:103, Whitney *et al*., 2005: E-6).

c) Mid- upper arm circumference

Mid-arm muscle circumference of the subjects was measured midway between the lateral projection of the acromion process of the scapula and the inferior margin of the olecranon process of the ulna. The middle point was marked with the elbow flexed at 90 degrees. The measurement was made with a flexible steel tape to the nearest 0,1 cm with the arm hanging loosely at the side of the body (European Health Risk Monitoring (EHRM), 2002).

Figure 14 Mid Arm Circumference (General Research Center 2002)

d) Waist circumference measurement procedure

The person who took the measurements stood at the side of the participant in order to have a clear view. Participants were standing with their feet fairly close together (about 12-15 cm) with their weight equally distributed on each leg. Participants were asked to breathe normal. The reading of the measurement was taken at the end of gentle exhaling. This prevented subjects from contracting their abdominal muscles or from holding their breath. The subjects were dressed lightly and the tape measure was wrapped around the waist. Waist circumference was measured at a level between the lower rib and iliac crest with the tape around the body in a horizontal position. The measuring tape was held firmly, ensuring its horizontal position. The tape was loose enough to allow the observer to place one finger between the tape and the subject's body, and then the readings were written down. The procedure was repeated twice (EHRM, 2002).

Figure 15: The position of the measuring tape and placement (EHRM 2002)

e) Biochemical measurements

A sub-sample of 80 blood samples were drawn by a qualified nursing sister in order to determine the serum vitamin A and E, haemoglobin, haematocrit (Hct) mean cell volume, RBC, WBC zinc, ferritin, transferring protein albumin and iron. A sub-sample was used due to the expense of the blood analysis. Blood was drawn from the *vena cephalica* of the seated subject after an 8-12 hour fast using a vacutainer needle, with minimal use of tourniquets. A qualified nursing sister collected all the blood samples from the subjects. Vacutainer blood collecting tubes were labelled in advance with the subject's trial number as well as the week number. Blood was collected as follows:

- 5ml Blood in an EDTA tube (purple lid) for full blood counts (Hb, Hct, RBC, MCV and WBC).
- 10ml Blood in a silicone-coated tube for preparation of serum for the analyses of ferritin, serum iron, transferrin, total protein, albumin.
- 10 ml Blood in a silicone-tube for preparation of serum for analysis of serum vitamin A, vitamin E and Zinc analysis. This tube was immediately (after collection) protected against UV light, by covering the tube with aluminium foil.

The blood was separated (centrifuged at 1,500Xg for 20 min) within two hours of blood collection. Separated plasma and serum were aliquoted in marked Eppendorf test tubes. Serum for the analyses of serum iron, transferring, ferritin, total protein and albumin were stored at -10°C until the analsis. Serum for serum vitamin A, vitamin E and zinc analysis was covered by an aluminium foil and stored at -10°C until sent to the National Intervention Research Unit at MRC in Cape Town.

4.3.2.7 Data analysis

Socio-demographic, health, anthropometric and biochemical were captured on an Excel® spread sheet.

- **Socio-demographic questionnaires**

After completing the fieldwork, questionnaires were sorted and checked for completeness, accuracy and sustainability by the researcher and n=170 were usable. The data on the questionnaire was captured on an Excel® spread sheet by the researcher. The demographic questionnaires were analysed by utilizing the SPSS for Windows version 10,0 programme. Descriptive statistics (frequencies, means, standard deviations and confidence intervals) were determined with the assistance of a well trained data capturer. Tables were drawn up with the percentages of the different variables included on the questionnaire. Standardised methods were used. Data were presented in terms of frequencies and percentages for the various categories.

- **A 24-hour recall questionnaire**

Twenty four hour recall questionnaires were completed during the personal interviews with the elderly people. Food models were used to assist in the quantification of the portion sizes. Data was captured and analysed by a qualified dietician using a Food Finder ® version 3,0 programme, based on the SA food composition tables (Langenhoven *et al.*, 1991) in order to determine the frequency mean and standard deviations. For both the anthropometric and biochemical measurements, SPSS version

12,0 for Windows was used to analyse continuous data and results were expressed as mean ± SD, median, minimum and maximum.

- **Anthropometric measurements**

All weight and height averages (average of the two readings were captured on an Excel spread). Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). MUAC and waist circumference measurements were captured on an Excel spreadsheet and converted to SPPS for description statistics (means+SDs).

- **Biochemical analysis**

Data was captured on Excel spreadsheets and analysed with the assistance of statistician for means and standard deviations and compared to the normal ranges for elderly people.

4.3.3 Phase three

Involves all stages occurring during development of the multimix and the processing.

4.3.3.1 Development of Food Multimix

The procedures carried out in the development of food multimix are illustrated following the steps in the Figure 16.

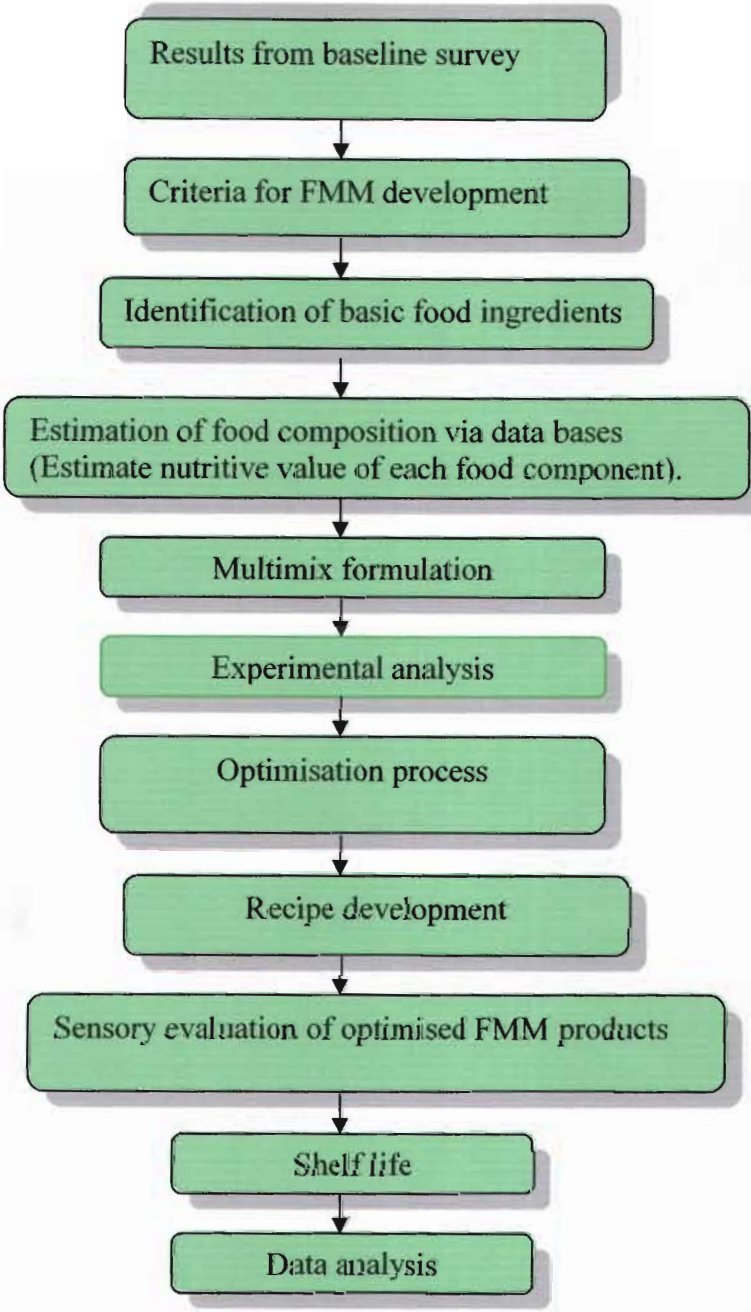

Figure 16 FMM conceptual framework phase three

4.3.3.2 Criteria for FMM formulation

The baseline results, the 24-hour recall questionnaire, health questionnaire and biochemical analysis indicated that there was prevalence of over-nutrition, hypertension and low intake of zinc amongst the elderly. These results were used for the formulation of the FMM. The FMM was developed using locally available major staples and the top 20 food items consumed were used as basis for the formulation of the FMM. The ingredients were selected to complement each other in nutrient strength. Examples

chosen for the multimix were maize-meal (maize) from the cereal group, kidney beans (legumes and pulses), spinach and tomatoes (vegetable group), milk powder (animal protein) and vegetable oil (fat group). These ingredients were mostly consumed by the elderly and also appeared on the list of top twenty food items (consumed by elderly) and were more affordable and readily available. The range of food commodities thus employed and identified are summarized in below. Quality control was achieved by adopting operating procedures that are internationally accepted as standards for food production, the Codex Alimentarius and the Hazard Analysis and Critical Control Point Programme.

Table 16: Summary of range of the foods that were employed in FMM formulation (Zotor, 2002)

Food Group/Commodities	Rationale for inclusion
Staple Foods (cereals, grains & tubers) maize *Legumes and pulses* kidney beans	Major staples commonly consumed and low-cost which form primary energy sources for the majority. The list reflects availability and consumption in different ecological zones within the country. Millet has the extra advantage of providing plant protein and a relatively good source of iron; potatoes have added value of beta carotene.
Vegetables and fruits spinach tomatoes	Excellent and inexpensive sources proteins and fibre; seasonality, locally accessible, affordable and are a good source of micronutrients Can be grown all throughout the year and are good sources of micronutrients (essential vitamins and minerals) complementary to other foods which are nutrient limiting. Low in fat and high in dietary fibre and complex carbohydrates
Animal protein and other nutrient sources milk powder	Rich micronutrient sources and of nutrients unavailable in adequate amounts from plant sources e.g. vitamin B_{12}

In the above table estimates of energy and nutrient content of each food ingredient (commodity) were determined using standard food composition databases (Langenhoven *et al.*, 1991).

- **The underlying principle for choice of food ingredients employed**

The FFM concept is built around obtaining a low cost, high value food product to meet the needs of vulnerable groups in poor and food insecure environments. The concept also depends primarily on using ingredients that are both familiar to and are commonly consumed by the elderly. ,Based on application of science of nutrition in order to maximize possible nutritional benefits of their consumption.

4.3.3.3 Identification of basic food ingredients

Locally available and commonly consumed staples and other major commodities were identified. There was a selection of foods that were cost effective and culturally acceptable to the subjects. A FMM was planned with a balanced nutritional value rich in energy, zinc and iron. It was an easy to prepare product with minimal waste. A target of a maximum of five food ingredients was selected to form the basis of the recipe for a composite product, the basis being that the more constituents of a multimix, the higher the cost and that would be counter-productive with respect to the FMM concept aimed at a low cost, high value product

To ensure maximum nutritional benefit it was necessary to consider other foods which would complement the staples. Vegetables e.g. spinach, tomatoes and carrots were chosen for their 'strengths' in micronutrients particularly B-vitamins, folate and beta-carotene (carrots and sweet potatoes) as well as minerals e.g. iron and zinc (spinach). These ingredients are grown across all ecological zones of the country and the effect of seasonality is relatively limited because of a home-gardening culture in the country. The bulk of ingredients in a multimix were plant-based, however, and dairy products (mainly milk) were included where appropriate to increase the biological value of proteins in the recipes as well as to provide other essential minerals and vitamins.

4.3.3.4 Estimation of food composition via data bases

The initial estimates of energy and nutrient content of the ingredients needed the appropriate food databases. Therefore, the FMM was developed and combined into a meal that provides at least 30percent of the dietary reference intake (DRI's) for energy and micronutrient requirements of the elderly. The nutrient content was calculated using

the SA food composition data (Langenhoven *et al.*, 1991) and the Food Finder programme was used.

The South African food composition tables were utilised to calculate the theoretical calculations of the multimix. Firstly the codes for food items were identified and entered in weights in the Food Finder programme. The ingredients were then added to a recipe analysis section of the programme in order to establish their theoretical value.

4.3.3.5 Multimix formulation

The initial step was to draw up a list of the required ingredients purchased for the formulation of the multimix. A drying process and chemical analysis were also involved so as to ensure adherence to the objectives of obtaining at least one-third of the daily requirements. The multimix was then developed into recipes for the sensory evaluation. The products formulated form the recipes and multimix powder was also analysed for the shelf life. Out of the top twenty food items maize meal, dried spinach, low fat milk powder, dried kidney beans, and cooking oil were selected using South African food composition tables. All the products were weighed before drying and after drying in order to determine the moisture lost during the drying period. Other food items were in a raw state and fresh, therefore, some required drying. The purpose of drying further the dried food items was to:

- To enhance the flavour.
- To reduce the cooking time.
- To reduce the moisture content and increase storage period and
- Prolong the preservation period (Amuna, Zotor, Chinyanga, & Sumar 2000:121and WHO/NUT, 1998:127).

4.3.3.5.1 Drying procedure

The highest standards of hygienic measures were taken into consideration to prevent any form of cross-contamination throughout the preparation process. The steps taken included the sanitising of all surfaces and equipment before starting with any procedure in the laboratory and safety gloves, mouth mask, hat and laboratory jacket were worn all

times. Food standards and safety procedures were adhered to at all the times to ensure that no cross-contamination occurred.

Oven drying was the easiest way to dry the food. It is also the quicker than sun drying or using a food dryer. Oven drying is essential for small quantities. The Rational convection oven was used to dry all the ingredients at 95°-120° at a set time depending on the type of quality and quantity of a product that was being dried. The food items were checked at 30 minute intervals in order to turn the product and to have even drying (avoid too much dying on one side). Each ingredient was dried separately as the moisture content varied. The maize meal and kidney beans were roasted to improve digestibility, flavour and to reduce cooking time. The beans contain an acid called phytic or phytate which is a phosphorus containing compound, found in the outer layer husks of the cereal grains. Phytic acid binds the micro-nutrients and inhibits the absorption. The compound's function is diminished by roasting, resulting in less binding of micro-nutrients and enhancing absorption within the body Anderson (2000:110-152). The spinach leaves were rinsed and the stalks removed due to too much water which takes longer to dry in the oven. The ratio of fresh and dried was determined by weighing the ingredients before and after the drying procedure.

Figure 17 Use of an accurate digital scale to weigh the powdered ingredients

4.3.3.5.2 The composition and blending of the food items

Kidney beans were ground using a coffee grinder (Princes) to make a super fine powder. All the ingredients were weighed according to their allocated grams and thoroughly mixed together to form a multimix. Then a 100g sample of a multimix was formulated as follows:

Mealie-meal 30g

Milk non-fat 15g

Kidney beans 25g

Spinach, dried 15g

Vegetable oil 15g

Afterwards all the ingredients were further mixed using the blender in order to have a thoroughly mixed multimix. The ratio of the energy percentage from the protein, carbohydrates and fat was designed taking into consideration the nutritional requirements of the elderly. The main objective was to achieve at least 30percent of the estimated average requirements (EAR) for energy in a 100g of the dry food FMM. The energy density ought to be high and achievable.

Figure 18 Blending of food items

4.3.3.5.3 The Index of Nutritional Quality (INQ)

The Index of Nutritional Quality (INQ) was used to detect the nutrient quality in the chosen foods. INQ is a concept of nutrient quality that allows the quantity of nutrient per 1000 kcal in a food, meal or diet to be compared with a nutrient standard (Lee & Nieman 2003). A food with an overall INQ greater than one is generally considered to be of good quality as it provides important nutrients in excess of calories.

Calculation of (INQ)

INQ = Amount of nutrient in 1 000kcal of food

Allowance of nutrient in 1 000 kcal of food

For example the protein content of an FMM was worked out to be 44g in 1 000kcal of energy RDA values for an adult male is 22g. Using the formula above the INQ for protein for the FMM sample would be 44 divided by 22 equals 2.0 .44/22=2.0. .

4.3.3.5.4 The costing of the multimix

It was important to develop an affordable multimix that is below cost in order to allow other food items and other needs of elderly to be meet. After calculation of the nutritional content of the multimixes, prices for food items used to prepare the multimix were obtained from nearby supermarkets and the price list was compiled. The known price for a particular quantity was multiplied with the quantity of the unknown price in order to determine the cost of a particular food item in the multimix per 100g. The affordable and cheapest multimix was selected for analysis.

4.3.3.6 Experimental analyses

Food composition tables give estimates of nutrient content of foods but this data may be incomplete. Regional or ecological differences may also affect nutrient content hence the differences commonly observed in the reporting of food data in nutrient databases.

Because of these variations, data may not be completely representative of the true macronutrient content of foods, hence the need to undertake proximate analyses (Damon, Zhang, Haytowitz and Booth, 2005:751). Proximate analysis was carried out to determine macronutrients such as energy, protein and carbohydrate and micronutrients such as zinc and iron content of multimixes. Carbohydrate and energy content were derived using data gained from the analytical procedures. Sub-samples of formulated FMM recipes were taken and prepared for analysis following the principles described by Pomeranz and Meloan (1994). Mineral content was determined by atomic absorption spectrometry (AAS) and/or inductively coupled plasma-mass spectrometry (ICP-MS). All the analyses were undertaken in triplicate.

4.3.3.6.1 Micronutrient analyses

The mineral content was determined by use of Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma Mass spectrometry (ICP-MS). Although the nature and qualitative composition of the FMM was generally known, there was a need for specific information of the nutrient content for the target group and qualitative analysis was carried out in order to establish how much of the micronutrient would be bio-available to the individual and whether the target group has being meet. The analytical procedure used as recommended by Pomeranz and Meloan (1994) FMM was prepared for analysis and converted into a form that allows an assay, calculation and interpretation of information.

4.3.3.6.2 Atomic Absorbance Spectroscopy method (AAS)

Principle

The FMM sample was heated in concentrated nitric acid and minerals bound in the sample were released, a process called thermal digestion. The AAS method was used to determine the mineral content in the digested sample by heating the aqueous sample in order to vaporize and atomise the minerals. A light of an appropriate wavelength for a particular element was shining through the flame. The atoms of the sample immersed some of this light. The concentration of the element was proportional to the amount of

light absorbed in the solution, and thus in the original object. Each element of interest was measured separately in order to attain a complete analysis of each sample

- **Instruments**

An AAS was used to determine the source of radiation and to calculate wavelength of atoms in the flame. An empty cathode formed a high intensity of radiation similar to that absorbed by the element to be determined in the flame. The chopper was required to produce a pulsating signal for easier amplification and to provide a means to differentiate hollow cathode radiation from flame radiation (Ceirwyn, 1999).

- **Calibration**

Standard solutions were assayed to get a standard curve for each mineral, which was utilised to determine the mineral content in the samples*1/10 dilution of stock. Each standard stock had strength of 1000ppm.

Table 17 Ppms of the standard solutions used for the AAS method

	Fe	Mg	Zn	Ca
Standard	Stock	Stock	Stock	Stock
	ppm	ppm	ppm	ppm
1	5,0	0,5	0,6	3,0
2	4,0	0,4	0,5	2,5
3	3,0	0,3	0,4	2,0
4	2,0	0,2	0,3	1,5
5	1,0	0,1	0,2	1,0

- **Procedures**

The 1,0g FMM samples were weighed using an analytical balance together with weight boat and placed in 2,5 x 30cm boiling tubes. The 10ml high-grade nitric acid (Aristar 68percent; BDH Laboratory Supplies, Poole, Dorset, UK) was measured and added to each boiling tube. Anti-bumping granules were also added to control boiling and the level of nitric acid marked. Then the tubes were placed in a heating block and held at

140-160°C for 90 minutes. The nitric acid level was regularly topped up as necessary. The tubes were allowed to cool off. The samples were accurately diluted to 50ml with ultra-pure water (conductivity of 0, 04 μS/cm) using a volumetric flask then assayed. There was further dilution of 1percent for the samples whose readings did not fall within that of the assayed standard solutions.

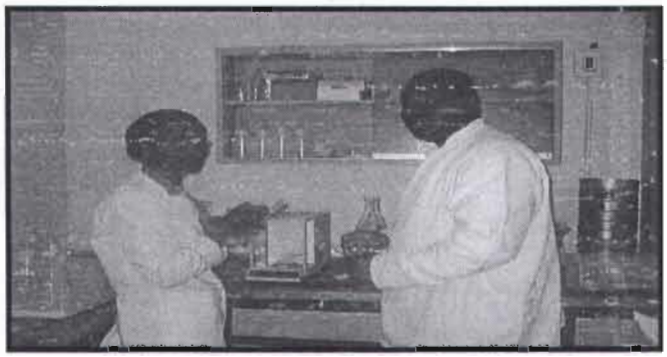

Figure 19 Labelling of the boiling tubes

4.3.3.6.3 The calculation of mineral content

The actual ppms for the samples were calculated using the following formula:

Ppm = Concentration x Dilution Factor/1000

For an example a material with a known iron content of 250/100g food gave a known Ca content of 208/100g food gave a reading of 0,062 after 1/10 dilution.

Ppm = 0,062*1/10

=10/1*0,062

Ppm =0,0062

4.3.3.6.4 Protein digestion and Kjeldahl protein analysis

- **Equipment**

Analytical balance - Sartorius 1801 (Sartorius GmbH, Gottinghen, Germany)

Boiling tubes (25 x 300) mm (Keldotherm; Gerhardt, Brackley, Northamptonshire, UK)

A 40-place standard heating block (Keldotherm; Gerhardt, Brackley, Northamptonshire, UK)

Spectrophotometer (UV-160A, UV-Visible Recording Spectrophotometer, Shimadzu, Japan).

- **Consumables**

Certified reference material - CRM 381 – rye flour is acceptable in the Community Bureau of Reference, Commission of the European Communities, Brussels and Belgium. All chemicals used were of analytical grade except for sodium hydroxide which was Aristar (Merck): Cupric sulphate pentahydrate ($CuSO_4.5H_2O$); sulphuric acid (H_2SO_4); sodium salicylate, (240g l^{-1}); sodium nitroprusside (1,4g l^{-1}); trisodium citrate (130g l^{-1}); sodium hydroxide (50g l^{-1}) and sodium dichloroisocyanurate (4g l^{-1}).

4.3.3.6.5 Digestion procedures

About 0,5 g triplicate samples of FMMs were weighed using a four-placed analytical balance (Sartorius 1801) (Sartorius GmbH, Gottinghen, Germany) and each one labelled and placed in 25 x 300 mm boiling tubes (which acted as self-contained air condensers). About 0,2 g cupric sulphate pentahydrate and anti-bumping crystals were added to each tube. 10ml concentrated sulphuric acid was then added cautiously using a digital pipette (Lab-3 adjustable volume digital pipette 1 000-5 000 ml capacity; National Labnet Company, Woodbridge, New Jersey, USA). The tubes were then placed in a Keldotherm thermal heating block held at 400°C for between 180 to 240 minutes until digests turned green. The temperature of the heating block where the thermal digests were carried out was monitored using a 500°C mercury thermometer (Fisher Scientific, Loughborough, UK). The level of concentrated sulphuric acid in each tube was periodically topped up to the 10 ml mark. All digestions were carried out in triplicate for each FMM and each digest was analysed separately.

Table 18: Steps involved in Kjeldahl method dilution process

Steps	Process	Dilution
1	Digestion: 0,5g in 10ml H_2SO_4	1:20
2	Dilution of the 10ml digest above to 250ml with H_2O	1:25
3	A further dilution involving taking 0.5ml from step 2 above and diluting to 50 ml using 1percent (v/v) H_2SO_4	1:100
Total Dilution	**(1:20 X 1:25 X 1:100) above**	**1:50,000**

After digestion, samples were taken and allowed to cool down to room temperature (approx. 25°C). Each digest was then transferred into 250 ml volumetric flasks, well mixed, and made to volume with ultra pure water (i.e. topped up to the 250 ml mark in each case) to act as stock. All water used was de-ionised to 0.05 μS cm^{-1} using a Purite reverse osmosis system (RO 200 fitted with a HP 700 cartridge) attached to a polishing cartridge (Still Plus HP, fitted with a N340 and C340 cartridge). A known volume of sample from each flask was transferred into labelled and sealed sample tubes and stored in a refrigerator at 4°C. For purposes of analysis, a further 1:100 dilution of the stored digest, in 1percent (v/v) sulphuric acid solution was carried out on the day samples were analysed.

Protein and other organic components of the FMM samples were digested with sulphuric acid in the presence of a copper sulphate catalyst. The extraction yields total nitrogen as ammonium sulphate. The organic nitrogen in the food reacted with hypochlorite (sodium dichloroisocyanurate) in the presence of a phenol source (sodium salicylate, chosen because of its low toxicity and ease of solubility in water) at a pH of 11.5 (Krom, 1980). The sodium dichloroisocyanurate, an organo-chlorite compound, was used as it will hydrolyse quantitatively to yield a more stable hypochlorite source. Sodium nitroprusside was used as a catalyst to accelerate dye formation and stabilise the indophenol dye. The nitroprusside also allowed the reaction to proceed with less dependence on pH so that a higher pH could be used without a reduction in colour development. Trisodium citrate (a chemical chelating agent) was present in the reactions to reduce interferences caused by metal ions (AOAC, 2000; FAO, 2003).

4.3.3.6.6 Manual method for protein determination

Two milliliters of each of the digests and standards were measured directly into plastic macrocuvettes of 4ml capacity (Fisher brand) using a digital pipette. The 1,0 ml of solution one (1) (50 g l^{-1} sodium hydroxide and 4 g l^{-1} sodium dichloroisocyanurate dissolved in water); was followed by 1,0ml of solution (2) (240 g l^{-1} sodium salicylate, 1,4 g l^{-1} sodium nitroprusside and 130g l^{-1} trisodium citrate dissolved in water). The cuvettes were covered with aluminium foil and stood at room temperature in the dark for 20 minutes until the absorbance to each cuvette was measured at 650 nm. Both solutions (1) and (2) are light sensitive and so were covered in aluminium foil. When stored at 22°C, solution (1) was stable for only five days whereas solution (2) could be stored for up to four weeks.

- **Calibration of protein standard**

A standard curve using a stock standard nitrogen solution prepared from ammonium sulphate at different dilutions in parts per million (ppm) is shown below in Table 19. A working standard of 10 ppm was used for the standard curve from which the nitrogen content and subsequently the protein content of FMMs were determined.

Table 19: Dilutions and concentrations (ppm) of standard solutions for spectrophotometer method

Tube number	[N] ppm	10 ppm standard nitrogen (mls)	1percent suplphuric acid (mls)
1	0	0	10
2	0,5	0,5	9,5
3	1	1	9
4	1,5	1,5	8,5
5	2	2	8
6	2,5	2,5	7,5
7	3	3	7
8	4	4	6

- **Preparation of nitrogen stock standard**

About 1 000 mg l^{-1} (1 000 ppm) nitrogen stock solution was prepared by dissolving 4,7193g of dry ammonium sulphate, in 1 percent (v/v) sulphuric acid. The ammonium sulphate was previously heated in an oven for 10 hours at 110°C and cooled in a dessicator before weighing. Nitrogen standard solutions were stabilised by storing in glass containers in a minimum of 1percent (v/v) H_2SO_4. All solutions were de-gassed in an ultrasonic bath before use.

Each sample, a blank and a refcrence material (CRM 381 – rye flour; Community Bureau of Reference, Commission of the European Communities, Brussels, Belgium) were digested. The standard curve was drawn by plotting known concentrations of standards in ppm against their corresponding absorbance at 650nm (UV-160A, UV-Visible Recording Spectrophotometer, Shimadzu and Japan). The concentration of protein (nitrogen) was derived from the standard curves in Figure 20.

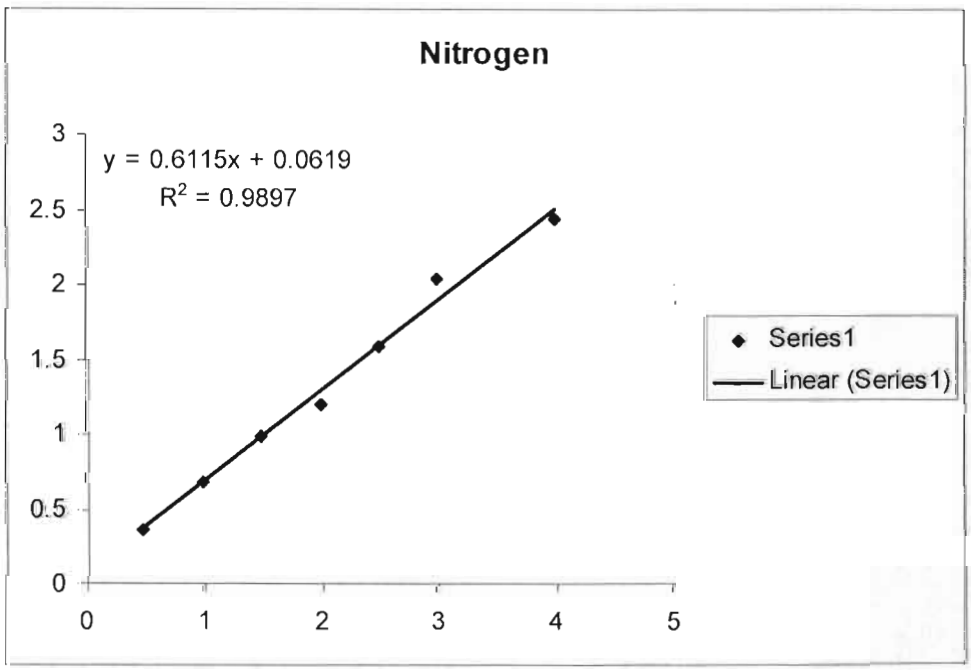

Figure 20 Standard curve for protein concentration using modified Kjeldahl by manual technique

4.3.3.6.7 Calculation of protein content

Readings obtained at a wavelength of 650 nm for each sample were plotted on the standard curve from which protein nitrogen values were subsequently derived. A solution with a concentration of 1 ppm has 1 g of substance for every million g of solution. This also implies one milligram of solute per litre of solution. By this definition, a 1 percent could also be said to have a concentration of 10,000 ppm. Since 1.0 ml of a substance contains 10,000 ppm from the stock standard nitrogen solution, the real ppm value was divided by 10.000 to obtain the amount in grams of nitrogen in 100g of food sample. The value obtained was later multiplied by the protein gram equivalent of 6,25 to get the protein value in grams per 100 g of food product. The dilution process was carried out to determine the true protein content in the FMMs by following the steps in Table 20. Any further dilution that was carried out on individual samples to give reading within standard curve was added to above total dilution.

- **Steps in the calculation of protein content**

A quadratic equation determined from the standard curve (from the standard nitrogen stock solutions) was used to determine nitrogen content of the samples at 650nm. The following calculation was used to calculate protein content of the samples.

A certified reference material (CRM 381) with a protein content of 8,948g/100 g food product gave on total dilution (dilution factor of 1: 50,000 see Table 20 above) an average absorbance reading (from triplicate readings) of 0, 29 at 650nm.

The equation from the standard curve is $y = 0{,}6115x + 0{,}0619$ (Figure 20 above)

Where x = unknown to be determined; and $y = 0.49$

Therefore, N (this is the x-value) calculated from curve (Figure 20 above):

$0{,}49 = 0{,}6115x + 0{,}0619$

$0{,}6115x = 0{,}49 - 0{,}0619$

x = (0,49 -0,0619)/ 0,6115

= 0,61341ppm:

Then multiply N ppm by dilution factor 50,000

N ppm = 0,61341 X 50000 =30670,48 ppm,

In converting ppm into percentage, 1percent = 10,000 ppm

This implies 30670,48 ppm (above) = 3,067percent

Then convert percent or g N into protein value using the factor 6.25 g protein = 1 g N

Therefore, 3,067 percent (g) X 6,25 = 19,169 percent or 19,169 g protein/100 g food

Percentage recovery=19,169x100/19 =100

Calculation of protein recovery using Kjeldahl method

Comparing experimental protein value to estimated calculation a recovery of 100percent was obtained. The recovery was calculated as follows:

CRM (theoretical) = 21,7g/100 g product

CRM (experimental) = 19,169g/100 g product

percent Lost = (21,7 – 19,1) x 100 / 21,7

percent Lost = (2,6 x 100)/21,7

[percent Recovery = 100 percent - percent Lost]

percent Recovery = 100 percent - 11,9 percent

percent Recovery = 88 percent

4.3.3.6.8 Fat Analysis by Hydrolysis Method

The dietary fat analysis method was adapted from an AOAC official method (922,06). This method utilised the organic solvents petroleum ether and hexane to break bonds between lipids and other compounds so that the free lipids can be solubilised and fat was extracted using alcohol and ether mixes.

Materials for Fat Analysis

Instrumentation and Equipment includes the following:

- Water Bath with sample agitator (Nickel-electro Ltd, Western Super Mare, Avon, UK)
- Oven (Gallenkamp hotbox oven, size 2, Gallenkemp, UK)
- Analytical balance (Satorius 1801, Sartorius GmbH, Gottinghen, Germany
- 100 ml conical flasks
- 10 ml measuring cylinder
- 5 ml volumetric flask
- 0 ml beakers, accurately weighed and dried to a constant weight.\
- Plastic 3 ml pipettes
- Reagents, reference materials and consumables
- Reference materials as for protein analysis
- Absolute Ethanol
- Concentrated HCL 37percent (Aristar, BDH Laboratory Supplies, Poole, Dorset, UK)
- Ethyl alcohol
- Diethyl ether (Sigma-Aldrich, Poole, Dorset, UK)
- Petroleum Ether (bp 60 – 80°C) (Fischer Scientific UK Ltd, Loughborough, Leicester, UK)
- Calibration Method
- Calibration of the results was determined using the reference materials described above. A blank was also used to standardise results.

Procedure for Fat Analysis

Two grams of the samples and reference materials were weighed to 2 decimal places using an analytical balance and placed into 100ml conical flasks. Two milliliters of absolute ethanol and 10 ml concentrated HCL 37percent were added to the conical flask and placed into the water bath at 70 – 80°C for 40 minutes with continual agitation of the sample to prevent lumping and through mixing.

Ten ml of ethyl alcohol was added using 10 ml measuring cylinder and the samples allowed to cool. Once cool, 25ml diethyl ether was measured using a volumetric flask and added to the samples which were well shaken for at least 1 minute. Twenty-five milliliters petroleum ether was added to each sample and shaken for a further minute then left to stand for the upper layer to become clear of greenish colour (FAO, 2003; AOAC, 2000).

A clean plastic 1 ml pipette was then used to extract the top ether-fat layer and placed in weighed and dried 50ml beakers. Fifteen milliliters of petroleum ether and 15 ml diethyl ether were added to the conical flask and shaken well for a further minute and left to stand as previously described. This step ensures maximum fat extraction. The ether-fat layer was then removed and placed into the 50ml beakers again. The beakers were then transferred to a water bath held at 40-50^{0}C until the ethers evaporated. The beakers were then placed in an oven at 100°C for 90 minutes to dry the sample; these were then left to cool for 30 minutes and reweighed.

4.3.3.6.9 Calculation of Fat Content

The weight of the clean dried beakers was subtracted from the weight of the beakers containing fat from the fat extraction. The value gained (g) was divided by the initial weight of the sample before extraction and the percent fat of the sample could then be calculated.

Fat (g) = $(wt_2 - wt_1)/wt_s$

wt_2 = weight of beaker with fat (g)

wt_1 = weight of clean beaker (g)

wt_s = weight of sample(g)

percent Fat = (Fat (g)/wt_s) x 100

4.3.3.6.10 Ash Analysis

The ash content was derived by weighing the dry residue of organic materials heated at temperatures of 550°C where by organic matter is burnt off leaving the inorganic ash fraction.

The following materials are used for ash analysis:

- Instrumentation and Equipment
- A six placed hot plate (Electromantle, ME, USA)
- Muffle Furnace (Carbolite, Sheffield, Yorkshire, UK)
- Analytical balance (Satorius 1801, Sartorius GmbH, Gottinghen, Germany) Silica crucibles
- Reagents, reference materials and consumables
- Reference materials as for protein analysis.

4.3.3.6.11 Procedure for Ash Analysis

Each labelled silca crucible was weighed and 5g of sample added (both weighed accurately to 4 decimal places). The crucible was then placed on the hot plate and left until the samples had turned black/grey and dry. The crucibles were then transferred to a furnace preheated to 550°C. The samples were furnaced for up to 3 hours until white/grey. The crucible was weighed accurately when cooled.

4.3.3.6.12 Calculation of Ash Content

Ash (g) = $wt_1 - wt_2$

wt_1 = weight of crucible and sample before ashing (g)

wt_2 = weight of crucible and sample after ashing (g)

wts = weight of sample (g)

Percentage Ash = (Ash (g) / wt_s) x 100

4.3.3.6.13 Determination of Moisture

Moisture content was calculated by weight as a percentage loss of the sample weight when heated at 105°C, with the moisture evaporating at this temperature. It is important to also include any moisture loss calculated in food roasting prior to FMM formulation. The moisture content of a food can affect the stability of it nutrients and its shelf life.

Materials for Moisture Analysis

Instrumentation and equipment:

- Oven (Minikitchen 2044, Cordon Bleu, UK)
- Analytical balance (Satorius 1801, Sartorius GmbH, Gottinghen, Germany)
- Thermometer
- Aluminium weighing boats
- Reagents, reference materials and consumables
- Reference materials as for protein analysis

4.3.3.6.14 Procedure for Moisture Analysis

The aluminium boats and 2,5g of each sample were weighed accurately to 4 decimal places. The samples were placed in a preheated oven at 105°C for 5 hours; the samples were reweighed after cooling (Ceirwyn, 1999).

Calculation of Moisture Content

Moisture (g) = $w_1 - w_2$

wt_1 = weight of aluminium boat and sample before drying (g)

wt_2 = weight of aluminium boat and sample after drying (g)

wt_0 = weight of sample (g)

percent moisture = $((wt_1-wt_2)/ wt_o) \times 100$

4.3.3.6.15 Derivation of Carbohydrate Content

Total carbohydrate content of the samples was derived by subtracting the weights of protein, fat, ash and moisture, derived analytically, from a known amount of the sample.

Total Carbohydrate = 100percent - (percentprotein + percent fat + percent ash + percent moisturc)

For this calculation to work, the numbers derived for each nutrient analysed chemically must be accurate.

4.3.3.6.16 Derivation of Energy Equivalent of Food Multi-mixes

An estimate of the energy equivalent in each sample was derived using the Atwater factors. This assumes that 1 g of carbohydrate or protein is equal to 4kcal and 1g of fat equal to 9kcal.

Energy (Kcal/100g) = (protein (g) x 4) + (Carbohydrate (g) x 4) + (fat (g) x 9)

As with the carbohydrate, the values used for energy calculation must be as accurate as possible to get a better estimate.

4.3.3.6.17 Determination of Fibre Content

An AOAC official method (991,42) for dietary fibre determination was the method of choice in this study. The samples are gelatinised with an alpha amylase (termamyl) and are then digested enzymatically, removing protein and starch. Soluble dietary fibre is

removed by washing filtering with water; the remaining residue is washed with ethanol and acetone and dried (AOAC, 2000; Ceirwyn, 1999).

Materials for Fibre Analysis

Instrumentation and Equipment:

- Analytical balance (Sartorius 1801, Sartorious GmbH, Gottinghen, Germany)
- 400ml beaker
- pH meter
- Water bath with agitator (B&T)
- Glass Crucibles
- Suction flask
- Vacuum oven
- Desiccator
- Reagents, reference materials and consumables
- Phosphate buffer pH (Sigma-Aldrich, Poole, Dorset, UK)
- Tremamyl solution (Sigma-Aldrich, Poole, Dorset, UK)
- Hydroxide (Sigma-Aldrich, Poole, Dorset, UK)
- Protease (Sigma-Aldrich, Poole, Dorset, UK)
- Hydrochloric acid (BDH Laboratory Supplies, Poole, Dorset, UK)
- Amyloglucosidase (Sigma-Aldrich, Poole, Dorset, UK)
- Celite (Sigma-Aldrich, Poole, Dorset, UK)
- 78percent ethanol (BDH Laboratory Supplies, Poole, Dorset, UK)
- 95percent ethanol (BDH Laboratory Supplies, Poole, Dorset, UK)
- Acetone (BDH Laboratory Supplies, Poole, Dorset, UK)
- Reference materials as for protein analysis.

Method Calibration

A blank and reference materials with known fibre contents were run to authenticate the method and results. One gram of samples was weighed into 400ml beakers, 50 ml of phosphate buffer (pH 6) were added, followed by 0,1ml termamyl. The beakers were

covered in aluminium foil and placed into a boiling water bath, being agitated continuously for 30 minutes.

Once cool, the solution was adjusted to pH 7.5 by adding approximately 10ml NaOH. Five milligrams of protease was added to each solution. As protease is difficult to handle, 50 mg was added to 1 ml phosphate buffer (therefore 0,1ml of this solution was added). The samples were then returned to the water bath at 60°C, continuously agitated for a further 30 minutes. Once cool, pH was adjusted to 4-4.6 with approximately 10ml HCl, 0,3 ml amyloglucosidase was added and incubated for a further 30 minutes at 60°C with continuous agitation.

Once cool, 280ml of 95percent ethanol was added to aid sample precipitation. The sample was then stood at room temperature for one hour. Meanwhile, crucibles containing 0,5mg celite were weighed to the nearest 0.1mg. The celite was wet with 75percent ethanol to create a bed in the crucible with suction ensuring an even covering. The mixture in the beaker was then added to the crucible, filtering into a suction flask. The residue was washed 3 times with 20ml 78percent ethanol, 2 times with 95percent ethanol and twice with acetone. The crucible was then transferred to a vacuum oven at 70°C overnight. The samples were then cooled in a desiccator and then weighed to the nearest 0,1mg.

Calculation of Total Dietary Fibre

$F_R = (wt_2 - wt_1) \times 100$

F_R = Fibre residue (g)

Wt_1 = weight crucible after heating

Wt_2 = weight of crucible + celite (g)

Total dietary fibre (g) = F_R – (weight of protein (g) + ash (g))

The results of energy, moisture and minerals contents are summarised on Table 20.

covered in aluminium foil and placed into a boiling water bath, being agitated continuously for 30 minutes.

Once cool, the solution was adjusted to pH 7.5 by adding approximately 10ml NaOH. Five milligrams of protease was added to each solution. As protease is difficult to handle, 50 mg was added to 1 ml phosphate buffer (therefore 0,1ml of this solution was added). The samples were then returned to the water bath at 60°C, continuously agitated for a further 30 minutes. Once cool, pH was adjusted to 4-4.6 with approximately 10ml HCl, 0,3 ml amyloglucosidase was added and incubated for a further 30 minutes at 60°C with continuous agitation.

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F_R = Fibre residue (g)

Wt_1 = weight crucible after heating

Wt_2 = weight of crucible + celite (g)

Total dietary fibre (g) = F_R – (weight of protein (g) + ash (g))

The results of energy, moisture and minerals contents are summarised on Table 20.

Table 20 Summary of actual analysis (BY ARC)

Analysis	Accreditation number	Unit	Multimix without oil
Ash	ASM 048	percent	6,21
Dry ma	ASM 013	percent	92,69
Moisture	ASM 013	percent	7,31
Fat	ASM 044	percent	1,34
Protein		percent	20,63
Vit A		mg/100g	0,17
Vit B_1	ASM 025	mg/100g	0,15
Vit B_2	ASM 025	mg/100g	0,71
Vit C	ASM 057	mg/100g	0,66
Calcium		mg/100g	451
Magnesium		mg/100g	258
Iron		mg/kg	70,50
Zinc		mg/kg	42,40
Carbohydrates(calculated)		g/100g	64,51
Energy(calculated		kJ/100g	1497

4.3.3.7 Optimisation process

During the optimisation process, the actual and theoretical nutrient composition were compared and shortfalls addressed by re-formulating the FMM theoretically to compensate for the nutrient short falls as shown by chemical analyses.

4.3.3.8 Recipe of the Product

The products developed were based on the following criteria: affordability, available foods that are commonly consumed, sustainability and addressing under-nutrition. The major ingredients were based on the staple foods that were most commonly used by the elderly as indicated in the baseline survey. The four products developed were soup, porridge, muffins and gravy. The soup and muffins were selected out of the four products. The soup and muffin were the best products in terms of preparation, best looking products, the pap was too stiff and dry as for the gravy it was bit too thick and with too many lumps and when cooled it looked like a soft porridge.

The criteria developed by Reed and Schuster, (2002) for the recipe development was utilised. Criteria for choosing the recipe were based on the following guidelines:

- Use low-cost readily available ingredients.
- Use basic equipments and appliances.
- Be easy to read.
- Be successfully tested at least by three people minimum.
- Teach at least one dietary meaning (Reed *et al.*, 2002:2).

The recipes were basically chosen on the essentialness of the cultural acceptability, foods mostly commonly consumed and purchased. The ingredients incorporated in both recipes are low cost and readily available and the equipments utilised are basic equipments and appliances. The two recipes were developed namely cream of spinach soup and spinach muffin that were low sodium to address hypertension and low zinc intake amongst the elderly people attending at the care centre in Sharpeville. The recipe for low sodium soup was named cream of spinach soup. Each recipe was developed following the above guidelines and nutritionally analysed. The recipes were also costed to ensure meeting the criteria.

4.3.3.8.1 A recipe pamphlet

A recipe pamphlets (Annexure G) containing the soup and muffin recipes was developed and printed for illiterate elderly people. The pamphlets were designed in such way that simple illustrations of both ingredients and tools were incorporated. The recipe pamphlet will in future be used to train elderly people and caregivers who are responsible for the preparation of the soup and muffins.

4.3.3.8.2 Estimated nutritional value of the recipes.

The 100g of the final formulated multimix powder was sent to the ARC to calculate the nutritional value and theoretical values were determined by the use of South African food composition tables. The recipes, namely cream of spinach soup and spinach muffin, theoretical values were determined using the Dietary Manager®. The nutritional values of the recipes were then compared with the RDA of 70 year old people in order to

determine whether the objectives namely, to supplement at least 30 percent of the daily nutritional requirements were achieved.

4.3.3.9 Sensory evaluation

This section presents a descriptive version of sensory evaluation of the two products that is, the soup and muffins.

Sensory panels of 20 elderly people were randomly recruited from the care centre in Sharpeville in order to evaluate the soup and muffins. The food samples were handed over to the elderly people by a field worker. The evaluation forms and a pencil were handed out to all the aged. The questionnaire consisted of sensory properties and hedonic faces to describe the acceptability. The panel was given a chance to profile the product for its aroma, appearance, flavour and texture. For each serving a piece of muffin was placed on a small plastic dish and soup was poured in small plastic containers with a teaspoon. The elderly people evaluated the muffin first, then soup on different forms. A glass of water was given to the elderly between tasting, to clear their taste buds and mouth before they tried the next sample. The elderly people evaluated the product by marking on the questionnaire according to how much they like or dislike the product with the help of a field worker. The procedure was carried out on two consecutive times. Annexure F indicates samples of the questionnaire used during the evaluation.

The hedonic scale method with different ratings was utilised to measure the level of the liking of the foods, or any other product where an affective tone is necessary. In hedonic testing, samples are presented in succession and the subject is told to decide how much he likes or dislikes the product and to mark the scale accordingly. The nature of this test is its relative simplicity. The instructions to the panelist are restricted to procedures, and no attempt is made at direct response. The subject is allowed, however, to make his own inferences about the meaning of the scale categories and determine for her/himself how s/he will apply them to the samples. A separate scale was provided for each sample in a test session. The scales were grouped together on the same page. Hedonic ratings were converted to scores and treated by analysis of variance. The data was analysed directly with no modification being required. The scores were based on the ratings of each face,

with the mark given for each sensory characteristic. The elderly were also asked to give an approval of the product in the following categories, the likeness, palatability and acceptability. This question was asked in order to give a clear indication about the product, whether in future the product can be prepared and commercialised.

4.3.3.10 Shelf life testing of the multimix

Processes of shelf-life testing

The shelf life testing of the multimix powder, soup and muffin were carried out at Vaal University of Technology laboratories by B Tech students in bio-chemical science. Later on the multimix powder was sent to anaccredited laboratory the ARC for better verification and better results. The multimix was analysed by an accredited laboratory ARC Microbiology section, the powder was kept at room temperature (±25°C) and analyzed on day 0 of arrival, day 3, seventh day, day 14, twenty-first day and day 28. Products were stored in sealed airtight plastic containers on the shelf in the laboratory at room temperature and the refrigerator and were monitored over time for signs of moulds, colour changes and change in the appearance and odour (aroma). The samples at Vaal University of Technology were subjected to microbiological examination after one month. Microbiological examination included bacteriological culture and microscopic examination for fungal growth. The organisms of particular interest were *Staphylococcus aureus*, *Bacillus spp* and *Aspergillus* because foods incriminated by these organisms were largely used in the FMM formulations for the various target groups such as: grains, vegetables, milk and eggs. These organisms were potential sources of enterotoxins and other infections which may cause food poisoning.

4.3.3.10.1 Microbiological analysis for multi-mix

Each time the sample was analyzed an aliquot of 10g was removed aseptically from the bag of powder. A Stomacher 400(HDK Pty Ltd) with 90ml of diluent (Buffered peptone water) was utilized to homogenize the samples. The samples were analysed for total aerobic plate count on Tryptone soy agar and incubated at 25°C for 72± 3 hours. The Coli form and *E.coli* count on violet red bile MUG agar and incubated for at 37°C for

24±2 hours. The yeast and moulds were analysed on Rose Bengal agar with Chloramphenicol and incubated at 25°C for 5 days. The procedure from the Vaal University was more less the same as the ARC.

4.3.3.10.2 Microbiological analysis for soup

The spread plate count method was utilised to determine the growth of the colonies. The sample (soup) of 1ml (3x) were measured out and added to 9 ml saline in MacCartney bottles, mixed well and transferred 1ml to the other 9ml of 10^{-1}, 10^{-2},10^{-3},10^{-4} and $10^{-5}$from each bottle onto the surface of agar plates corresponding to each dilution factor. The plates were incubated at different temperatures, room temperature (25°C) and refrigerator (4°C). The same procedure was followed for the incubator at (37°C), except for the dilution factors that were reduced to 10^{-1}, 10^{-3}, 10^{-5}, 10^{-7} and 10^{-9} (1x) and the transfer of 0,1ml onto the surface of the agar plates instead of 1ml. This was due to the growth of too numerous colonies observed over the period of first four days.

- **Spectrophotometer: Absorbance readings**

A 50ml bottle of the sample was incubated at different temperatures. A 5ml (3x) of the sample were measured out and mixed with 50ml (3x) of nutrient broth (glucose added to the broth) and each sample was incubated at different temperatures : incubator at (37°C), room temperature (25°C) and the refrigerator (4°C). This method is less sensitive, quick and easy to use. It was used for daily absorbance readings of the samples i.e. to determine the cell numbers.

- **The biolog identification procedures**

A plate of BUGM (Biolog Universal Growth Media) was inoculated with a culture in question and incubated overnight. The plate was pretreated with 7.6percent thioglycolic acid solution using a cotton swab, this prevents clumping. The cells were harvested and suspended into inoculation fluid until desired turbidity was reached. Hundred and twenty-five microliters of inoculation mix was transferred well into the specific Biolog

plate, the readings were taken every 4-6 hours. Other readings were taken at 16 hours and other at 24 hours.

- **Endospore staining**

A smear (bacteria emulsified in a drop of water and allowed to air dry) of the organism was prepared and heat fixed. A filter paper was placed over the smear and flooded with malachite green (dye) over a beaker with boiling water for 5 minutes. The slide was removed and rinsed with tap water. The slide was flooded with safranin (dye) and left for 1 minute. The slide was rinsed with tap water and air dried. Catalase test was done in the following, a few drops of 3percent hydrogen peroxide were placed in a test tube and a loopful of the test culture was placed in the tube. Bubbling indicates a positive test. The starch agar was inoculated with the test organism in the centre of the plate. The plate was incubated for 24hrs, afterwards the iodine solution was poured over the growth and clear zone will show a positive test.

- **Gram staining**

A smear was prepared and heat fixed of culture. The smear was flooded with crystal violet and left for 1minute. The slide was rinsed with tap water and a second dye (Gram iodine) was applied in, left for 1minute and rinsed with tap water. A second dye was applied (Gram's iodine) and it was left for 1minute, rinsed with tap water. Afterwards the slide was decolorized with acetone-alcohol for 5seconds and rinsed with tap water. The slide was counterstained with safranin for 1 minute, rinsed and blot dried. A tube of typtone broth was inoculated with the culture and incubated for 48 hours. One mililiter of Kovac's reagent was added, shaken gently and allowed to stand. There was development of bright cherry red colour within seconds in the upper layer indicating a positive test.

4.3.3.10.3 Microbiological analysis for muffin

It was carried out at VUT Laboratory by the microbiology student using the institutions, facilities. The spread count method was used for the shelf life analysis of the muffins.

- **Spread Plate Count Method**

One gram (3x) of the sample (muffin) were weighed out and added to 9ml saline in MacCartney bottles (10^0, 3x), mixed well and transferred 1ml(s) to other 9ml(s) of 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} bottles (2x). Other 1ml(s) were transferred from each bottle onto the surface of agar plates corresponding to each dilution factor, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} plates (2 xs). The plates were then incubated at different temperatures, room temperature (25°C) and refrigerator (4°C). The same procedure was followed for the incubator (37°C), except for the dilution factors that were reduced to10^{-1}, 10^{-3}, 10^{-5}, 10^{-7} and 10^{-9} (1x) and the transfer of 0.1ml onto the surface of the agar plates instead of 1ml. That was done due to the growth of too numerous colonies observed over the 1st 4 days.

- **Spectrophotometer: Absorbance Readings**

Five grams (3 x s) of the sample were weighed out and mixed with 50ml (3 x s) of nutrient broth (glucose added to the broth) and incubated each sample at different temperatures: incubator (37°C), room temperature (25°C) and refrigerator (4°C). This method is less sensitive, quick and easy to use. It was used for daily absorbance readings of the samples, i.e. to determine the cell numbers.

- **Identification of Microorganisms**

The substrates were incubated at different temperatures: room temperature (25°C), incubator (37°C) and refrigerator (4°C). Different types of growth were observed from all the substrates. For the substrate from room temperature the growth was dark green (soft texture, mould type of growth) and black and yellow (a shiny look and soft texture, yeast type of growth). The substrate from the incubator was hard and had a small white growth (mould type) and the one from the refrigerator was white and pinkish (soft texture, also mould type of growth).

- **Preparation of Media**

Nutrient agar weighed 25g in 500ml of distilled water. Boiled on Bunsen burner to mix, then autoclaved the medium (at 121°C for 30 minutes). After sterilization, the medium was poured into petri dishes under the laminar-flow hood. After the medium had solidified, spoiled growth on the substrate was streaked onto the agar plate and incubated until there were growth/colonies. The Gram staining method would be used to identify the types of organisms grown on the plate.

The above preparation procedure for nutrient agar was followed for yeast extract agar, sabouraud dextrose agar, malt extract agar and potato dextrose agar. Except for the Gram staining part, these are the selective media used for detection, isolation, and identification of yeasts and moulds. Hence the organisms grown on these media are only identified by wet preparation method. Plate count agar was used for dilutions that were done at the first part of the project (determination of shelf life). Preparation of the Nutrient Broth was different from the one of agars in the sense that the broth was weighed out, autoclaved and after sterilization it was ready to be used. The broth was used as a blank when reading the absorbance and also the substrates (muffin) incubated at different temperatures, were inoculated into the nutrient broth (determination of shelf life).

- **Gram Staining**

Prepared a fixed smear (a drop of water was mixed with a small portion of a colony) of each culture on a microscopic slide. Flooded the slide with crystal violet was allowed to stand for 1 minute, washed off with tap water. Flooded with Gram's iodine (a mordant which fixes the crystal violet to the cell wall) was left for 1 minute, washed with water. Decolorized with acetone/ alcohol (50/50percent) for 5 seconds (Gram-positive bacteria can resist decolorisation, but Gram-negative bacteria are destained, and crystal violet is removed from the cell.), rinsed with water. Applied safranin (the counterstain) for 1 minute, rinsed with water. Plotted dry with paper towel and examined under the microscope. Gram-positive cells that have already been stained with crystal violet appear

blue/violet. If the organisms were Gram-negative, they could take up the secondary stain and appear red/pink.

4.4 CONCLUSION

In this chapter the methodology employed in this study is discussed. All questionnaires that were used to collect data in this research, tests, information on the development, optimization and nutritional analysis of multimix, recipe development, sensory evaluation and its analysis, and information on the shelf life of the product were provided. In the next chapter a discussion of the results will be given.

CHAPTER 5: DISCUSSION OF RESULTS

5.1 INTRODUCTION

In this chapter data collected by means of questionnaires and tests are analysed. It was necessary to analyse the multimix powder for its shelf life and the two recipes which are the cream of spinach soup and low sodium muffin for shelf life and acceptability.

5.2 DATA ANALYSIS OF RESULTS

5.2.1 Phase 1: Results of planning

The permission for conducting research was granted by the board of directors of the care centre in Sharpeville. The prior evaluation which included the evaluation of the setting (kitchen, number of the aged attending the centre, and recruitment of the elderly etc.) was conducted. The elderly were informed about the study and how they would benefit should they decide to take part. Prior to data collection elderly people were told that participation in the study was voluntary, that they were free to withdraw their participation at any stage during the study and that the data would be presented as aggregate. They were assured that all data provided would be treated with strict confidentiality.

Questionnaires were drawn up piloted and after they were approved by the study supervisor they were distributed to the participants. Trained field workers administered the questionnaires. Data collectors who spoke at least two local languages were utilised.

5.2.2 Phase 2: Baseline survey

5.2.2.1 Socio-demographic and health data

- **Characteristics of the respondents**

The results in Table 22 below indicate that the majority of the respondents were female (87,1percent) and their mean age was 71,7 years. The majority of the respondents were Sotho-speaking (84,7percent) with a low education level as only 23percent attended high school or college. The majority of the subjects were widowed (70percent) and only 19,4percent married. However, a small percentage (4,7percent) lived alone, whilst the majority shared the house with other family members.

- **Living conditions**

The results in Table 21 show that 99percent of the respondents lived in brick houses with ≤ 2 rooms (29,4percent), 3-4 rooms (40.6percent) or > 4 rooms (30percent). The average household size was 4,9 persons. The majority of the respondents had resided in Sharpeville permanently for more than five years (96,5percent).

Table 21: Demographic data of the sample

Variable	N=170	100percent	Variable	N=170	100percent
Age of respondents			Number of people in household		
Mean age	71,70 years		1	8	4,7
Age range	60-110		2	24	14,1
Gender			3	22	13
Male	22	12,9	4	33	19,5
Female	148	87,1	5	25	14,8
Role in the family			6	21	12,3
Grandmother	114	67,2	7	14	8,2
Mother	28	16,4	8	4	2,3
Grandfather	20	11,5	9	4	2,3
Father	5	3,3	≥ 10	15	8,8
Other	3	1,6	Mean number of people in household	4,9	
Marital status			Type of house		
Widowed	119	70	Brick	168	99
Married	33	19,4	Zinc shack	2	1
Single	11	6,5	Number of rooms		
Divorced	7	4	≤ 2 rooms	50	29,4
Education level of respondents			3-4 rooms	69	40,5
None	32	18,8	> 4 rooms	51	30,1
Primary school	99	58,2	Time of residency in present house		
Secondary school	29	17,1	< 1 year	6	3,5
Post-School	10	5,9	> 5 years	164	96,5
Home language					
Sotho	144	84,7			
Zulu	15	8,8			
Xhosa	6	3.5			
Other	5	3			

- **Socio-economic indicators**

The socio-economic indicators of the sample are depicted in Table 22. The majority of the households had access to clean, safe water (93,7percent), electricity (100percent), toilet facilities (94,7percent) and waste removal services (96,5percent). Most of the households had a gravel road in front of the house (80,6percent) and the presence of household pests was reported by all (100percent). These included rats, mice, ants and cockroaches.

Table 22: Socio-economic indicators of the sample (Water and environment).

Variable	N	percent	Variable	N	percent
Clean, safe water availability at home	170	100	Total household income per month	161	100
Tap inside the house	36	21,1	< R500 (76 US$)	1	0,6
Tap outside the house	75	44,1	R501-R1 000 (78-154 US$)	106	65,8
Tap in- and outside house	45	26,5	R1 001-R1 500 (155-231 US$)	34	21,2
Fetch water from elsewhere	14	8,3	R1501-R2 000 (232-308 US$)	12	7,5
Toilet facilities	170	100	R2 001-R2 500 (309 – 385 US$)	2	1,2
Flush/sewage	161	94.7	> R2 500 (386 US$)	6	3,7
Other	9	5,3	Number of people contributing to household income	161	100
Access to electricity	170	100	1	116	72
Waste removal facilities	164	96,5	2	37	23
Gravel road in front of house	137	80,6	> 2	8	5
Tarred road in front of house	19	11.2	Household member responsible for household money expenditure	170	100
Pests	170	100	Father	12	7,1
Mice/rats	40	23,5	Mother	53	31,2
Cockroaches	23	13,7	Grandfather	93	54,7
Mice/rats & cockroaches	42	24,7	Grandmother	4	2,3
Mice/rats, cockroaches & ants	30	17.6	Other	8	4,7
Mice/rats & ants	10	5,8			
Other	25	14,7			
Respondents on pension	170	100			
Period of pension	170	100			
6-12 months	4	2,3			
1-3 years	13	7,6			
> 3 years	153	90,1			
Partner employed	7	4,2			

- **Income levels and procurement patterns**

All the subjects in the sample received a state pension and the majority (90,1percent) had been receiving this for longer than three years. In 4,2percent of the cases, the partner was employed. The majority of households (65,8percent) had a monthly income of R 501-1 000 and in the majority of households (72,0percent) the pensioner was the only contributor to household income.

The results in Table 23 indicate that monthly food shopping was done by the majority of households (81,8percent) and mostly at supermarkets (68,2percent). The majority of subjects (63,1percent) spent less than R200 per week on food for the household. The results further indicated that in these households the mother or grandmother was responsible for household expenditure (31,2percent and 54,7percent respectively). In a relatively large percentage of households the grandmother was responsible for food preparation (40,6percent), food procurement decisions (47percent) and feeding the children (43,5percent).

The results in Table 23 indicate a possible household food insecurity as 7,4percent, that they always had a money shortage to procure their basic needs, whilst 47,9percent often had the problem and 25,1percent sometimes did not have enough money for their basic needs. Only a small percentage seldom (10,4percent) or never (9,2percent) experienced this problem. However given these income patterns, the risk of food insecurity is increased amongst the elderly in Sharpeville.

Table 23: Food procurement and preparation patterns of the sample

Variable	N	percent	Variable	N	percent
Frequency of food shopping	**170**	**100**	**Household member responsible for food procurement decisions**	**170**	**100**
Every day	8	4.7	Mother	44	25.9
Once a week	12	7	Grandmother	80	47
Once a month	139	81,8	Other	46	27,1
When money available	11	6,5	**Household member responsible for feeding the children**	**170**	**100**
Place where food is bought most of the time	**170**	**100**	Mother	63	37,1
Spaza shop	9	5,3	Grandmother	74	43,5
Street vendor	4	2,4	Other	33	19,4
Supermarket	116	68,2	**Reported head of the household**	**170**	**100**
Spaza shop & street vendor	3	1,8	Mother	53	31,2
Spaza shop & supermarket	7	4,1	Grandmother	93	54,7
Street vendor & supermarket	18	10,6	Other	24	14,1
Other	13	7,6	**Number of meals served per household per day**	**170**	**100**
Weekly food expenditure	**160**	**100**	1	10	5,9
R0 –R50 (0-8 US$)	30	18,8	2	49	28,8
R51-R100 (9-15 US$)	34	21,2	3	100	58,8
R101-R 150 (16-23 US$)	18	11,2	>3	11	6,5
R151-R200 (24-30 US$	19	11,9	**Place where most of the food is consumed**	**170**	**100**
> R 200 (30 US$)	32	20	Home	170	100
Do not know	27	16,9	**Frequency of money shortage for basic needs in household**	**163**	**100**
Household member responsible for food preparation	**170**	**100**	Always	12	7,4
Mother	74	43,5	Often	78	47,9
Grandmother	69	40,6	Sometimes	41	25,1
Other	27	15,9	Seldom	17	10,4
			Never	15	9,2

- **Household assets**

It was found in the study that 84,1percent and 77,6percent of the households owned a radio and television set respectively. Cooking facilities included an electrical stove (73,5percent), a gas stove (24,7percent) and a paraffin or coal stove (10,6percent). Cold chain facilities were encouraging as 81,8percent owned a refrigerator and 15,9percent a freezer.

5.2.2.2 Health data

The major health problems experienced by the subjects, as reported in Table 24, were ear, nose and throat (ENT) infections (72,4percent), painful joints (70,6percent) and chronic headaches (48.2percent). The majority of subjects used chronic medication (55,9percent) of which 40,6percent was for the treatment of high blood pressure. The mean systolic blood pressure was 168,6 mm Hg and the diastolic blood pressure 101.0 mm Hg. The subjects were not very active as 9,4percent reported heavy exercise/activity levels and 43,5percent, 27,6percent and 19,5percent reported moderate, light or no exercise/activity levels respectively. The results in Table 36 indicate that the majority of respondents visited the local clinic on foot (66,2percent) when ill.

Table 24: Health indicators

Variables	Frequencies	Percentages
History of chronic diseases in family	**170**	**percent**
Skeleton disease (painful joints)	120	70,6
Ear, nose and throat (ENT) infections	123	72,4
Heart disease	59	34,7
Respiratory & chest disease	55	32,4
GIT abnormalities	37	21,8
Genital abnormalities	28	16,5
Mental disorders	23	13,5
Headaches, chronic	82	48,2
High blood pressure medication	69	40,6
Activity levels	**170**	**100**
Heavy/rigorous	16	9,4
Moderate	74	43,5
Light	47	27,6
None	33	19,5
Experience of weight loss during the past month	**49**	**28,8**
Experience of a recent change in appetite	**51**	**30**
Experience chewing problems	**53**	**31,2**
Experience problems with swallowing	**24**	**14,1**
Often experience of nausea	**32**	**18,8**
Often experience of diarrhoea	**26**	**15,3**
Often experience vomiting	**15**	**8,8**
Often constipated	**33**	**19,4**
Experience of fatigue	**170**	**100**
Always	30	17,7
Sometimes	103	60,7
Never	37	21,6
Hearing/speech/sight defects	**110**	**64,7**
Use of chronic medication	**95**	**55,9**
Type of health facility visited	**140**	**100**
Traditional healer	6	4,3
Private doctor	28	20
Clinic	94	67,1
Hospital	12	8,6
Access to health facilities	**151**	**100**
On foot	100	66,2
Taxi	51	33,8

- **Smoking and drinking patterns**

The results indicated that 88,3percent of the respondents never smoked and 88percent did not take alcohol, however, a relatively large percentage of the sample used snuff (32,5percent) or had a history of snuff usage (4,6percent).

5.2.2.3 Data on dietary intake and food consumption patterns of respondents

Table 25 indicates that although the majority of households ate three (58,8percent) or two (28,8percent) meals per day, the nutrient analysis of both the 24-hour recalls of the female subjects indicated deficient intakes for a number of nutrients when compared with the required daily allowances (RDA's) (Institute of Medicine,2002). These included: total energy and dietary fibre intake as well as calcium, magnesium, zinc, selenium, iodine, vitamins B1, B2, B6, C, D, E, folate, biotin and pantothenic acid. Furthermore, the main source of nutrition was carbohydrates.

Table 25: Analysis of 24-hour recall: daily mean intakes of a sample of the female elderly subjects (n=88)

Nutrient and unit of measure	24-hour recall (mean ± SD)	RDA
Energy (kJ)	5 041,2 ± 2 299,6	6 185(EER)
Total protein (g)	50,4 ± 28,2	46
Total fat (g)	38,9 ± 28,2	
Cholesterol (mg)	268,7 ± 535,9	
Carbohydrates (g)	149,0 ± 76,6	100
Total dietary fibre (g)	12,3 ± 8,7	21
Calcium (mg)	220.8 ± 209.8	1200 #
Iron (mg)	5,9 ± 3,7	5
Magnesium (mg)	195,1 ± 99,2	265
Potassium (mg)	1 337,6 ± 809,1	
Zinc (mg)	6,4 ± 3,7	6,8
Copper (mg)	0,74 ± 0,82	
Chromium (mcg)	33,8 ± 41,6	20 #
Selenium (mcg)	30,2 ± 42,6	45
Iodine (mcg)	33,3 ± 66,9	95
Vitamin A (RE) (mcg)	649,2 ± 2 007,9	500
Thiamin (mg)	0,7 ± 0,4	0,9
Riboflavin (mg)	0,75 ± 0,79	0,9
Niacin (mg)	12,17 ± 8,42	11
Vitamin B6 (mg)	0,7 ± 0,45	1,3
Folate (mcg)	157,0 ± 159,4	320
Vitamin B12 (mcg)	4,67 ± 18,2	2
Pantothenate (mg)	4,64 ± 4,50	5 #
Biotin (mcg)	23,78 ± 38,96	30 #
Vitamin C (mg)	38,4 ± 90,5	60
Vitamin D (mcg)	3,65 ± 10,2	10-15
Vitamin E (mg)	4,0 ± 5,2	12

*Estimated Average Requirement (EER, Institute of Medicine, 2002) for females aged 51-70 and >70 years old calculated with physical activity level factor of 1,0 for sedentary women. # Adequate Intake levels for females aged 51-70 and >70 years old

The dietary data intake in Table 26 showed that the elderly consumed insufficient quantities of most of the nutrients, except for protein, CHO, iron, Cromium and vitamin A. From Table 28 indicating the top 20 most frequently consumed items, the participants in this research according to the 24-hour analysis frequently consume: tea (299 g), stiff maize meal porridge (273 g), brown bread (93 g), full cream, fresh milk (67 g), chicken, cooked (103 g), beef, cooked (125 g), fermented maize drink (mageu) (212 g), eggs (123 g), apple (160 g) and orange (189 g). The average daily intake is indicated in brackets.

Table 26 Top 20 food items consumed measured by 24-hour

Food item	**Mean daily intake (gram per person)**	**Number of respondents with daily consumption**
Tea, brewed	299	119
Maize meal, cooked, stiff porridge	273	79
Brown bread/rolls	93	89
Milk, full cream, fresh	67	73
Chicken	103	38
Beef	125	21
Fermented maize drink (mageu)	212	15
Egg, cooked	123	24
Apple	160	15
Orange	189	11
Maltabella, cooked	281	6
Coffee, brewed, instant	267	6
Potato, boiled	105	15
Sugar, white	16	95
Cold drink, carbonated	280	5
Soup, bean and meat	321	4
Orange Juice	319	4
Rice, white, cooked	87	14
Cabbage, cooked	46	22
Spinach, cooked	49	18

5.2.2.4 Biochemical blood results

The serum minerals and vitamins in Table 27 indicate that the standard deviations and means of iron, ferritin, folic acid, vitamin A and vitamin B_{12} were within the normal range and zinc was below the normal range which indicated the deficiency. Biochemical results in Table 27 indicate that the majority of respondents had normal haemotological indices. The distribution of serum minerals levels indicated that the majority of respondents had normal iron and ferritin levels but 73,1percent of the subjects had low serum zinc levels(<50µg/Dl) (Yetiser,Tosun, Arslanhan, Akcam& Ozkaptan, 2002:329-333). However, 42,4percent and 3percent of the respondents had serum ferritin and iron levels higher than the cut-off point respectively. Only 20,9percent of the respondents had low serum iron levels (<9 and 11,6µmol/l for women and men respectively), but 35,8percent and 47percent had low heamatocrit and heamoglobin levels which could be indicative of iron deficiency anaemia. The majority of the elderly had normal serum vitamin B_{12}, vitamin A and folate values. The data was further analysed for correlations

between BMI and serum glucose levels, cholesterol and triglycerides, based on the one-tail Pearson correlation test, no statistically significant correlations were found.

Table 27:Selected biochemical indices of the elderly subjects (n=67)

Parameter	Normal range	Total (n=67) Mean±SD	Total group(percent) with low*/high**values
Total serum iron#	10-30µmol/l	16,0±7,8	20,9*/3,0*
Serum ferritin§	18-250 ng/ml(m) 12-160 ng/ml(w)	178,9±265,1	4,5*/42,5**
Haemoglobin#	13.5-17.5g/dl(m) 11.5-15.5 g/dl(w)	13,6±1,6	44,8*/1,5**
Haematocrit#	40-52 percent(m) 36-48 percent(w)	41,8±4.4	32,8*/3,0**
Serum zinc^	50-150 µg/dl	64,9±9,1	73,1*/0**
Serum folate¶	5.9-45.4 nmol/l	14,6±6,5	0
Serum retinol	20-30 µg/dl	55,8±16,6	0
Vitamin B_{12}	156-672pmol/l	333,1±134,8	3*/1,5**

*low values, **high values (compared to normal range)

(Hoffbrand et al, 2001:331; §Konelab 20i reagent Kits; SA Medical Research Council, ^ Yctiser, Tosum, Sa et al., 2002:329-333)

Figure 21 and 22, as well as Table 27 indicate that majority of elderly in this sample had normal vitamin A Fe, B_{12} and folate levels. Zinc, however was a problem as 73,1percent of the elderly had low serum zinc levels. Which give a clear indication that elderly people were zinc deficient. Other vitamins such vitamin, A, B_{12}, and folate were above 90percent.

In Figure 21 it can be seen that the zinc deficiencies was the major problem experienced by this sample of elderly people as 73,1percent of the sample had low serum zinc levels, compared to 20,9percent iron and 4,3percent ferritin.

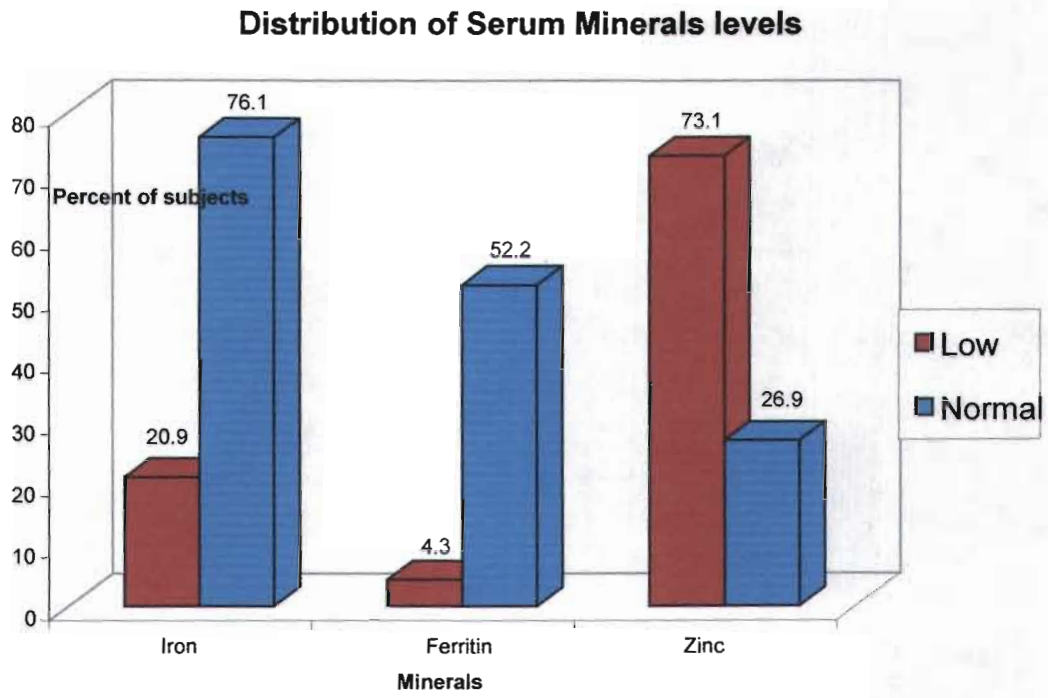

Figure 21 Distribution of serum mineral levels of the elderly people in care centre in Sharpeville

The results in Figure 22 indicate that no major vitamin deficiencies were prevalent in this elderly community as the majority of the sample had normal vitamin B_{12}, folate and vitamin A levels.

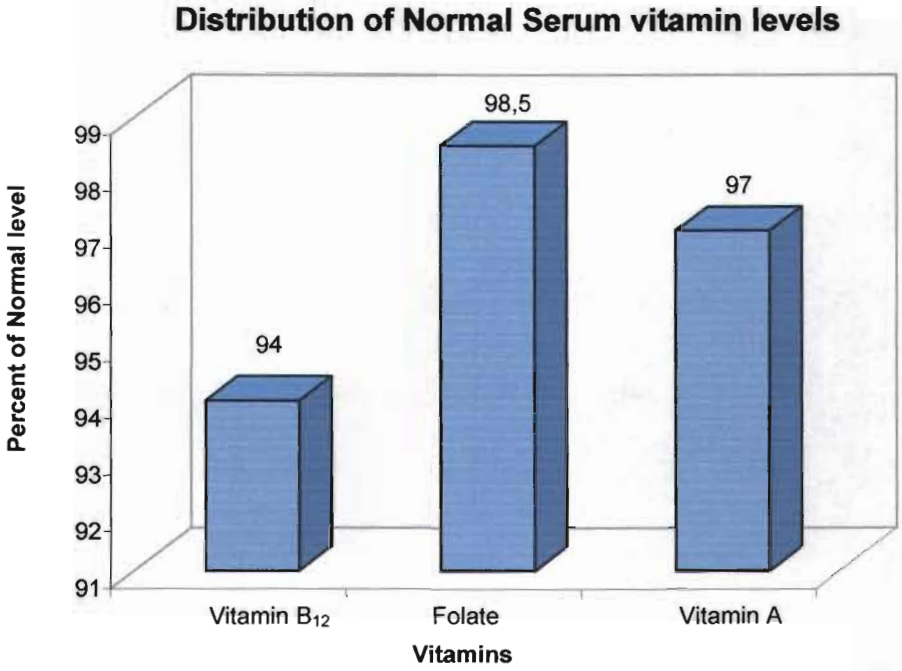

Figure 22 Distribution of normal serum vitamin levels of the elderly people in care centre in Sharpeville

5.2.2.5 Anthropometric data

The anthropometric RESULTS of the female subjects are reported in Table 28 as they were the majority of the sample and indicated that the mean (±SD) weight, height and BMI were 77,1±17,3 kg, 1,56±7,6 m and 31,1±6,4 respectively, indicating obesity. The BMI indicated 16,4percent had normal weight (BMI 18-24,9), 29,5percent were overweight (BMI25-29,9), 27,9percent obese (BMI 30-30,5) and 26,2percent very obese (BMI ≥35). No respondents in the sample were underweight.

Table 28: Summary statistics of MUAC and waist circumference

	MUAC cm	Waist circumference cm
Mean	33,4	99,3
Median	33,0	100,5
Standard deviation	5,2	13,6
Minimum	22,5	68,0
Maximum	45,5	129,0

The mean (±SD) MUAC was 33,4±5,2 cm, falling between the 75th and 90th percentile of the United States Health and Nutrition Examination Survey (NHANES 1) for the elderly between 65 and 74,5 years old (Mahan & Escott-Stump, 2000:1037). This is further proof of the obesity in this sample.

5.2.3 Phase 3: FFM results

5.2.3.1 Introduction

The results from the baseline survey indicate that this is a low-income community with household food insecurity and compromised nutrition, mainly overnutrition due to a mainly carbohydrate-based diet and were zinc deficient. The study demonstrated that overweight exists among the food insecure. The results of this survey will facilitate planning and implementation of sustainable community-based interventions to promote healthier lifestyles. Therefore the criteria formulated for the FMM were to be:

- Cost effectiveness: less than R1.80 per portion, per day
- Low in energy: not more than 30percent of RDA.
- Nutritious: high in zinc and iron content, at least 30percent of RDA.
- Safe for human consumption.

5.2.3.2 Identification of food ingredients

Table 29 below indicates the types of food items that appeared and were mostly consumed by the elderly from the top twenty food list. The items and quantities of ingredients constituted the multimix. Maize is the most prominent staple food consumed

in the Vaal Triangle Area in the form of mealie-meal and is one of the four basic staple foods in South Africa, and combined with vegetables such as spinach and kidney beans which are easily grown in the home gardens. Beans were are a form of nonheme protein that is more affordable when compared to heme protein products

Table 29: The list of ingredients incorporated in the multimix

FOOD DESCRIPTION	Weight (g).
Maize meal	30
Milk, non-fat,	15
Spinach dried	15
Kidney beans-dried	25
Vegetable oil)	15
Total	100

5.2.3.3 Changes occurred during drying procedure

The food items were dried at different temperatures within 90°C-120°C. The maize meal during the drying lost about 25g as the moisture content, spinach lost about 3,8kg and kidney beans lost 150g. There was also colour change to the ingredients, maize meal turned yellowish brown, spinach turned very dark green and brittle and kidney beans turned brown with a nutty aroma. Table 30 shows a summary of fresh and dry weights of the ingredients.

Table 30: The comparison of fresh and dried weights of the ingredients in the multimix

Food item	Temperature	Pre-mass	Mass-after	Time taken
Maize meal	120°C	750g	725g	1hour
Spinach (fresh, raw)	90°C	4kg	200g	2hours
Kidney beans (dry)	120°C	1,5kg	1.35kg	1h30

5.2.3.4 Results of blending

In Table 31 below after blending of the ingredients the target of a multimix was able to contribute at least 30 percent of the RDA. Most of the deficient vitamins such Mg, Fe, vitamin A and vitamin B_{12} were above 30 percent and energy was also high.

5.2.3.5 Theoretical calculation

Table 31 indicates the theoretical calculation of the nutrients present in the FMM, based on the SA Food Composition tables (Langehoven *et al.*, 1991) and calculated using food finder. The iron and zinc content is112,5 percent and 37,5percent of RDA respectively and the energy content 12,5percent, thus meeting the criteria of 30percent of RDA.

Table 31: The theoretical nutrient composition of foods used in the formulation of nutrient–enriched food multimix (per 100g edible portion)

Food description	Wt. (g)	Energy (KJ)	Protein (g)	CHO(g)	Fat (g)	Fibre (g)	Ca (mg)	Fe (mg)	Vit_{B1} (mg)	Vit_{B2} (mg)	Vit_{B3} (mg)	Na (mg)	Zn (mg)	Mg (mg)	P (mg)	VitC (mg)	Fol (µg)	Vit_{B12} (µg)	VitA (µg)
Maize-meal	**30**	**485**	2,8	25	0,8	1,1	1,2	0,22	0,10	0,09	1	2,2	0,28	523	54	0	4,9	0	0
Milk	**15**	**227**	5,42	7,65	0,12	0	189	0,04	0,06	0,23	0,14	76,3	0,66	0	0,6	1,02	7,5	0,612	6,3
Kidney beans, dry	**25**	**30**	1,7	1,14	0,14	4,8	5	0,22	0,1	0,07	0,9	4,5	0,11	5,8	10,2	10,8	15,5	0	0
Spinach, dried	**15**	**280**	8,6	10,6	1	8,6	298	8,2	0,23	0,6	4	237	1.6	237	147	84	5,8	0	0,2
Sunflower oil	**15**	**555**	0	0	15	0	0	0	0	0	0	0,00	0	0	0	*	*	*	0
Total	**100**	1577	19	44	17	15	493	8,68	0,49	0,99	6,4	320	2,65	766	212	95,82	33,7	0,6	6,5
RDA		**#6182(W) #6809(M)**	**0,80**	**130**	**35**		**800**	**8,0**	**1,1**	**1,3**	**16**	**500**	**8**	**320**	**700**	**75**	**400**	**2,4**	**8**
percentRDA		**12,5**	**2 375**	**33,8**	**95**		**62**	**112,5**	**45**	**75,3**	**37,5**	**64**	**37,5**	**239**	**30**	**128**	**8,4**	**25**	**0,8**

*RDA for elderly people for 50-70 years old (NICUS, 2003). w = women, m = men

#Estimated Energy Requirements (Institute of medicine, 2003) for sedentary men aged 71.3 years, height = 1.67m and weight = 76.3 and females of = 71.8 years, height = 1.6m and 75.8kg, Wt=Weight.

Note: for the purpose of this study, the energy requirements for women were used as they were the majority of this elderly community.

5.2.3.6 The costing of the multimix

Foodstuffs commonly sold in most South African food supermarkets were used and their relative costs are summarised. Prices for food items used to prepare the multimix were obtained from nearby supermarkets and the price list was compiled in 2006when the experimental fieldwork was undertaken. The known price for a particular quantity was multiplied with the quantity of the unknown price in order to determine the cost of a particular food item.

Maize meal 1kg =R5,99=30g*R5,99/1kg =0,17

Kidney beans 500g=R5,00=25g*R5,00/500g =0,25

Spinach 500g= R3,00 15g*R3,00/500g =0,09

Instant Milk Powder 2kg=R114,99=15g*114,99/2kg=0,86

Vegetables oil 750ml=R5,99 1g=1ml 15g=15ml 15ml*R5,99/750 =0,11

The total cost =R1,48

5.2.3.7 Experimental results

ARC analysed the multimix which excluded oil. The comparison between the estimated and experimental nutritional values is reflected in Table 32. The chemical analysis provided information on nutrients relevant to the study. The nutritional value of iron and zinc were 39,2percent and 5,25percent or RDA respectively indicating sufficient iron but only 5,25percent Zn therefore not sufficient zinc.

Table 1: Comparison between theoretical and experimental values.

Analysis	Unit	Experimental values(ARC)	Theoretical values	Variance	percentvariance
Energy	**kJ**	1 497	**1 207**	**290**	**19**
Protein	**g**	20,63	**19**	**1,63**	**7,9**
Carbohydrates	**g**	65	**44**	**21**	**32**
Fat	**g**	1,34	**17**	**-15,7**	**-1 168**
Calcium	**mg**	451	**493**	**-42**	**-9,3**
Iron	**mg**	7,05	**8,68**	**-1,63**	**-23**
Magnesium	**mg**	258	**766**	**-508**	**-196,9**
Zinc	**mg**	0,42	**2,65**	**-2,23**	**530,9**

5.2.3.7 Optimisation

The results of the chemical analysis in table 32 showed that only 16percent of the theoretically calculated zinc was present in this sample. The iron content showed 78 percent retention, but the experimental value met the formulation criteria of 30percent of RDA. For this reason, the optimisation process focused on increasing the zinc content of the FMM theoretically. It was calculated that the FMM should contain 16,5 mg of zinc theoretically to acquire 2.6 mg of zinc needed as the criteria, assuming 16percent retention as found in the ARC results.

Various (n=20) formulations, using the same ingredients were used to theoretically formulate the FMM. However, it was impossible to meet this without compromising the other ingredients and for this reason the original FMM developed was used to develop recipes for acceptability and shelf life testing. This was a limitation of this study and more research is required to formulate and develop the "optimum" FMM with regard to the zinc content in this FMM. Variances occurred in almost all of the nutrients when the theoretical and experimental values were compared, indicating the need for optimisation of the FMM.

5.2.3.8 Recipe compilation

The recipe was compiled and prepared and some alterations were made in order to improve the nutrient intake and to enhance the flavour. In the Tables 33 below are the examples of the recipes that were utilised for sensory evaluation. The cream of spinach soup was further enriched by incorporating the onion and tomato that is rich in vitamin C.

Table 2: Cream of spinach soup.

Quantity	Ingredients
20g	Onion
50g	Tomato
10ml	Cooking oil
100g	Spinach multimix

Method

Soak the multimix in cold 500ml water

Peel and chop the onion and tomato

Heat oil in a pan and sauté the onions for 5 minutes

Add the tomato and stir for five minutes

Pour water into a pan, add the multimix and simmer for 45 minutes.

The elderly had a prevalence of malnutrition and high cholesterol. The muffin recipe in Table 34 was also formulated to correct these problems and to add variety of products that can be easily formulated from the multimix. Canderel was used since it is sugar free and apple was also added to enhance the flavour.

Table 3: Low sodium muffin recipe.

Quantity	Ingredient
100g	Multimix
4ml	Baking powder
10ml	Canderel
1	Egg
90ml	Water
5ml	Oil
60g	Apple

Method

Combine flour, baking powder and canderel. Blend on low speed for 10 seconds. Combine egg, water and oil. Add to dry ingredients, mix at low speed for 25 seconds only. Fold apples into batter, soak the mixture for 20 minutes before baking. Measure with no 24 dipper non stick muffins pan. Pour the batter into the muffin pan and bake 180°C for 15 minutes until golden brown.

5.2.3.8 Nutritional analysis

- **Nutritional analysis of recipes**

Nutritional analysis for both recipes was carried out at Vaal University of Technology. The dietary finder programme was utilised to determine the quantities of nutrients that are in the products. Table 35 below indicates the nutrient distribution of ingredients contained in the cream of spinach soup and the energy distribution of each ingredient in the recipe. The total energy of the recipe per 180g and 100ml serving for the elderly person was 1713 kJ.

Table 4: The ingredients contained in cream of spinach soup.

INGREDIENTS Total mass	180g	Energy 1713 KJ		Carbohydrates	Protein	Fats
Milk non fat dry	15g	13percent	227	8	5	0
Onion , raw	20g	2percent	32	2	0	0
Tomato , raw	50g	3percent	44	2	0	0
Maize meal,	30g	28percent	485	24	3	1
Kidney beans	25g	2percent	32	1	1	0
Spinach	15g	1percent	15	1	0	0
Oil	25g	53percent	925	0	0	25

Table 36 indicates minerals and vitamins contained in the cream of spinach soup recipe, Mg and Ca were above the target percentage (30percent). Although iron was slightly below and Zinc was even lower due to the fact that all the ingredients were plant sources. The ascorbic acid, vitamin K, and E were also above, which indicate that this product could at least meet the minimum requirements.

Table 5: The Nutritional Analysis of cream of spinach soup.

	Units	Average	Added for 100percent	RDA 100 percent	RDA
Kilojoules	KJ	1 713	6 238	22percent	7 950
Total protein	gm	9,81	40	20percent	63
Total fat	gm	26,08			
Total carbohydrate	gm	35,56			
Dietary fibre	gm	1,8			
Calcium Ca	milligram	213	587	27percent	800
Iron Fe	milligram	0,92	9	9percent	10
Magnesium Mg	milligram	58	222	21percent	280
Phosphorus	milligram	221	579	28percent	800
Potassium K	milligram	506	1 494	25percent	2000
Sodium Na	milligram	359	141	72percent	500
Zinc Zn	milligram	1,10	11	9percent	15.
Vitamin A IU	1 008				
Vitamin A	retinol Equivalents	161	639,2	20percent	800
Thiamin B_1	milligram	0,27	0,7	27percent	1,0
Riboflavin B_2	milligram	0,41	0,8	35percent	1,2
Nicotinic acid B_3	milligram	2,0	11,1	8percent	15,0
Vitamin B_{12}	microgram	0,6	1,4	30percent	200
Ascorbic acid C	milligram	16	43,8	27percent	60,0
Vitamin D	microgram	1,13	3,9	23percent	5
Vitamin E	milligram	0,54	7,5	7percent	10,0
Vitamin K	microgram	78	2	98 percent	80,0

Table 37 below indicates the nutrient distribution of ingredients contained in the muffin recipe, the energy distribution of each ingredient in the recipe and total energy of the recipe.

Table 6: The ingredients contents of muffin recipe.

INGREDIENTS Total mass	 210g	Energy 1771 KJ		Carbohydrates	Protein	Fats
Eggs	50g	16percent	312	1	6	5
Milk non fat dry	15g	12percent	227	8	5	0
Apple	60g	8percent	148	9	0	0
Maize meal,	30g	25percent	485	24	4	1
Kidney beans	25g	2percent	32	1	1	0
Spinach	15g	1percent	14	1	0	0
Oil	15g	38percent	555	0	0	20

In Table 38 the mineral contents of Mg, Zn, Ca, Fe are higher than the target percentage (30percent), which indicates that the muffin recipe could provide half of the daily nutritional requirements of an elderly person. Most of the vitamins were higher than 30 percents. Addition of animal products such as the egg further enhanced the recipe compared to the cream of spinach soup which contains only non heme products.

Table 7: Nutritional analysis of muffin recipe.

	Units	Average	Added for 100percent	RDA 100percent	RDA
Kilojoules	KJ	1771	7795	22percent	7950
Total protein	gm	15,97	34	32percent	50
Total fat	gm	21,49			
Total carbohydrate	gm	43,59			
Dietary fibre	gm	3,0			
Calcium Ca	milligram	87	562	30percent	800
Iron Fe	milligram	1.70	8	17percent	10
Magnesium Mg	milligram	64	216	23percent	280
Phosphorus	milligram	307	493	38percent	800
Potassium K	milligram	604	1 396	30percent	2,0
Sodium Na	milligram	159	341	32percent	500
Zinc Zn	milligram	1,64	10	14percent	12
Vitamin A IU		1 357			
Vitamin A	retinol Equivalents	259	540,7	32percent	1,0
Thiamin B_1	milligram	0,30	0,7	30percent	1,0
Riboflavin B_2	milligram	0,67	0,5	56percent	1,2
Nicotinic acid B_3	milligram	2,0	11,1	15percent	15,0
Vitamin B_{12}	microgram	1,1	0,9	46percent	2,0
Ascorbic acid C	milligram	18	25,9	31percent	60,0
Vitamin D	microgram	0	0	0	5
Vitamin E	milligram	1,23	3,*9	15percent	8,0

The theoretical (based on the food composition tables) and the experimental values (based on chemical analysis that was carried in the Laboratory) showed the nutritional analysis of the multi-mix. Energy and carbohydrates were lower compared to the actual values. All the other nutrients were higher when compared to actual values.

5.2.3.9 Sensory Evaluation

- **Sensory evaluation of the soup**

The recipe was prepared and taken to the care centre in Sharpeville where the randomly chosen elderly gave their views. Each one of the twenty elderly was given a questionnaire to complete. The ratings had two sets of keys, the first key being Like rated on 1, Neither rated on 2 and Dislike rated on 3 was represented by the hedonic faces of a smile, not sure and sad and the second key was the No rated on 1 and Yes response rated on 2. The results on sensory evaluation are as follows:

Figure 23 shows that 80 percent of the elderly liked the appearance of the soup compared to 50 percent who liked the flavour and 60percent who liked the taste. Only 20percent of the elderly were uncertain about the appearance, 30percent were uncertain about the flavour and 40percent were not sure whether they liked or disliked the taste. Only 10percent disliked the flavour and taste of the soup.

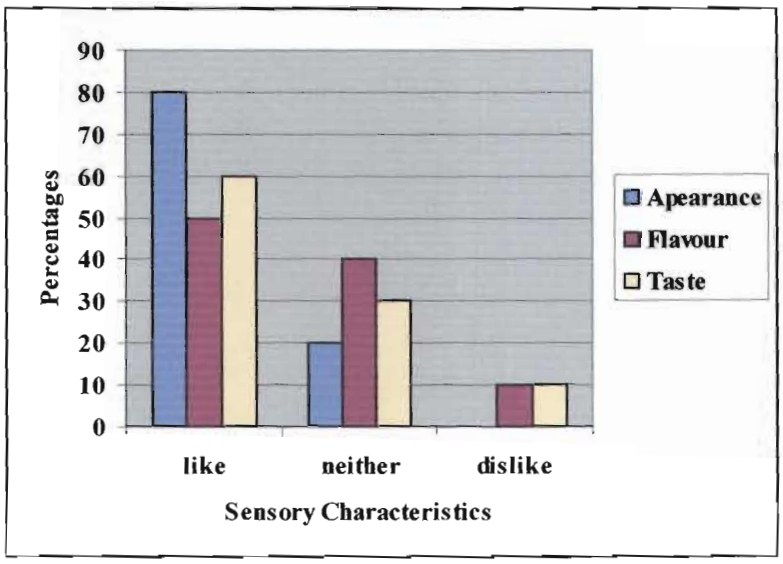

Figure 23 Sensory characteristics on appearance, flavour and taste of the soup.

Figure 24 the consistency of the soup was 100 percent (100percent) and only 10 percent indicated that they are unable to eat it. This indicates that the elderly may be able to eat

the soup, but they are hindered by the flavour. The fact that the elderly were briefed about the nutrients contained in the soup is indicated by their acceptance of the soup (80percent) and thus their indication of buying the product (80percent) contributed to the high percentage of acceptance. The soup contained micronutrients needed most by the elderly for their good health.

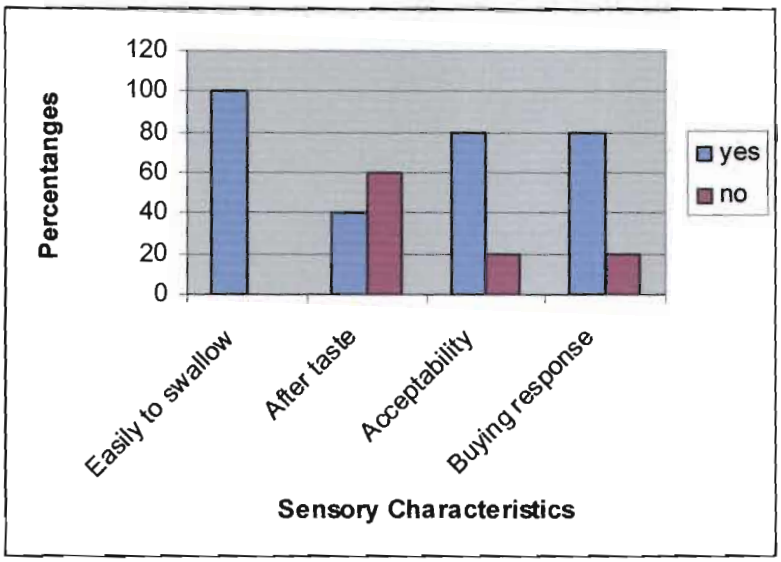

Figure 24 Sensory evaluation taste and swallowing the soup.

- **Sensory Evaluation of a muffin**

The recipe was prepared and taken to the care centre in Sharpeville where the randomly chosen elderly gave their views. Each one of the twenty elderly was given a questionnaire to complete.

In Figure 25 55percent of the elderly accepted the appearance, 75percent accepted the smell of the product because the tobacco smell from the dried spinach mixed with the apple blended very well and for taste only 15 percent disliked the taste.

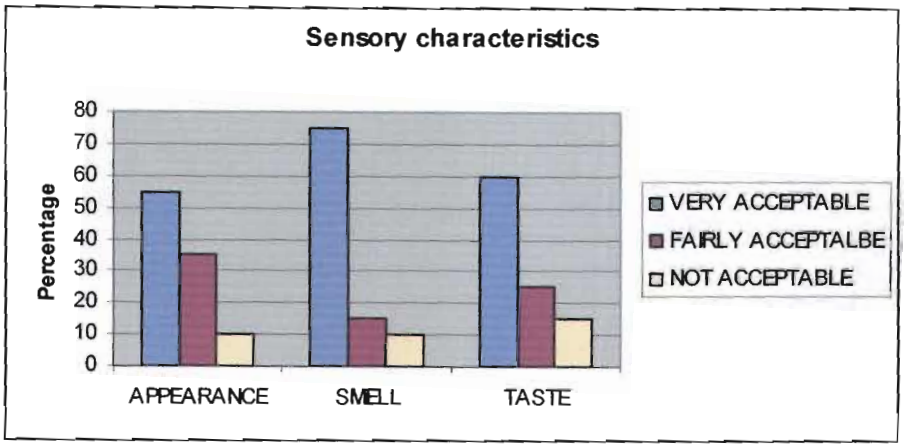

Figure 25 Sensory characteristics of the muffin.

Figure 26 indicates different categories of mouth feel, product taste and the way the elderly felt. Approximately 50percent across the board accepted that the texture of the product was soft, firm and rough because of the unpeeled grated apple texture.

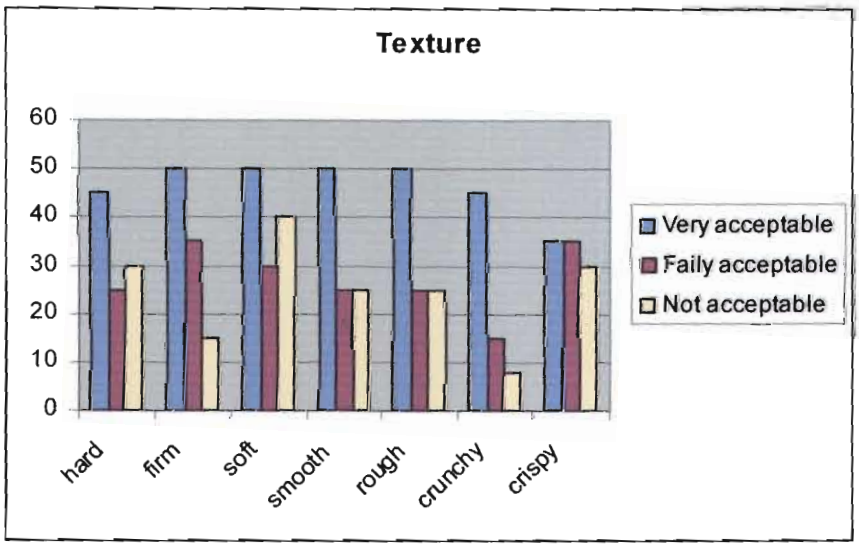

Figure 26 Different categories of mouth feel for a muffin.

In Figure 27 below the muffin received a 100percent approval, meaning that if the product can be commercialised elderly people will be able buy it, about 45percent appreciated the palabilty and approximately 70percent of the elderly liked the product because it was neither too sweet nor salty and the taste was blended quite well. The elderly that were partial to the product were just 25percent and only 5percent disliked the product.

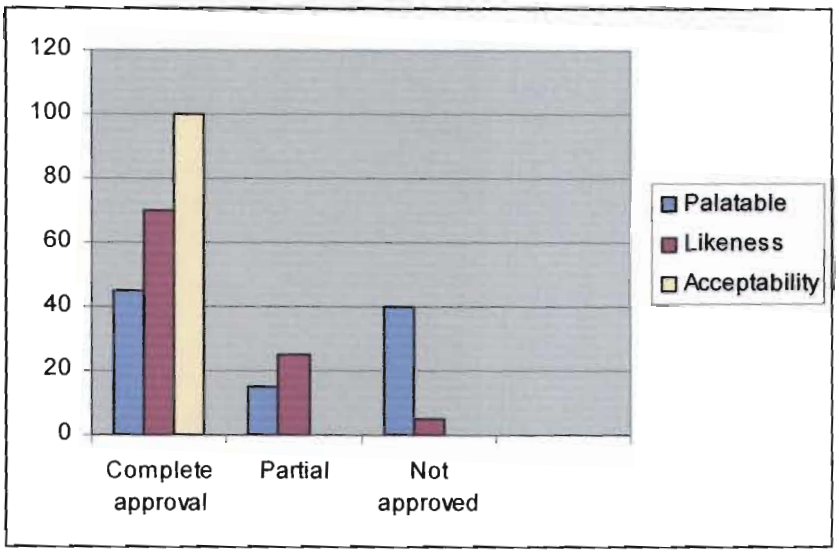

Figure 27 The approval of the muffin in case of commercialisation.

5.2.3.10 Shelf life analysis

Shelf-life testing of edible products is a routine process in food product manufacture. This often involves storage under different temperatures and humidity conditions and testing for microbes commonly associated with particular ingredients and/or products. This is a measure of microbiological safety of the product and is conducted to provide information about a product's spoilage risks under real-life conditions. Testing for fatty acid oxidation (rancidity) is also a useful way of ascertaining the ability of the product to keep well under different conditions i.e. a measure of wholesomeness and palatability of the product. In this study, monitoring the shelf-life of FMM products was part of the quality control process to ensure they were safe for human consumption over time.

- **Microbial analysis of nutritional multimix powder**

In Table 39 *E.coli* was detected for the multimix powder throughout the trial. The *Coliform* count for the multimix stated with less than 10 cfu/g and remained below log 2/g throughout the trial.

Table 39: The results of multi-mix stored at 25°C for 28 days.

Sample	Total Aerobic plate count Cfu/g	*E.coli* Cfu/g	*Coliform* Cfu/g	Yeast and Moulds Cfu/g
Day 0	180	-	-	<10
Day 3	560	<10	<10	<10
Day 7	650	<10	<10	<10
Day 14	5750	<10	<10	<10
Day 21	<1000	<10	63	10
Day 28	<1000	<10	<10	10

Note:<10 reflects the accuracy of the procedure and for all practical purposes implies the absence of the organism indicated.

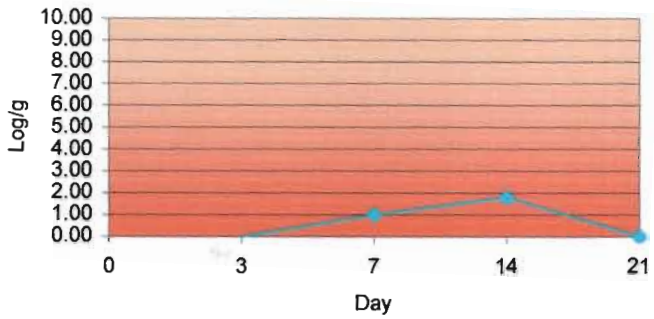

Figure 28 *Coliform* count for multi-mix powder stored at 25°C for 28 days

In Figure 29 indicates the total aerobic count for the multimix started at 180 cfu/g and increased with 1 log/g to 5 750 cfu/g on the day 14 and remained below log 3/g for the rest of the trial. The reason for the counts not having a value on day 21 and 28 are because the sample was not evaluated on those days.

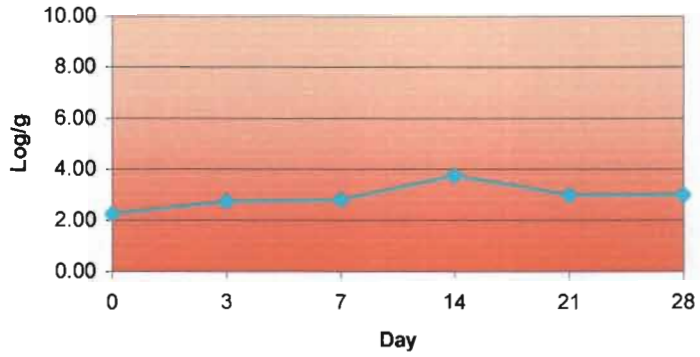

Figure 7 Total aerobic plates count for multimix powder stored at 25°C for 28 days

In Figure 30 the yeast and mould count for the multimix started at a very low <10cfu/g and remained low (10cfu/g on day 28) throughout the trial.

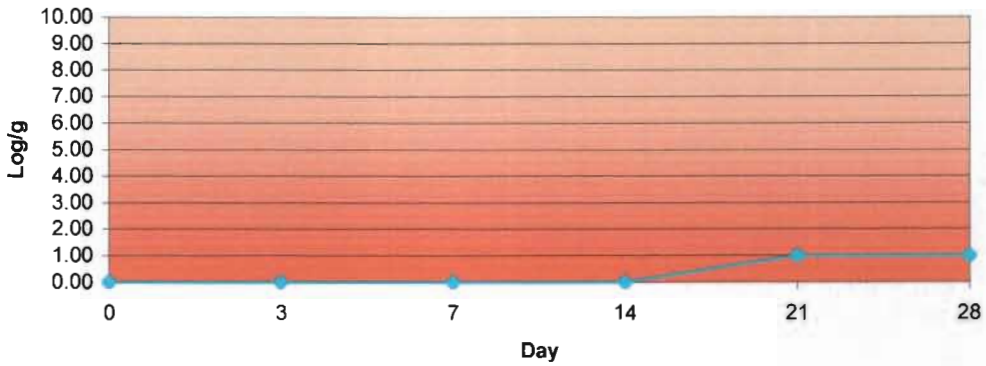

Figure 8 Yeast and mould count for multimix stored at 25°C for 28 days

- **Shelf life testing for soup**

During the biolog identification an organism called the *Bacillus cereus* was identified. The organism produced spores. The soup started to spoil at room temperature after two days. The soup started to be watery and had a change in colour and an odour. This was

also witnessed in the event of reheating it faster. The sample that was placed in the refrigerator took seven days longer to spoil, thus a shelf life of six days were recommended.

In Figure 31 indicates all the stage of bacterial growth during the first 12 days of the incubation. These stages are the lag phase, exponential phase, stationary phase and then the death phase. These are the results of samples that were stored at 30°C. After the 12th day there was a decline in the number of bacterial growth, this showed that after the death phase waste accumulated and that is what was indicated on the spectrometry records.

In Figure 31 the microorganisms started with the log phase where the was no growth of organisms, then in the lag phase microorganisms started to grow until they reached the stationary phase with the absorbance reading of 4. Microorganisms remained constant at the reading of 4 and never reached the death phase

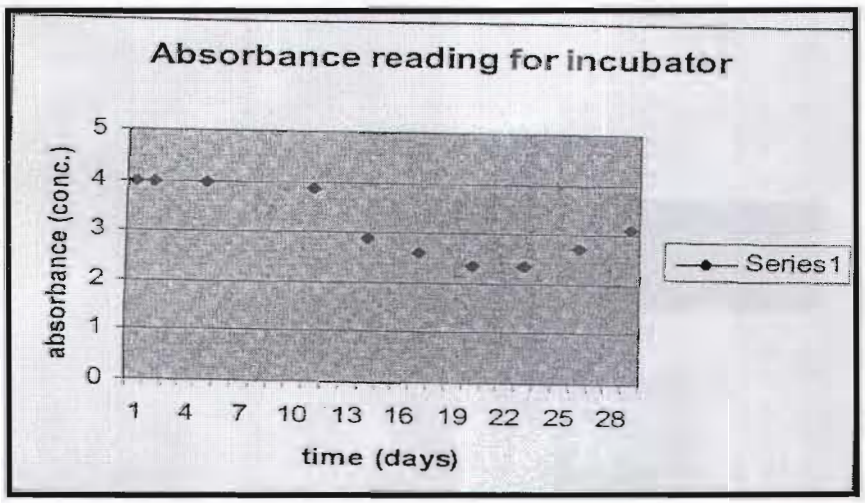

Figure 9 The bacterial growth of soup mix

Shelf life testing for muffins

In Figure 32 the microorganisms started with the log phase where the was no growth of organisms, then in the lag phase microorganisms started to grow until they reached the stationary phase with the absorbance reading of 4. Microorganisms remained constant at the reading of 4 and never reached the death phase

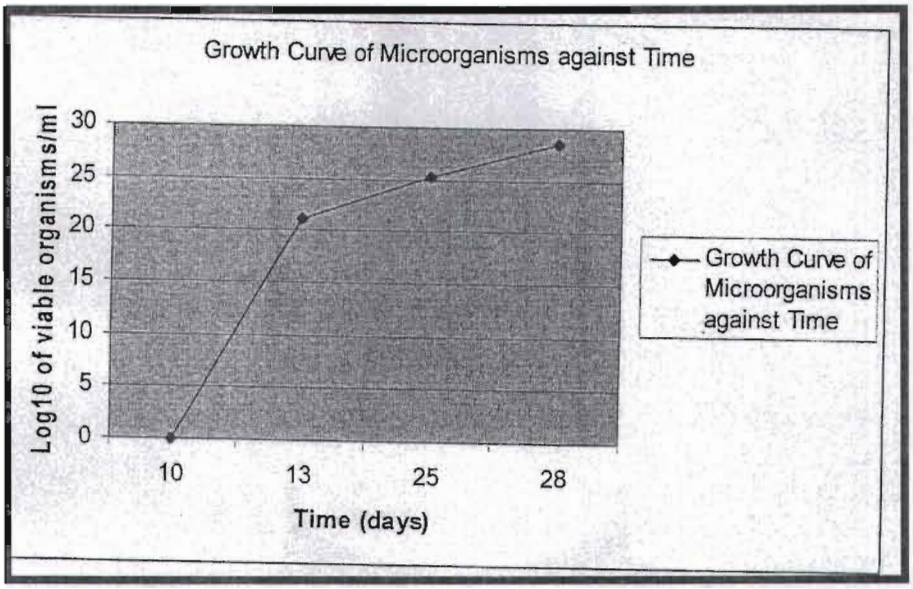

Figure 10 Gr owth curve of micro organisms against time for muffins

The results obtained in Figure 33 indicate that more nutrients from the sample were still present because the growth curve never reached the stationary and death phase. The cells continued to grow as indicated in the figure below. Although, some of the microorganisms died whilst others continued to grow. Hence there was fluctuation of absorbance readings that were not stable. The incubator with high temperatures of 30°C was used for determining the summer conditions of a muffin and as expected the muffin was spoiled within 3-4 days. The mould started to grow on the muffin after three days and at a moderate temperature of 25°C room temperature and the refrigerator was used for winter conditions. At room temperature mould started to show within 6-7 day. The

refrigerator was used for extremely cold conditions such as low temperature of 4°C and there was never growth for over a month.

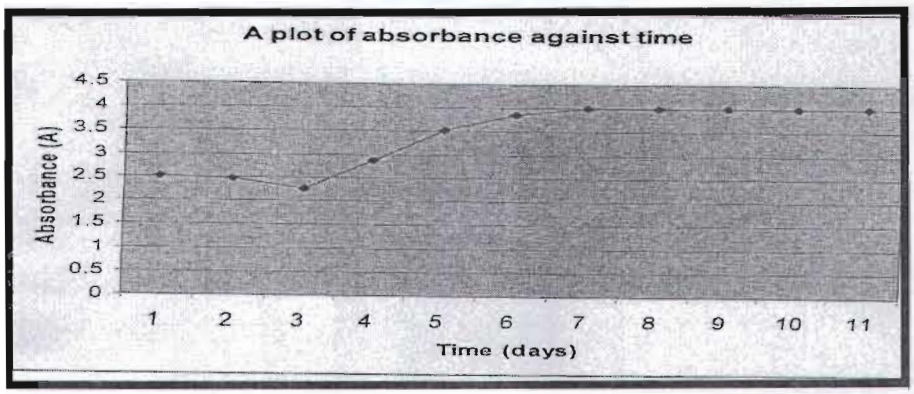

Figure 11 Absorbance against days in incubator storage of muffins

The results proved the theory that muffins are not spoiled by bacteria, but by moulds and yeasts. As observed from the growth of the substrate originally before they could be streaked onto the nutrient agar, mould growth was identified with the naked eye. The Gram staining method that ruled out the bacteria followed, as the cells that were observed were large. Studies state that yeasts are differentiated by bacteria from their larger cell size and their round, oval elongate or spherical cell shapes. The Gram staining was followed by wet preparation that confirmed the larger cells to be yeast cells. The API 20C AUX strip containing different sugars was used to identify specificity of the yeast studied. A *Cryptococcus albidus* was predicted to be the yeast observed. This organism rated 95,7percent with five tests being positive and only two were b negative from the strip. The mould that was identified was *Alternaria sp.* This organism causes spoilage of fruits and vegetables.

The overall counts of microorganisms for the FFM powder were very low throughout the trial. The identification for the mould ***Alternaria*** could be true, since the muffin was made out of spinach as one of the ingredients because this organism causes spoilage of fruits and vegetables. It is safe to consume the soup that is kept at room temperature

within a day (24 hours) during summer, 7 days in winter and less than a month in the refrigerator. The muffin is safe to be eaten within three days during summer time, six days in winter time and over a month in a refrigerator.

5.3 CONCLUSION

In this chapter the socio-demographic data and nutritional status of the elderly poeple in the care centre in Sharpeville was determined, after which a food multimix supplement was developed according to the set formulation criteria. Iron and zinc were the micronutrients considered important since these were the deficiencies found to be present in the baseline survey.

The process proved that it is possible to formulate a FMM or a novel food product according to certain formulation criteria as the theoretically formulated FMM met the criteria of at least 30percent RDA of energy, zinc and iron. However, when chemically analysed the values were lower than the theoretical values thus leading to an optimisation process of the FMM to ensure the criteria would be met even after chemical analyses of the product

Furthermore, the process proved that it is possible to develop recipes, based on the FMM that are culturally acceptable to the consumers. The sensory analysis indicated that the majority (80percent) of the respondents liked the soup, 85percent liked the muffin and the respondents gave 100percent approval for muffin commercialisation.

The shelf life testing proved that the FMM powder will have a longer shelf life for more than 28 days, however, the soup is safe for human consumption within a day at room temperature and muffin is safe to be eaten within three days.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 DISCUSSION

There are numerous ways to prevent malnutrition and ways to advance nutritional status. These involve activities to prevent mineral and vitamin deficiencies in vulnerable populations through dietary diversification, micronutrient supplementation and fortification of commonly eaten food. The prevalence of malnutrition and household food insecurity identified in the elderly attending a care centre in Sharpeville, SA motivated this study in order to develop an appropriate nutrition intervention programme to meet their needs and tastes for maximum compliance. The objective of this study was to develop a nutrient dense product that could be implemented as an intervention programme to address malnutrition in the elderly people attending at care centre in Sharpeville.

This study provides an opportunity to determine the nutritional status and consumption patterns of the elderly people in the care centre in Sharpeville with the background of poor socio-economic status. The outcomes of this research led to the development food of a multimix that is affordable, acceptable, safe for consumption, nutritious and easy to prepare from the ingredients that are readily available in the households in the community.

At present there is paucity in the literature addressing malnutrition in the elderly in Africa and there is much information that needs to be discovered about the elderly on the African continent.

6.2 LIMITATIONS

The essential limitation of this study is the fact that the biochemical analyses for the determination of the nutritional deficiencies had to be carried by an accredited laboratory.

This was very costly and the analysis that was conducted was that of multimix powder, but the optimized recipe, muffin and soup could not be analysed.

This study was carried out in one centre in the Vaal Triangle and it would have been more beneficial if it covered other centres in the area, but the results can be used as a pilot study for further research to be undertaken in this field.

6.3 Main findings

6.3.1 Baseline survey

Based on the baseline survey the results indicate that this was a low-income community, resulting in possible household food security. About 81,8percent of the respondents indicated that they bought food only once a month and the food was generally bought from supermarkets (68,2percent) which are generally very expensive. Most of the households (63,1percent) spent less than R200 on food per week. Taking into consideration that the average household size was 4,9 percent people, it was calculated to be less than R5,80 per person per day. This was equivalent to a loaf of bread or litre of milk. The Top 20 food consumption list indicated that the majority of food items consumed were carbohydrate-based, and although chicken, beef and eggs appeared as protein sources, these were consumed by a minority of subjects. However milk, was consumed by subjects (43 percent), but the mean daily intake was small (67 g).

The dietary intake results confirmed that these households consumed mainly a carbohydrate-based diet (149percent) of total Energy (E) intake and although the daily protein intake (109,5percent) of total E intake was sufficient, the intake was deficient for total energy and dietary fibre, as well as a number of micronutrients including calcium, magnesium, zinc, selenium, iodine, thiamine, riboflavin, vitamins B6, C, D, E, biotin, pantothenate and folate. These findings indicated the prevalence of undernutrition. The low zinc and iron intakes were confirmed by the biochemical results indicating zinc deficiency in 73,1percent of the respondents and a marginal iron deficiency. However, no other micronutrient deficiencies were prevalent when blood results were analysed for folate, vitamin A and vitamin B_{12}

The anthropometric data in this study indicates that the majority of the female subjects were overweight and obese, signifying overnutrition, thus the double burden of disease is prevalent in this sample of elderly people. The health status of the respondents was compromised. A large number of subjects were taking chronic medication (55,9percent) and suffered from a number of disorders including painful joints (70,6percent), ear, nose and throat (ENT) infections (72,4percent) and chronic headaches (48,2percent). About 40,6percent of the subjects received chronic blood pressure medication, but blood pressure (BP) was measured, the results indicated only 10percent of the subjects with a normal BP. In South Africa the coexistence of undernutrition with overnutrition is evident from the elderly with high prevalence of obesity in black women, as well as hypertension and stroke in urban Africans (Oldewage-Theron, 2001:160). It is known that hunger and obesity can exist within the same household (Townsend, 2006:34; Scheier, 2005:883). This is especially true for low-income households, as was found in this community.

6.3.2 Findings concerning the development of multimix

The criteria for the development of a multimix were to use locally available food items and to select foods that complemented each other in terms of zinc and iron content to achieve at least 30 percent of the RDA for energy, zinc and iron in a 100g of the dry food FMM. Furthermore the FMM had to be affordable and safe for human consumption. This study showed that it was possible to formulate a FMM meeting these criteria. However, it is important to use both theoretical and biochemical analysis method as theoretical calculations cannot be relied upon. The results indicated that 73,5percent of the respondents had electric stoves and the preparation method had to take this into consideration. Therefore, soup and muffins were developed as this could be prepared by the majority of subjects. The product was cost effective as it would cost R1,48 per person per day and acceptable to the elderly in order to ensure compliance. The soup and muffin were convenient products to be consumed in both summer and winter. The muffin is palatable in summer as much tea is drunk and the soup in winter can replace a muffin. The sensory evaluation of the soup and muffin also showed that both products

were acceptable to the majority of the elderly as they received high scores for taste, appearance and general acceptability.

The shelf life and results showed that the FMM has a shelf life longer than 28 days. The soup results showed a recommended shelf life of two days at room temperature (24°C) if not reheated and the muffin was also tested for shelf life and the results indicate a recommended shelf life of three days at room temperature (24°C). This indicates that the FMM and recipes were safe for human consumption and in households where no fridges were available (2,3percent).

6.4 CONCLUSIONS

From the results the following conclusions are drawn:

1. Malnutrition remains an important risk for morbidity and mortality in the elderly. There are various effects of malnutrition in the elderly including poor dietary intake which results in impaired immunity leading to an increased risk of infectious disease. While these adverse effects are applicable to all age groups, the elderly were found to be especially at risk and the many side-effects of malnutrition exacerbate their health status (Watson, 1993:1; Azad, 2002:8 and Thomas *et al.,* 1991:335).
2. Various strategies may be implemented to address the persistent malnutrition problem and all have their advantages and disadvantages.
3. Food diversification is a strategy adopted globally to alleviate hunger and household food insecurity.
4. A novel food was developed to address the problem of malnutrition among the elderly attending the care centre in Sharpeville. An affordable and safe acceptable food product, meeting 30percent of the RDA's for the iron, micronutrients was developed. However, with the ingredients used for the initial FMM it was not possible to meet the criterium of 30percent zinc. No special equipment was required and ingredients available in the household can be used for preparation.

5. The multimix, soup and muffin developed in this project, met all the criteria for the intended use as a feeding intervention for this community in the Vaal Triangle.
6. A sustainable solution for intervention programmes may be thus possible.
7. The recipe pamphlet especially developed for illiterate elderly can be utilised to teach the elderly to prepare the recipes.

6.5 RECOMMENDATIONS

Recommendation 1: FMM development

This research project provided the opportunity to determine the nutritional status of the elderly attending a care centre in Sharpeville. The output of this research is aims a novel food product in the form of FMM that is culturally acceptable, affordable, nutritious regarding iron content and easy to prepare from ingredients usually available in the households with no need for special equipment or utensils. More research is, however, needed with different formulations to obtain the "optimum" product meeting all the formulation criteria.

Recommendation 2: Nutrition education

Nutrition education is still lacking in the communities because it is not sustainable and it is something that is carried out once in a while when there is an epidemic or new outbreak of a disease. There should be a continuous programme that is sustainable to educate people about nutrition so as to improve their dietary patterns and food habits within the budget available in the household.

Thereafter, the recipe leaflets can be made available to the elderly and to the kitchen staff of the care centre in Sharpeville so that they can be trained in the preparation of the multimix products for the incorporation of the muffins and soup in the meals of the elderly. Multimixes can also be developed for other conditions such as for HIV/AIDS, weaning powders for children and small businesses can be the result thereof.

6.5.2 Recommendations for further research

Furthermore, more research is required to determine market needs, packaging materials, product lines and distribution of multi mix. Further research on the bio-availability of the nutrients in the FMM is required.

It is recommended that FMM be implemented as part of the intervention programme to measure the impact of daily FMM consumption on the nutritional status of the elderly, as well as the compliance over a long-term period.

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ANNEXURE A: Ethical clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Oldewage-Theron

CLEARANCE CERTIFICATE	PROTOCOL NUMBER M040835
PROJECT	Sharpeville Integrated Nutrition Project for the Elderly
INVESTIGATORS	Prof W Oldewage-Theron
DEPARTMENT	Hospitality & Tourism
DATE CONSIDERED	04.08.27
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 04.09.03 CHAIRPERSON .....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof Ce Venter

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. I agree to a completion of a yearly progress report.

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

ANNEXURE B: Socio-demographic questionnaire

SOCIO-DEMOGRAPHIC QUESTIONNAIRE

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

GENERAL INFORMATION

Date : .....

Name : .....

ID Number : .....

Address : .....

.....

.....

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

Example: In what town do you live?

Johannesburg	Bloemfontein	Cape Town	Vanderbijlpark	Durban

PERSONAL INFORMATION

Your role in the family

Mother	Grandmother	Father	Grandfather	Other, specify……..

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

2.3 How old are you? _____ years

2.4 Gender:

Male	Female

Are you?

Single	Married	Widowed	Divorced	Other……..

3. ACCOMMODATION AND FAMILY COMPOSITION

Where do you live?

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

Do other people live in your house?

How many people are living in your house?

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

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

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

Are all members permanent residents in this house?

Yes	No

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

< 1 year	1-5 years	>5 years

3.7 Do you have another home outside the Vaal Triangle?

Yes	No

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

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

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

Yes	No

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

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

Do you have the following facilities at home?

Water

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

3.11.2 Toilet facilities

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

3.11.3	Waste removal	Yes	No

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

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

.....
.....

3.13. Do you have problems with the following?

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

INCOME

How long have you been on pension?

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

Is your spouse (partner) in paid employment at present?

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

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

4.4 What is the total income in the household per month?

<	R501-	R1001-	R1501-	R2001-	>

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

Always	Often	Sometimes	Seldom	Never

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

0	1	2	3	4	5	6	7	8	9

People

4.7 How often do you buy food?

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

4.8 Where do you buy food?

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

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

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

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

Food item	**Yes**	**No**	**Food item**	**Yes**	**No**
Chicken			Cheese		
Beef			Eggs		
Mutton			Fresh milk		
Tripe			Powdered milk		
Fish			Condensed / Ideal milk		
Canned fish eg pilchards			Cremora		
Polony and other processed meat			Frozen vegetables		
Canned meat eg bully beef			Fresh vegetables		
Cold drink			Canned vegetables		
Sugar			Fresh fruit		
Maize meal			Canned fruit		

Oil			Fruit juice		
Butter / margarine			Coffee, instant		
Peanut butter			Tea		
Fish paste			Cheese curls		
Jam			Sweets		
Bread, brown			Chips		
Bread, white			Maltabella		

5 EDUCATION AND LANGUAGE

What is the highest education you have?

None	Primary School	Secondary school	College	Other post school

5.2 What language is spoken mostly in the house?

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

6 ASSETS

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

How many meals do you eat at per day?

0	1	2	3	> 3

Where do you eat most of your meals?

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

Does your home have the following and how many?

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

Thank you very much for your co-operation.

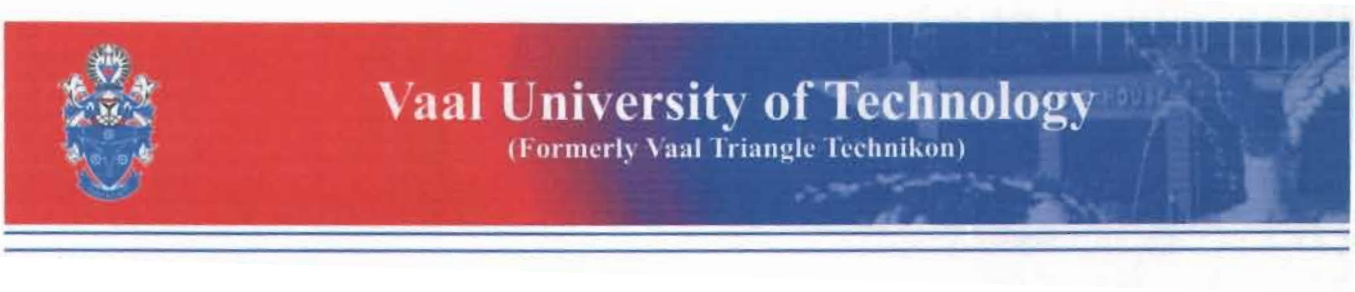
Wilna Oldewage-Theron (Prof)

Activity leader: Sharpeville Integrated Nutrition Project

Tel: 016 950 9279

Fax: 016 950 9788

ANNEXURE C: Health questionnaire



SHARPEVILLE INTEGRATED NUTRITION PROJECT (SINP)

ANTHROPOMETRIC, HEALTH, MEDICAL AND BEHAVIOURAL QUESTIONNAIRE

Section A:

1.

Surname		ID number (if applicable)	
First Names		Age	
Height	m	Weight	kg
Gender	Male ☐Female ☐		

Section B:

HEALTH QUESTIONNAIRE:

2.

ARE YOU SUFFERING OR HAVE YOU SUFFERED FROM	**YES**	**NO**	**IF ANY ANSWER IS YES, GIVE DETAILS OF THE NATURE, SEVERITY AND DURATION OF ILLNESS**
1. Any skin disease?			
2. Any affection of the skeleton and/or joints?			
3. Any affection of the eyes, ears, nose or teeth?			
4. Any affection of the heart or			

circulatory system?			
5. Any affection of the chest or respiratory system?			
6. Any affection of the digestive system?			
7. Any affection of the urinary system and/or genital organs?			
8. Any nervous affection or mental abnormality?			
9. Any headaches			
10. Any other illness?			

3.

	YES	**NO**
Have you lost weight during the past month?		
Have you had a recent change in appetite?		
Do you have problems with the following:		
* chewing?		
* swallowing?		
* nausea?		
* diarrhoea?		
* vomiting?		
* constipation?		
Do you follow a special diet?		
If yes, specify…….		
Are you allergic to any foods?		
If yes, specify		

4.

Would you say your usual level of physical activity is:	**Tick the correct block**
1. Heavy/ rigorous (running, playing tennis, swimming, doing heavy gardening, etc., at least three times per week)	
2. Moderate (Taking rigorous exercise once or twice a week, or steady walking, or other moderate activities at least three times per week)	
3. Light (playing golf, taking a stroll, or doing none rigorous activities occasionally)	
4. None (No exercise whatsoever)	

5.

How often do you get tired?	**Always**	**Sometimes**	**Never**

6.

	YES	**NO**
1. Do you suffer from any defect of hearing, speech or sight?		
2. Are you physically disabled and do you use artificial limbs?		
GIVE DETAILS OF THE NATURE AND SEVERITY OF THE DISABILITY		

7.

Do you smoke at this moment?	**Tick the correct block**
1. Yes	
2. No (Never smoked	
3. No (Stopped)	

8. If yes in question 5, answer question 6.

What do you smoke and how many per day?	**YES**	**NO**	**NUMBER per DAY**

Cigarettes, home made			
Cigarettes, bought			
Cigarettes, bought, light			
Cigars			
Pipe			
Other, specify			

9.

Does you're spouse or partner smoke at this moment?	**Tick the correct block**
1. Yes	
2. No	
3. Not applicable	

10.

Do you make use of snuff at this moment?	**Tick the correct block**
1. Yes	
2. No (Never used)	
3. No (Stopped)	

11.

Do you use alcohol on a regular basis ?	**Tick the correct block**
1. Yes	
2. No	
3. Not applicable	

12.

If you use alcohol, How often?	**Tick the correct block**

1. Every day	
2. Once a week	
3. Occasionally	

13.

What type of alcoholic drinks do you drink?	**Tick the correct block**
1. Commercial beer / cider	
2. Home brewed beer	
3. Strong liquor ex. Whiskey, brandy, Vodka etc.	
4. Wine	

14.

	YES	**NO**
Have you undergone any operations?		
GIVE DETAILS OF THE NATURE AND DATE OF THE OPERATION/S …… …… ……		

Section C:

MEDICATION AND HEALTH FACILITY QUESTIONNAIRE:

1.

1. Do you use any medication?	**Yes**	**No**
2. If no, go to the next block.		
3. If yes, what for/why? ……		

…… ……		
4. What is the name of the medication you are taking? …… …… ……		
5. What is the dosage and how often do you take this medication?. …… ……..	**Dosage**	**How often?**

2.

Do you take any supplements?	**YES**	**NO**

3. If yes in previous question.

Specify the type	Vitamins, specify…… …… ……	Minerals, specify…… …… ……	Multivitamin	Other, specify…… …… ……

4.

Which health facility is commonly used by you?	**Tick the correct block**
1. Private Doctor	
2. Clinic	
3. Hospital	
4. Traditional Healer	
5. Other (please state)	

5.

How do you travel to the health facility?	**Tick the correct block**
1. On foot	
2. Taxi	
3. Bus	
4. Own transport	
5. Other (please state)	

I declare that the above-mentioned information is true and correct and that I have not withheld any information.
Signature.....Date.....

Thank you very much for your co-operation.

Wilna Oldewage-Theron (Prof)

Activity Leader: Sharpeville Integrated Nutrition Project

Tel: 016 950 9279

Fax: 016 950 9788

ANNEXURE D: 24-hour recall questionnaire

24-HOUR RECALL

Subject's date of birth : ----------Age-------- Gender Male/ Female

Interviewer:----------

Name---------- Date----------/----------/2005

Address:----------

Tick what the was yesterday:

Monday Tuesday Wednesday Thursday Friday

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

Yes No

If not, why?

I bought some My visitor brought me some Other **reasons(please**

food food specify)

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

Time (approximately	Place	Description	Amount in g(office use only)	Code(officeuse only)
From waking up to going to work ,or starting the day's activities				

During morning(after breakfast)					
Time (approximately)	Place	Description of food	Amount	Amount in g(office use Only	Code (office use only

Middle of the day(Lunch time)					
During the afternoon					
At night(dinner time)					

Time (approximately)	Place	Description of food	Amount	Amount in g (office use Only	Code(office use only)
After dinner,before going to sleep					

*Do you take any vitamins(tablets or syrup)	Yes	No
Give the brand name and dose of the vitamin/ tonic		

ANNEXURE E: ARC multimix report

ARC • LNR

ARC-Livestock Business Division

Nutrition and Food Science

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

Enquiries / Navrae

Jansie Krüger

Tel: (012) 672 9392/9338

Fax: (012) 665 1551

2005-12-05

Noloyiso

Fax: (016) 950 9788

Tel: (016) 9509722

Noloyiso

Please find attached the final report on the nutritional powder.

Regards

Jansie Krüger

Shelf life analysis of Nutritional Powder

Introduction

The Nutritional powder was delivered to the ARC-Microbiology section on Monday afternoon the 12th of September 2005. The powder was packed in a plastic bag.

Shelf life study

The powder was kept at room temperature (±25°C) and analyzed on day 0 (12 September 2005, day of arrival) day 3 (15 September 2005), 7 (19 September 2005), day 14 (26 September 2005), 21 (3 October 2005) and day 28 (10 October 2005).

Microbiological analysis

An aliquot of 10g of sample was removed aseptically from the bag of powder each time it was analyzed. The samples were homogenized in a Stomacher 400 (DHK Pty Ltd) with 90 ml of diluent (Buffered peptone water). The samples were analyzed for Total aerobic plate count on Tryptone soy agar and incubated at 25°C for 72 ± 3 hours and for Coliform and *E.coli* count on Violet red bile MUG agar and incubated at 37°C for 24 ± 2 hours. Due to no instructions included with the samples, *E.coli* and Coliforms analysis was left out on day 0. After consultation with the responsible person, these analyses were included in the rest of the trial. The Yeast and Moulds were analyzed on Rose Bengal agar with Chloramphenicol and incubated at 25°C for 5 days.

Table 1. Result of Nutritional Powder (Multimix N1) stored at 25°C for 28 days

Sample	Total Aerobic Plate count Cfu/g	*E.coli* Cfu/g	Coliform Cfu/g	Yeast and Moulds Cfu/g
Day 0	180	_	_	<10
Day 3	560	<10	<10	<10
Day 7	650	<10	<10	<10
Day 14	5750	<10	10	<10
Day 21	<1000	<10	63	10
Day 28	<1000	<10	<10	10

Cfu/g = Colony Forming units per gram of sample

Note: <10 reflects the accuracy of the test procedure and for all practical purposes implies the absence of the organism indicated.

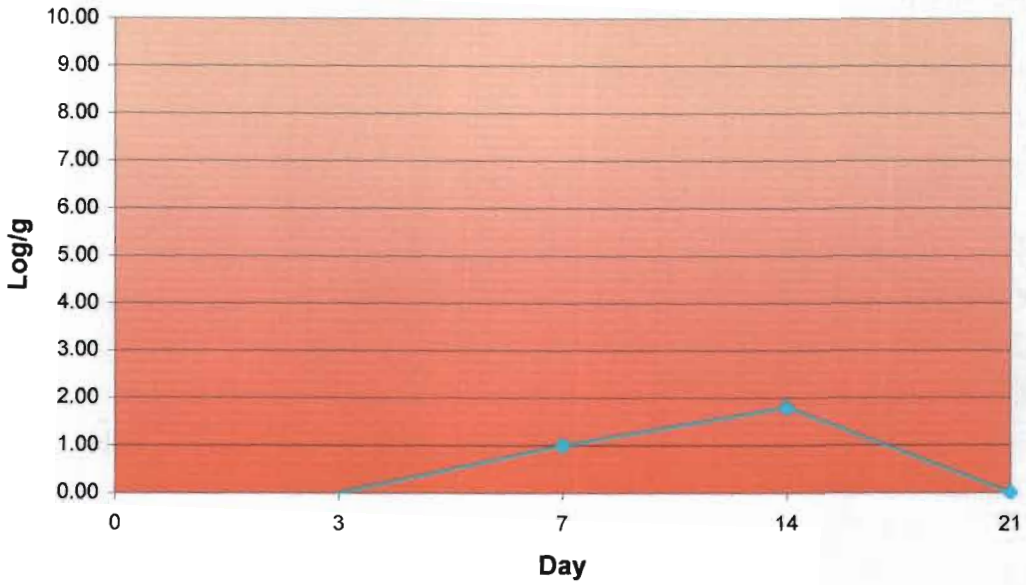
Discussion

Coliform and *E.coli* count

N *E.coli* (Table 1) was detected for the Multimix N1powder throughout the trial.

The Coliform count (Figure 1) for the Multimix N1 started with less than 10 cfu/g and remained below log 2 /g throughout the trial.

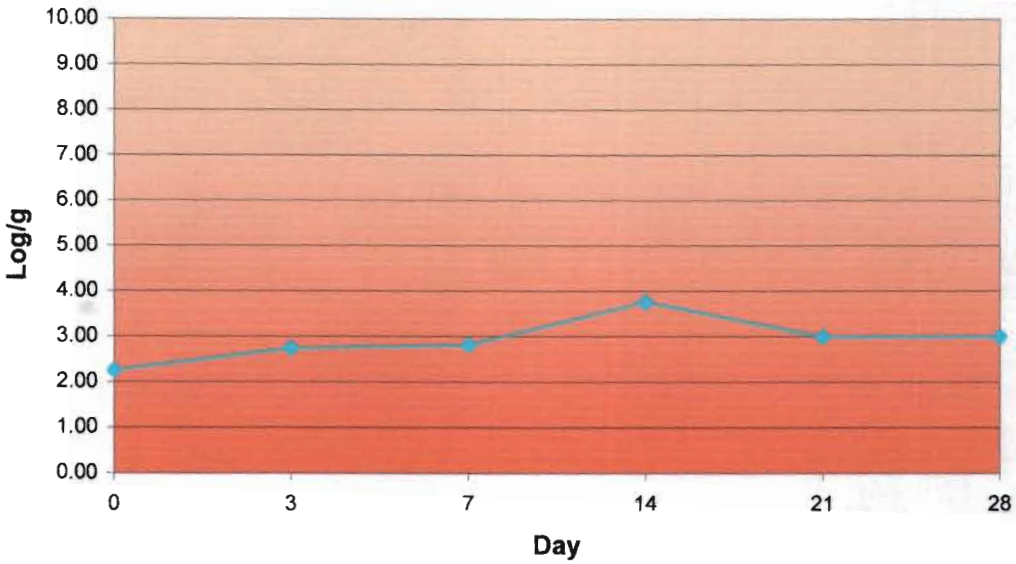
Figure 1. Coliform count for Multimix N1 stored at 25°C for 28 days



Total aerobic count (Figure 2)

The Total aerobic count for the Multimix N1 started at 180 cfu/g and increased with 1 log/g to 5750 cfu/g on day 14, and remained below log 3 /g for the rest of the trial. The reason for the counts not having a value on day 21 and 28 are because the sample was evaluated according to the results from the previous day's analysis, and since the count was at log 4 per gram, the analyst assumed that the count will increase, and did not prepare a full dilution range. No growth could be detected on a 10^{-3} dilution, and thus the count can only be expressed as less than a 1000 organisms per gram.

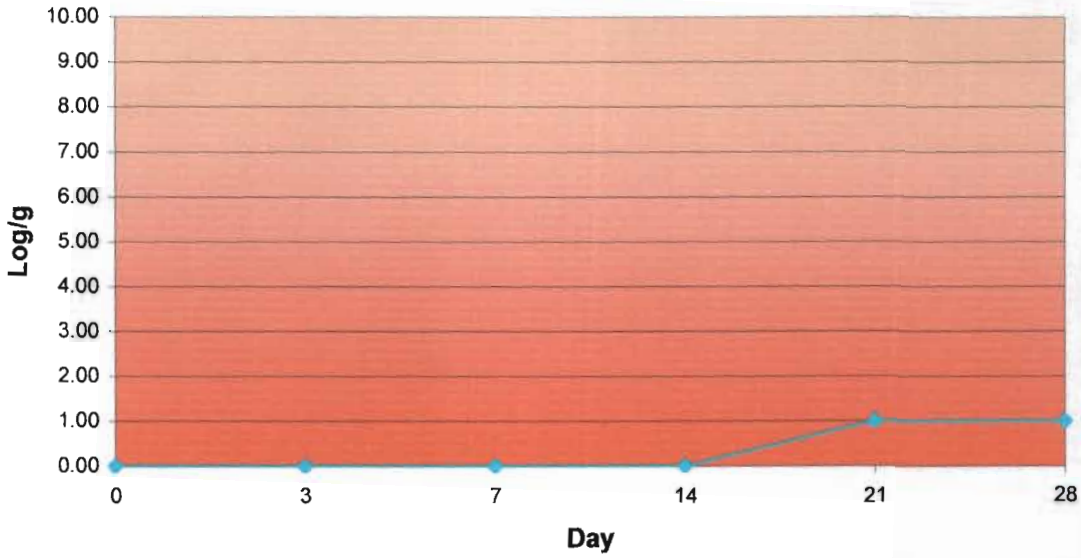
Figure 2. Total aerobic plate count for Multimix N1 stored at 25°C for 28 days



Yeast and mould count (Figure 3)

The Yeast and mould count for the Multimix N1 started at a very low <10 cfu/g and remained low (10 cfu/g on day 28) throughout the trial.

Figure 3. Yeast and Mould count for Multimix N1 stored at 25°C for 28 days



Conclusion

The overall counts for the Multimix N1 are very low throughout the trail. The Multimix N1 will have a longer shelf life than 28 days.

ANNEXURE F: Sensory evaluation questionnaire of cream of spinach soup and muffin

Cream of Spinach Soup:..... **Date.....**

1. **Subject No**..... **3. Age** (Yrs).....

2. Location ..... **4. Gender [M], [F]**

Please indicate the degree of acceptability of the following products using the codes: **Like(☺)**, **Neither** (😐), and **Dislike** (☹)

CHARACTERISTICS	☺	😐	☹
Appearance			
Flavour			
Taste			

CCHARACTERISTICS ☺ 😐 ☹
Consistency
Portion size
Eating response

CHARACTERISTICS	**YES**	**NO**
Easy to swallow		
After taste		
Acceptibility		
Buying response		

Spinach Muffin ..... **Date.....**

1. **Subject No.....** 3. **Age (Yrs).....**

2. Location ..... **4. Gender [M], [F]**

Please indicate the degree of acceptability of the following products using the codes: **Very acceptable** (☺), **Fairly acceptable** (😐), and **Not acceptable** (☹)

CHARACTERISTICS	☺	😐	☹
Appearance			
Colour			

SMELL	☺	😐	☹
Pleasant			
Fruity			
Fishy			
Revolting			
None			

TEXTURE	☺	😐	☹
Hard			
Firm			
Soft			
Smooth			
Rough			
Crunchy			
Crispy			

TASTE	☺	😐	☹
Salty			
Sour			
Bitter			
Sharp			
Bland			

APPROVAL RATING

Please indicate your overall approval of the product on a care centre in Sharpeville of 0 to 10:

A (O) = **Not approved, B** (5) = **Partial approval, C** (10)= **Complete approval**

RATING	**A**	**B**	**C**
Palatability			
Likeness			
Acceptability			

ANNEXURE G: Recipe pamphlets

CREAM OF SPINACH SOUP

X 

100g Spinach multi- mix

X 

10ml Cooking Oil

20g Onion

50g Tomato

Method

1. Wash onion and tomato.
2. Chop onion and tomato
3. Heat oil in a pan and saute the onion for five minutes
4. Add the tomato and stir for five minutes
6. Add water into a pan, add the multi-mix and simmer for 45 minutes
7. Liquidize and serve

SPINACH MUFFIN

¾ Spinach multi- mix

1x teaspoons canderel

2x teaspoon Oil

1X egg


¾ cup grated apple

Method

1. Combine all dry ingredients. Blend on slow speed for 10 seconds
2. Combine egg, water and oil. Add to dry ingredients, mix at slow speed only to blend for 25 seconds
3. Fold apples into batter, soak them for 20 minutes before you bake.
4. Measure with no.24 dipper into greased muffin pan.
6. Dip butter all at once.

7. Remove from pan as soon as baked.

ANNEXURE H: Language editing certificate

This is to certify that the language editing of the dissertation entitled: *Development of a food multimix to address malnutrition amongst the elderly*, written by Ms NB Matiwane was done by the undersigned.

Prof L A Greyvenstein is a member of the South African Translators' Institute, membership number: 1001691. She completed her primary, secondary and tertiary education, including a doctoral thesis, in English. She has done the English language editing of many proposals, dissertations, theses and scientific articles.

Lesley Ann Greyvenstein (Prof)
(South African Translators' Institute: membership no. 1001691)
P O Box 6722
Flamwood
Klerksdorp
2572
Tel: 018 468 5058
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