A FOOD MULTI-MIX SUPPLEMENT FOR PREGNANT WOMEN IN THE VAAL REGION

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The financial assistance of the National Research Foundation and VUT towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at are those of the author and are not necessarily to be attributed to other researchers.

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

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This dissertation is being submitted in partial fulfilment of the requirements for the degree of MTech Food and Beverage Management

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DEDICATION

This dissertation is dedicated to my nuclear family, the Ahene – Affoh's (Francis, Doreen and Charles) and Mr. and Mrs Jerry Dwansah Drammars.

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LIST OF ABBREVIATIONS

AAS	Atomic absorption spectrometer
AIDS	acquired immune deficiency syndrome
ARC	Agricultural Research Centre
BMI	Body mass index
BMR	Basal metabolic rate
CD	Co-efficient of digestibility
CHU	Child health week
CQHC	centre for quality health care
DNA	Deoxyribonucleic Acid
FMM	food multi-mix
HB	haemoglobin
HCT	haematoid
HPLC	high performance liquid chromatography
Ht	Haetocrit
ICP	Inductively coupled plasma
IDA	iron deficiency anaemia
IOM	Institute of medicine
MCV	mean corpuscular volume
MI	Micronutrient initiative
NID	National Polio immunization days
NTD	Non transmitted Disease
NTDS	neural tube defect syndrome
PHN	Public health nutrition
RDA	Recommended daily allowance
SSA	Sub Saharan Africa
TFRS	transferring receptors
TIBC	Total iron-binding
TSST	Trier social stress technology
UNICEF	United Nations children's Fund

UNSSC	United Nations special session on children
USAID	United States Aid
VAD	Vitamin A Deficiency
WHO	World Health Organization

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ABSTRACT

Good maternal nutrition is vital for the health and survival of the developing foetus. Nutritive inadequacy has been associated with pregnant women in developing countries particularly Sub Saharan Africa. Adequate intake of both macro and micronutrients by this vulnerable group must be ensured to avoid maternal and infant morbidity and mortality. In this study, a novel approach was employed to develop a cost effective, culturally acceptable and nutrient-dense food multi-mix (FMM) supplement that would help meet 20-25 percent of the recommended daily allowance (RDA) of pregnant women aged between 20and 30 years in the Vaal region.

Twenty FMM supplements were formulated using South African food composition tables to ensure adequate nutritional content. Two out of the twenty, were selected and named FMM C1 and C3 respectively. FMM C1and C3 was selected owing to their better nutrient contents and affordability when compared with the others. Food items used to formulate FMM C1 included maize meal, pea powder, peanut dry, milk powder and kidney beans. FMM C3 was formulated with sorghum, maize meal, peanut dry and onion powder. Chosen food items were dried, roasted, ground and mixed together proportionately. FMM supplements (C1 & C3) were analyzed using standard laboratory techniques to determine their nutrient content. Results obtained were from the Agricultural Research Council (ARC). The shelf life of the FMM supplements was microbiologically tested. Shelf life testing proved safety for the time of consumption, as very little microbiological growth was found in 28 days. The FMM supplements were then incorporated in the development of two acceptable recipes (soup and gravy).Simple recipe leaflets were developed for use by the subjects. The process proved that it is possible to formulate a FMM or any other food product according to certain formulation criteria since formulated FMM supplements (C1 and C3) met the criteria of at least 20% RDA of Protein (g). However, the criteria for micronutrients and energy were difficult to meet as folate iron and energy showed lower percentages of 10%, 14% and 18% respectively in the experimental situation. Sensory evaluation was conducted to ascertain the acceptability of the developed recipes (soup and gravy). The sample consisted of pregnant women randomly selected from John Haynes and Sharpeville clinics respectively, it can be concluded it is possible to formulate and develop products that were culturally acceptable to the consumers (pregnant women) as sensory analysis indicated the majority (85%) of the respondents liked the gravy and 65% liked the soup. Further research is needed to address the impact on nutritional status, long-term compliance and development of range of FMM with various ingredients to determine the most nutritional, cost effective and acceptable product for pregnant women.

CHAPTER ONE

THE PROBLEM AND ITS SETTING

1.1 INTRODUCTION

This chapter presents a background of the study and discusses the prevalence of malnutrition in pregnant women globally, in Africa, and for the purpose of this study, in the Vaal region of South Africa. Some individual countries that display high prevalence of maternal malnutrition are mentioned. Special nutrition concerns during pregnancy are discussed (Fleck 2005:369). The chapter concludes with the objectives and scope of the study.

1.2 BACKGROUND TO THE STUDY

Successful pregnancy requires continuous adjustments in maternal body composition, metabolism and the functions of various physiological systems. Most women in all countries get pregnant too frequently and therefore become, malnourished or anaemic and die of causes which can be easily prevented (Sharma 2006:195). Pregnancy is a critical period during which the diet of a pregnant woman reflects not only on her own health but on the health of the foetus as well (Petrakos Panagopoulus, Koutras, Kauzis, Kanellopoulus, Salamekis & Antorios 2006:166). Nutritional adequacy both in quality and quantity during this period is important for the physical and mental development of the infant later in life. It is therefore very important for the pregnant woman to understand these necessities (Petrakos *et al* 2006:167). The nutritional state of a pregnant woman at the onset of pregnancy is an important factor in determining the condition of the foetus (Fleck 2005: 369).

Good maternal nutrition is vital for the health, and reproductive performance of women and the development of the pregnant woman's children. However, these reproductive years are periods of nutritional stress for many African women and pregnancy's related health and nutritional problems affect the quality of the pregnant women's lives and that of their new born infants well beyond delivery (Ladipoo 2001:90). A woman's body changes dramatically during pregnancy. The uterus and supporting muscles increase in size and strength and the blood volume increases by half to carry the additional nutrients and other materials. The expectant mother's joints become more flexible in preparation for child birth. The pregnant woman's feet swell in response to high concentration of the hormone oestrogen, which promotes water retention and helps to ready the uterus for delivery, and breasts grow in preparation for lactation. The hormones that mediate all these changes may influence her mood. She can best prepare to handle these changes if she is given a nutritious diet and if she engages in regular physical activity. The pregnant mother must have adequate rest and caring companionship (Whitney, Cataldo & Rolfes 2002:472).

1.3 GLOBAL MALNUTRITION AMONG PREGNANT WOMEN

Child bearing in the third world involves a high risk of death. Maternal mortality accounts for almost 25 percent of deaths among women of child bearing age in developing countries compared with one percent in the USA. The World Health Organisation 2002:3 revealed in a study that about problems associated with child birth, that up to sixty women die every hour world wide from malnutrition. In the developing world, risk of dying when giving birth is one in forty as compared to one in four thousand in the developed world. There has been a growing realization by international agencies and policy makers in developing countries that the neonatal period warrants special focus. Globally, more than 9 million deaths occur before or just after birth each year, 98% of them in developing countries. About 56 of every 1000 babies born die in the prenatal period and about 34 of every 1000 live born babies suffer neonatal death (Anthony, Costello, Mwansambo and David 2007:553). Another national survey conducted by WHO (2002:3), fixed the average maternal mortality rate in the developed world at 30 per 100,000 live births, while those of Africa, Asia and Latin America were fixed at 640, 420 and 270 respectively. The tremendous health hazards under which pregnant women live in developing countries is also established. The major opinion of the World Health Organization is that emphasis should be put on pregnant women when promoting the health and well- being of those who deserve it most and receive it the least. The organization asserts that, the world will be a better place where children will have a better future when pregnant women become healthier, better nourished and live above the poverty line. Malnourishment the organization believes shows characteristics, opposite to the qualities of a healthy person and is the leading cause of iron deficiency in pregnant women globally (WHO 2002:3).

Data from hospitals and clinic records during World War II revealed that the controlled and improved diet of the period had a positive effect on pregnant women in spite of other adversities (Fleck 2005: 369) Research carried out in some parts of the world on pregnant women has revealed that if such women receive all their nutritional requirements, maternal and infant mortality and stillbirth will be drastically reduced (Uddoh 2002:123). The daily intake of adequate amounts of good quality food remains a major global challenge in the 21st Century (Amuna, Tewfik and Zotor 2004:129).

Nearly two thirds of the pregnant population of western and central Europe live in countries deficient of iodine. Damage to reproductive function and to the development of the foetus is the most important consequence of iodine deficiency. A search made on the nutritional status of pregnant women in Europe revealed that most pregnant women there have poor nutritional status and most lack iodine. Less than 50 percent of pregnant women in Europe receive supplementation with iodine and other nutrients. Most pregnant women in European countries should be given an iodine containing supplement (approximately150mg/cay) and that professional organizations, should comply with European Union legislations to ensure adequate nutrition and optimal doses for iodine in prenatal vitamin supplements (Zimmermann and De Lounge 2004:979).

Pregnant women in Ireland have since been advised to take foods that contain more nutrients. They were also advised to take folic acid tablet supplements and also to eat foods which are rich in folate or fortified with folic acid. This policy however, has not proved very effective in reducing the number of pregnancies affected by neural tube defect (NTD). A north and south Ireland Food Consumption Survey (IFCS) found out that pregnant women should have a daily intake of 270μg of folate on average. This included 200μg of folate naturally present in food and 70μg from supplementation (30μg of folic acid from fortified foods and 40μg from vitamin tablets). The survey found that, 40% of pregnant women in Ireland do not consume any foods fortified with folate (FACS 2005:10).

Similarly, a study involving pregnant women in Japan showed higher intakes of carbohydrates, calcium, and vitamins than in most developing countries. Out of the three hundred and thirty (330) pregnant women used for the analyses in Tokyo, only 22.9 percent proved anaemic. Also pregnant women in Japan were found to be aware of adopting healthy behaviours during pregnancy (Takimoto, Yoshire, Katagiri, Ishida & Abe 2003:1).

The adequacy of nutrient intake and iron status of pregnant women in Indonesia in the Purworejo District, Central Java was investigated and the results showed that 40 percent of the pregnant women were at risk of inadequate intake of energy and protein and 70 percent were in need of vitamin A, calcium and iron. Poor pregnant women of urban cities were the most affected. The researchers are of the opinion that the number of pregnant women with anaemia could increase even though prevalence may be reduced (Hartini,Winkvist, Lind Holm, Stenlund, Persson, Nurdiati and Surjono, 2003: 657).

In a related study on nutrient deficiency disorders in pregnant women of Delhi (in India), a sample of 829 pregnant women was used. The results revealed that 78.8 percent were anaemic, while 40 percent were suffering from a morbidity condition (Kapil, Pathak, Tandon, Singh, Dwivedi and Pradhan 1999:993). The Indian Council of Medical Research (ICMR) confirms the need for additional energy during pregnancy to support the growth of the foetus, placenta and maternal tissues as well as to meet the increased basal metabolic rate (BMR). Basal metabolic rate increases by about 5 percent during the first and second trimester, and by about 12 percent during the third trimester. The ICMR therefore recommends an additional energy allowance of 1200 kJ/ day during pregnancy (ICMR 2004:56).

A pilot programme by The Bangladesh Integrated Nutritional Program (BINP) was set up by the government of Bangladesh to improve the nutritional status of pregnant women in the country. The two effective measures considered were targeted at efficiency improvement in the nutritional status of beneficiaries (pregnant women in this case) and the persistence of nutritional effects. Data was collected from 2000 randomly selected pregnant women. Thirty nine percent (39%) of these pregnant women were targeted by the programme's food supplementation programme. The programme reduced the prevalence of malnutrition amongst subjects by 39 percent (Kham, Armed, Protica, Dhar and Roy 2005:983).

UNICEF (2002:4) assessed the nutritional status of pregnant women in Democratic Republic of Korea. Anaemia was found to be widespread and the investigations showed that 11percent of women during pregnancy get anaemic and almost forty percent of children born annually were found to be underweight at birth. The organization believed that maternal health services were not as effective as they should and therefore initiated a programme to improve the situation with the office for the coordination of humanitarian affairs of the Democratic Republic of Korea (OCHA 2005:6).

New Foundland has one of the highest rates of neural tube defects (NTD) in North America. A cross- sectional study, conducted revealed that, median values for serum folate, red blood cell folate and vitamin B12 were 25nmol/L, 650nmol/L and 180pmol/L respectively. Eleven percent (11%) of the 1424 pregnant women, were deficient (<340nmol/L) and a further 12% were classified as indeterminate (340 -420nmol/L) for red blood cell folate status. The study further revealed that a large proportion of women surveyed in Newfoundland had low red blood cell folate levels. In Newfoundland, the incidence of NTD is one of the highest in North America, with 3.2 neural tube defects per 1000 births (James, Sandra, Ratman, Ives, and Brosnan 2002).

A study conducted on the health outcomes of nutritional adequacy and infant birth weight of low income pregnant women in USA Illinois revealed that most pregnant women of this area are not meeting the nutritional requirement of pregnancy. Data consisted of low-income pregnant women in their first trimester (n=55). The study further confirmed that even though nutritional adequacy in the first trimester and infant birth weight are not significantly related, most low- income pregnant women in Illinois, need to be provided with nutritional education throughout pregnancy which may lead to improved dietary patterns amongst these women in Illinois (Fowles & Gabrielson 2005: 117).

Data collected in a national nutritional survey in Mexico suggests that there has been increase in malnutrition, specifically amongst pregnant women, from 15.5 percent in 1988 to 20.8 percent in 1999 (Alcanta 2004:2). Anaemia is one of the nutritional deficiencies that plague Mexican women. Blood samples were taken from 187 pregnant women to determine the prevalence of nutritional deficiency (especially anaemia), in pregnant women in rural Mexico and the food intake of over 66.5 percent of the women showed poor dietary nutrient availability. Another survey was done with two hundred Greek pregnant women stationed in the USA. The sample consisted of 98 pregnant women in their second trimester and 102 in their third trimester. This sample was randomly chosen. The survey revealed that, sufficient micronutrients appeared to be received in adequate amounts from the diet, except for folic acid and iron which had to be taken in the form of nutritional supplements (Petrakos, Panagopoulus, Koutras, Kauzis, Kanellopoulus, Salamekis & Antorios 2006:167).

Table 1: Global maternal mortality patterns (WHO, UNICEF, 2004:4)

Region	Maternal mortality (maternal deaths per 100,000 births)	Number of maternal deaths (per annum)	Lifetime risk of maternal death
Developed regions	20	2500	2800
Developing regions	440	527, 000	61
Africa	830	251, 000	20
Asia	330	263, 000	94
Latin America& Caribbean	190	22,000	160
Oceania	240	530	83
South Africa	150	1600	70

In Table 1 Maternal global mortality patterns are shown as expressed by WHO, and UNICEF.

1.4 MALNUTRITION AMONGST PREGNANT WOMEN OF AFRICA

The mortality rate of pregnant women in Africa is high and continues to rise. According to a survey, this is due to poverty and lack of strategies in place to correct the nutritional status of pregnant women. In Africa, 30 million infants born to pregnant women suffer growth retardation and nearly 200 million pregnant women in Africa are severely undernourished. It is believed that children born to these malnourished pregnant women will grow up with impaired mental development (Iyenga 2002:2).

A study on the prevalence of anaemia and severe anemia in pregnant women of Tanzania showed rates of 60 percent and 3.8 percent respectively. The study also found that adolescent pregnant women were more anemic with an overall prevalence of anemia of 76 percent. Another revelation was that malaria and other infections were common in anaemic pregnant women. A team of researchers at the School of Public Health (SPH) in Tanzania also found that vitamin supplements offer a low-cost way to lower the risk of adverse pregnancy outcomes, and raise the immune status of pregnant women. The study was conducted among a 1075 pregnant women in Tanzania. The doses of vitamins reduced foetal deaths, low birth weight and severe pre-term births by 40 percent. The immune status of the pregnant women also improved significantly and the pregnant women exhibited an increase in blood cells, which increased immunity (Massawe 2002: 1).

Pregnant women in Kenya showed even higher rates of malnutrition than children did. This was revealed in a survey by UNICEF nutritionist, where more than 60 percent of pregnant women in Samburu, (a suburb in Kenya) were malnourished, placing their lives and those of their unborn babies at risk. The survey further identified the rate of malnourishment in women of the Marsabit district, to be 37 percent lower than in Samburu. In Moyale (another suburb in Kenya), 29 percent of pregnant women showed signs of malnourishment. The surveys conclude that poor living conditions are a contributory factor to the high rates and recommends education programmes to improve the situation. (Carter 2004:1).

In the West African context, a study to assess deficiency of iron, folate and vitamin B12 was conducted, on 146 pregnant women in Gombe, Nigeria. Fifty four percent of the women were in their third trimester and the common cause of anaemia in pregnant women of northern Nigeria was found to be malaria. Malaria parasites were found in the blood of 9.4 percent of the 146 subjects. Based on study results, 30% of the pregnant women were classified as anaemic. Researchers concluded that a high percentage of the pregnant women were classified as anaemic and therefore, suggested iron supplementation for this vulnerable group and their children. Fortification, of food with, iron, folate and B12 was suggested for the prevention of neural tube defects (Vanderjact, Brock, Melah, Nafata, Crossey & Glew 2004:6).

Anaemia during pregnancy remains a challenge for the West African region and is a major contributory factor to the high maternal mortality rate. The organisation is of the opinion that implementation of an iron /folate supplementation programme seems to be less effective, judging from the continued high prevalence of anaemia in pregnant women. UNICEF states further that under-nutrition in pregnant women cannot be solved with a single intervention, but requires a multi-sectoral approach. Results of the survey conclude that 10% of babies born to pregnant women in Ghana have low birth weight (UNICEF 2002:

4). Looking at the different studies, it can therefore be concluded that the rate of malnutrition amongst pregnant women of Africa is very high.

1.5 PREVALENCE OF MALNUTRITION IN SOUTH AFRICA

The Demographic and Health Survey of South Africa (1998) estimated the maternal mortality ratio for South Africa to be 150 per 100,000 live births. The South Africa Demographic and Health Survey revealed that the health of women follows closely on the socio- economic welfare of the family and community in South Africa as is the case worldwide. According to a preliminary report by DHS of South Africa, this figure means that about 1.1 million babies born in South Africa and over 1550 women annually die from pregnancy related conditions. The DHS confirmed that most of the deaths occur among poor women with insufficient access to health services (Department of Health, Iyenga 2002:2& South Africa Demographic and Health Survey, 2003:2).

1.5 MALNUTRITION IN PREGNANT WOMEN OF THE VAAL REGION

Evidence of poor nutrition practices equally exist in the Vaal Region (the area of research). A study conduced by Kesa (2001:5) examined the iron status of pregnant women in Vaal region. There was clear evidence of poor dietary practices amongst women of the Vaal region. The study revealed that due to too much intake of carbohydrate and very little protein, 72.12% of pregnant women are over weight during and after pregnancy. The sample consisted of 300 pregnant women aged between 20 and 35 years. Most of these women lived in townships and 79.3% were unemployed. Their diets consisted primarily of plant food. Apart from milk, animal food was not easily affordable. Maize meal was the most commonly consumed food.

Out of blood samples taken from (30) pregnant women, 50% were malnourished due to inadequate intake of foods rich in iron and showed clear signs of iron deficiency anaemia (Kesa 2001: 2). Based on the results of the previous study, it is clear that food insecurity and malnutrition are evident in pregnant women in Vaal region.

1.6 MOTIVATION FOR THE STUDY

Low birth weight (LBW, i.e. less than 2500g) is a major factor in infant mortality and other health problems such as disabilities and learning disorders. Poor nutritional status prior to conception and low pre-pregnant weight of the mother also negatively influence birth weight (Mahan & Escott-Stump2001:168). Fleck (2005:371) also confirms that adequate nutrition during intra-uterine life is critical for the development of a healthy baby and will be reflected in later life.

Food insecurity and malnutrition that are evident in pregnant women of the Vaal region could be due to poverty (Kesa 2001:5). This study will thus attempt to develop a cost-effective multi-mix dietary supplement that can be afforded by pregnant women in low income groups in the Vaal region.

Maternal weight gain during pregnancy results in low birth weight, especially in undernourished women (Galloway 2002:3). Food fortification, supplementation and diversification are current strategies adopted globally to address malnutrition amongst pregnant women. Inadequate intake of certain nutrients needed early in pregnancy results in negative birth outcomes (Galloway 2002:4).

Results of previous studies revealed the poor conditions in which pregnant women of Vaal region live (Kesa 2004:5). Therefore in this study, a novel approach was employed to develop a cost effective culturally acceptable and nutrient dense food multi-mix (FMM) supplement that will meet 20-25% of the recommended daily allowance (RDA) for iron, folate, calcium and protein for pregnant women between 20 and 35 years of age in the Vaal region. It would be very useful, therefore, to conduct this research to improve the nutritional status of pregnant women of Vaal region.

1.7 PROJECT OBJECTIVES

The major objective of this project was to develop a multi-mix dietary supplement that was cost effective, culturally acceptable and nutrient-dense for consumption in the household, most especially for pregnant women in the Vaal Region. Successes have been obtained in dietary diversification in Ghana, and similar principles can be employed in this study (Amuna, Zotor & Yewfik 2004:168).

1.7.1 Specific objectives

Specific objectives of this project included:

- Formulation and chemical analyses of a food multi-mix supplement (FMM) to satisfy the nutrient needs of pregnant women in the Vaal region.
- Determination of the shelf life of the FMM supplement
- Development of two recipes (soup and gravy) incorporating the developed FMM supplement and development of recipe leaflets
- Sensory evaluation to test for consumer acceptability.

1.8 SCOPE OF STUDY

It was necessary to develop a cost effective, culturally acceptable and nutrient dense multi-mix dietary supplement to improve the nutritional status of pregnant women in the Vaal region. The scope of the study included pregnant women aged between 20 and 35 years who attended ante natal clinics in Johan Haynes and Sharpeville clinics respectively.

1.9 STRUCTURE OF DISSERTATION

Chapter one describes the prevalence of malnutrition amongst pregnant women globally, in Africa and the Vaal Region.

Chapter two describes the role of nutrients (vitamins A, B complex, C,D,E and K and mineral salts iron, calcium, sodium, potassium, magnesium) in pregnant women, as well as their recommended daily allowances (RDA). Under the nutrient iron (known to prevent anaemia during pregnancy (Mora 2002:91) loss of iron through blood loss and preventing anaemia is discussed. Folate, another important nutrient needed to prevent neural tube defects (NTD) in pregnant women, (Eastwood, 2003: 210) is discussed. The second part of this chapter includes the scientific processes that increase the consumption of macro and micro nutrients as well as fortification, supplementation, and dietary diversification.

Chapter three discusses the development of a food multi-mix supplement (FMM) as a strategy for addressing malnutrition in pregnancy. In this chapter the development as well as the technical process of the FMM supplement is described with the help of a flow diagram. Typical shelf life design, recipe development, and sensory evaluation as a process were discussed.

Chapter four describes the research methodology utilised in this project involving, formulation of the FMM supplement, chemical analysis, shelf life determination of the FMM, recipe development incorporating the FMM and sensory evaluation of the recipes which were developed with affordable and familiar foodstuffs.

Chapter five contains the report on the empirical research executed. This involves the presentation of the research results and discussions in scientific format. The results are explained with graphs for all methods used.

The final chapter (chapter six) comprises the recommendations and conclusions as well as practical implications.

CHAPTER TWO

LITERATURE REVIEW: Nutritional requirements during pregnancy

2.1 INTRODUCTION

From a nutritional point of view, the nine months of pregnancy must be considered a period of stress during which the nutrients demands of the developing foetus are superimposed on those for normal maintenance of the adult woman. This chapter is devoted to a thorough review of existing literature on the needs of pregnant women. The role, basic amounts required and the likely effects of essential nutrients are covered. In line with the proposition of The Institute of Medicine Subcommittee on Nutritional Status and Weight Gain during Pregnancy (2004:3) on excess sugar intake especially in pregnant women, the effects of excess sugar and protein intake on pregnant women and on the foetus are also discussed. The recommendations of the committee on weight gain during pregnancy are examined as presented in Table 2.1. The chapter further examines relevant literature on strategies employed in addressing malnutrition in pregnant women and sets out a framework for the study. The strategy of using a food multi-mix, the main focus of this study concludes the discussions on this chapter.

2.2 NUTRITIONAL NEEDS OF PREGNANT WOMEN

Pregnancy puts extra demands on nutrients for both the woman and the developing foetus. These demands thus define the type of nutritional techniques preferable for the health of both foetus and prospective mother.

2.2.1 The need for a variety of foods

A great deal of consensus exists on the need for special dietary schemes especially during pregnancy. For example, Fleck (2005:368) agrees with Gray (2000:494) in asserting that a variety of foods from all food groups is important throughout pregnancy. He stresses that foods within the same food group do not contain exactly the same amount of nutrients.

Nutritional needs increase substantially when a woman is pregnant and proper nutrition has a great effect on the health of both the baby and the mother (Fleck, 2005:368). Also, Thomas (2002:37) posits that nutrition is important not only at the onset of pregnancy, but throughout pregnancy and long before conception.

Feeding during pregnancy should be regulated so as not to lead to excess weight as this can result in problems in future. Increased weight as a result of foetus development is usually of concern. Emphasis is to be placed on high-energy food group items that contain less fat and sugar. It is recommended that less weight gain be ensured and that pregnant women choose from the lower-energy food groups. Several other works found out that high sugar intake would not be advisable for women gaining more than the recommended weight or for those women who are having difficulty controlling normal blood glucose levels. But high sugar intake would be beneficial for women requiring increased weight gain. However recommendations regarding sugar intake for pregnant women depend on weight gain and maternal blood glucose levels (Rooney 2002:12).

2.3 MACRONUTRIENTS

Macronutrients are generally required in large quantities and are essential for health, growth and development. These nutrients are discussed according to the specific nutritional needs of the body. The subsections under this heading deal with these in detail.

2.3.1 Energy requirements

Energy is one of the essential requirements for life and activity in humans. In the case of pregnant women, energy requirements may vary according to certain factors such as age and Body Mass Index (BMI). The recommended daily intake for a pregnant woman (aged 19-50 years) is 10,044, 11466 and 11 934 kJ during the first, second and third trimester respectively. In general, between 9240 and 11,750kJ per day is sufficient for most pregnant women. In this the, Institute of Medicine (2003:1) agrees with other writers that pregnant women need to increase levels of iron, folic acid and B6 to prevent birth defects. It asserts that this must be adjusted for physical activity and pre-pregnancy weight gain to meet recommendations. A woman with low pre- pregnancy body mass index (BMI) and a high activity level would require more energy than a woman with a high pre- pregnancy BMI and a sedentary lifestyle (Boushey, 2001:1).

2.3.2 Carbohydrates

Carbohydrates come from cereals and grains, and both are products of the agricultural revolution. They come in three basic forms: simple, refined, and complex. Simple carbohydrates have one, two, or at most three units of sugar linked together in single molecules and refined carbohydrates are made of flour foods like pastries, breads and pastas. Complex carbohydrates come in two varieties: high fibre and low fibre (UNICEF/UNU/WHO 2006:4)

Fibre is more difficult for the body to digest and usually is usually excreted without being 100% digested. Constipation is a result of less intake of fibre and increases the incidence of gastrointestinal disorders of many different varieties for example, hiatal hernia, diverticulitis, appendicitis, gallbladder disease, irritable bowel syndrome, hypoglycemia and intestinal cancers. Pregnant women should, therefore, eat enough fibre to avoid any such deseases (FAO/WHO 2005:11).

Empirical evidence support reduced sugar intake during pregnancy. A high sugar intake for women who are experiencing excessive weight gain or having difficulty maintaining normal glucose levels could result in increased maternal risk for complications associated with too much weight gain, such as diabetes, hypertension, and premature delivery Thomas (2002:36).

2.3.3 Proteins

Proteins are defined as very large molecules made of amino acids, of which there are twenty types. Eight of these amino acids are "essential," meaning that they cannot be synthesised in the body even though they are necessary for life. Essential amino acids must be consumed from sources outside the body (FAO/WHO 2005:18).

2.3.4 Consequences of excess protein intake in pregnant women

A study by Beaton in 2001 proved that maternal consumption of a high meat, low carbohydrate diet, in late pregnancy, results in severe growth restriction and raises blood pressure and glucose intolerance, in the offspring. In a recent study, pregnant women were advised to eat half a kilogram of red meat (0.45kg) per day during pregnancy and to avoid carbohydrate-rich foods. During the study Beaton found out that those women who consumed higher protein delivered babies with raised fasting plasma cortisol levels (Beaton, 2001: 715).

2.3.5 Fats

Fats are generally categorized into four different kinds based on their composition in human nutrition. These are categorized according to its saturation. Saturation refers to the number of hydrogen atoms attached to the fat molecule. If a fat molecule contains the maximum number of hydrogen atoms, it is said to be "saturated". It is called "hard fat," because it remains hard at room temperature. If one pair of hydrogen atoms is missing, the molecule is said to be "monounsaturated", for example, olive oil. Monounsaturated fat is the healthiest and the most easily digested form of fat.

2.4 MICRONUTRIENTS

Micronutrients can be classified as vitamins and mineral elements. Micronutrients are a group of organic compounds that are essential in small quantities for metabolism of other nutrients such as protein and carbohydrate. A wide choice of foods from as many sources as possible is important for pregnant women. Other micronutrients found in food include vitamins such as thiamine, niacin, riboflavin and folic acid and minerals such as calcium, zinc and selenium. (Lutz & Prytulski 2005:90).

2.4.1. Micronutrient needs during pregnancy

Micronutrient deficiency, may affect growth, cognition and reproductive performance. Moderate to severe deficiencies of iron, zinc and folic acid have been shown to increase risk of low birth weight, pregnancy complications and birth defects. Any attempt to introduce a micronutrient supplementation programme during pregnancy must be based on adequate data on the prevalence of micronutrient deficiencies, their adverse effects and the potential for reversing these through supplementation. Iron deficiency and anaemia affect 50% or more of pregnant women and the prevalence of folic acid deficiency is up to 30-50% and there is evidence to suggest that zinc deficiency is likely to be widespread. However the links between micronutrient deficiencies and prenatal mortality and duration of gestation are limited and the evidence base for individual micronutrient effects on neonatal mortality and morbidity is not substantial (Seshadri 2005: 92).

2.5 VITAMIN NEEDS

"Vitamins" according to Lynch, is a general term given to a group of organic substances that are present in food in minute quantities but are distinct from carbohydrates, lipids and proteins. They are essential for normal healthy growth and this term was proposed by Funk in 1911 to indicate that the accessory food factor necessary for life, is vital- amine. Specific deficiency diseases result when vitamins are not adequately supplied by diet or are improperly absorbed from food (Lynch 2000:443).

Table 2: Vitamins – roles, sources and RDA for pregnant women (IoM, 2003).

Vitamin	Role/Deficiency	Source	RDA
Vitamin A	Necessary for normal foetal growth and development, improves the immune system, protecting foetus foetus and mother from infection	Carrots, spinach , cantaloupe, fortified skim milk, sweet potato, red pepper, fish liver oils, egg yolk, yellow fruits, and squash	700µg/day
Vitamin B6	Helps in urea production and in metabolism of essential fatty acids acids. controls nausea and vomiting during pregnancy	Muscle meat, liver, pork, egg, whole grain, and soybean	1.9ug per/day
Vitamin C	Converts ferric to ferrous iron to facilitate absorption and wound healing.	Oranges, broccoli, strawberry, guava, kiwi, green pepper brussels sprouts	85mg
Vitamin D	Stimulates absorption of calcium and utilization of iron	Fish liver oils, and fortified foods	Adequate intake of 5g per day
Vitamin E	A biologic anti–oxidant, able to of protect cellular membranes from oxidative damage It also inhibits the accumulation of ceroid pigments granules.	Fortified cereals, almond, sunflower seeds hazelnuts, avocado, roasted nuts, seed oils	15mg/day
Vitamin B1 (also known as thiamin)	Deficiency includes fatigue, muscle weakness and cardiovascular abnormalities.	Sources include yeast and liver pork, wheat, black beans, sunflower seeds and fortified cereal	1.4 mg day
Vitamin B2 (Ribo flavin)	Deficiency shows lesions of the lips and dermatitis	Green leafy vegetables, are rich in riboflavin, but meat and dairy products are the most important sources.	1.4mgday.

Table 2 continues

Vitamin	Role/Deficiency	Source	RDA
Folate	Participates in many bodily processes especially rapidly growing tissues functions as a co-enzyme in the transfer of single carbon units from one compound to the synthesis of nucleic acids and the metabolism of amino acids. As the mother and foetus are developing new tissues rapidly, per-tabulation in folate intake might be expected to result in adverse pregnancy. Clear and consistent relationship between low folate intake and foetal neural defects and possibly cleft lip and palate has been identified.	Found in beans and peas, oranges, orange juice and especially in green leafy vegetables, such as spinach and broccoli. The synthetic form of folate, folic acid is added to breads, cereals, flours, corn meal, pastas, rice and other grain products, making them good sources as well. Other sources include breakfast cereal, beef liver, lentils, chickpeas, asparagus, spinach.	600ug per day
Vitamin B3 (Niacin)	A co- enzyme in the production of energy.	Food sources found in lean meat, poultry, fish, peanuts and yeast	18 mg
Vitamin B12	Deficiency leads to pernicious anaemia which is characterized by numbness in the hands and feet, confusion and delusion.	Synonymous with animal products	2.6μg/day

2.5.1 Folate

Folate is as an essential nutrient for pregnant women as they cannot manufacture folate and must rely on dietary intake and absorption. Folate (also called folic acid) is widely known for its role in reducing the risk of serious birth defects, such as spina bifida. Folate helps with body resistances and inadequacy may reduce the level of the amino acid homocysteine, and implicate cardiovascular disease. A recent study by the Food and Nutrition Board showed that folate helps prevent mental decline in old age and that the most critical time of need for pregnant women is the first few weeks of pregnancy. The need for an adequate supply of folate has been established. Other folate functions include participation in many bodily processes, especially rapid growth of tissues and also acting as a co-enzyme in the transfer of single carbon units from one compound to the synthesis of nucleic acids and the metabolism of amino acids. (Food and Nutrition Board 2001:10)

2.5.1.1 Folate deficiencies

Folate deficiency works with multiple factors to cause birth defects. Generic factors appear to be a strong factor. The rate of neural tubes varies considerably in different populations, (one per 1000 births in the United States, 6 per 1000 births in Ireland and 10 per 1000 births in northern China). Women with previous child birth defects have a 1.6% risk of re-current neural tube defects. The level of risks is predicted by the frequency of occurrence of neural tube defects in the immediate family. A clear and consistent relationship has been identified between low folate intake and foetal neural defects and possibly cleft lip and palate as the mother and foetus are developing new tissues rapidly, inadequate intake of folate might be expected to result in adverse pregnancy (Gibley *et al* 2004).

2.5.1.2 Maternal folate deficiency and neonatal Health

Owing to increased folate requirements during pregnancy, inadequate supply could result in maternal folate deficiency. As pregnancy progresses the importance of folate in maternal health becomes evident. Folate deficiency (responsive megaloblastic anaemia) occurs in up to 24% of un-supplemented pregnancies in certain parts of Asia, Africa, Central and South America and 2.5-5.0% of those occur in the developed world. Another indication of folate deficiency which occurs in as many as 25% of pregnant women who do not receive supplements is bone marrow megaloblastosis. (Gibley et al 2004: 295).

Even though there is an increase in folate defects this is not seen where folic acid supplementation is introduced or where there is sufficient dietary folate to meet the increased requirements of pregnancy. Poor maternal folate status has consequences not only for the mother's health but also for that of the foetus. Low Birth Weight (defined as weighing less 2.5kg at birth) is associated with poor maternal folate status and has shown important implications for the health of the neonate infant (FNB 2001:10).

Throughout pregnancy, folate plays an important role in the maintenance of maternal, embryonic, foetal and neonatal health, and in protecting against a number of potential adverse outcomes for the mother and baby (Gibley et al 2004:296).

2.5.1.3 Neural tube defect syndrome (NTDS)

Folate deficiency has long been regarded as a cause of neural tube defect syndrome (NTDS). The mean intake of additional folate required by pregnant women is set at 600 micrograms per day. A dietary supplement of eight glasses of orange juice, 10 servings of broccoli and three servings of brussels sprouts are required to supply this increased need. It is difficult for pregnant women to do without folate supplementation. The neural plate begins to close on day one of conception to form the neural tube, which will eventually become the spinal column in the foetus. Incomplete closure of the spinal column results in spina bifida which results in various levels of disability, from an almost abnormal life to severe disability, including paralysis of the lower limbs and bladder. (Eastwood 2003:210).

The potential for an adverse outcome for either the baby or the mother have been associated with low folate status. Spina bifida make up about 40 – 50% of NTD. There is ample evidence that NTD rates increase after times of nutritional deprivation in pregnant women and that a part from congenital birth defects, a considerable number of conditions such as loss of the baby as a result of poor development of the foetus (intrauterine growth retardation) or the health of mother (preclampsia) may occur (Gibley *et al* 2004:294).

2.5.1.4 Prevention of adverse effects of folate in pregnancy

Folate is needed in cell division and a wide range of other reactions during pregnancy so its sufficiency is advised to prevent adverse effects of pregnancy. Pregnancy is a complex period resulting in huge physiological and nutritional demands upon the mother and that the rapid fertilization of the ovum, through implantation and subsequent growth and delivery of the foetus, represents the period of greatest risk to a pregnant woman (World Bank 2003: 33.).

Table 3: Advantages and disadvantages of folic acid supplementation (FACS 2005: 10)

ADVANTAGES	DISADVANTAGES
Reaches those with unplanned Pregnancy	Requires legislative change regarding use of logo label and health claim
Potential to reach all pregnant women regardless of socio economic status	Requires agreement amongst all players in the flour industry to ensure effective uptake
Facilitates provision of folic acid to pregnant women	Monitoring of folic acid content of bread would be required
Consumer choice is maintained	May add costs for the food industry

Table 3 describes the advantages and disadvantages of ensuring adequate folic acid intake by pregnant women to reduce NTDS (Folic acid consultations submissions, (FACS 2005: 10).

2.6 MINERALS

2.6.1 Calcium

Calcium is famous for building and maintaining strong bones, but it also plays a role in blood clotting, blood pressure and muscle and nerve functioning. Calcium accounts for 1 to 2% of adult human body weight more than 99% of total body calcium is found in teeth and bones and the remainder is present in the blood, extra-cellular fluid, muscle and other tissues, where it plays a role in mediating vascular contraction and vasodilatation, muscle contraction, nerve transmission and glandular secretion. (Combs 2000: 298).

2.6.1.1 Sources and utilisation of calcium

Milk can be classified as fresh (whole, or skim) evaporated or dry yogurt or butter milk and can be said to be a good source of calcium. Hard cheese and canned salmon are also excellent sources. Calcium absorption from the intestinal tract is regulated according to the body's needs for maintenance and growth. RDA of calcium for pregnant women is set at 1000mg.and the daily absorption range from 10-40% (Combs 2000: 88).

2.6.2 Iron

Iron is particularly essential during pregnancy. Infants are normally born with high haemoglobin levels of 18 to 22 mg/100ml of blood and with a supply of iron to last three to four months. Thus mothers are called upon to transfer about 30mg of iron to the foetus. It has been discovered that iron is part of the haemoglobin molecule in the blood and accounts for two thirds of the body's iron content which is necessary for carrying oxygen from the mother to the foetus. About five percent of the body's iron is found in the myoglobin (an iron protein complex) that is found in muscles which supply extra energy needed during pregnancy (Atukorala *et al* 2004: 286).

2.6.2.1 Need for iron during pregnancy

Pregnancy imposes additional needs that can be difficult to meet by regular diet and therefore demands supplementation to avoid risk of iron deficiency anaemia. The loss of iron involved in a normal pregnancy demands 27 mg per day for absorption (Andrew 1999: Barasi 2001:185, 114, Combs 2000: 125).
During pregnancy, the body makes several adaptations to help meet the exceptionally high need of iron. Few women enter pregnancy with adequate stores of iron, so daily iron supplementation is recommended during the second and third trimesters, for all pregnant women. To enhance absorption, the supplement should be taken between meals or at bed time, on an empty stomach with liquids other than milk, coffee or tea which inhibit iron absorption (Davidson 2001:42).

2.6.2.2 Role of iron during pregnancy

The fact remains that pregnant women need iron to support their enlarged blood volume and to provide for the placental and foetal needs. The developing foetus draws on maternal iron stores to create stores of it's own to last through the first four to six months after birth when milk which is poor in iron will be its sole food (WHO 2003: 5).

2.6.2.3 Major signs and symptoms of iron deficiency anaemia

Signs and symptoms of all anaemia and iron deficiency include fatigue (feeling tired).Fatigue is caused by having too few red blood cells to carry oxygen to the lungs and the rest of the body. Lack of oxygen in the body can cause dizziness and headache, or even unconsciousness when changing position. Since the heart must work harder to move the reduced amount of oxygen, signs and symptoms may include shortness of breath and chest pain (Ferguson, Skikne, Simpson, Baynes and Cook 1992:386).

2.6.2.4 Anaemia in pregnant women

Fifty percent of all pregnant women develop iron deficiency anaemia because their volume of blood increases and because the foetus needs iron. Anaemia during pregnancy can lead to an increased risk of premature delivery and low birth weight in the baby. To prevent these problems, it is advised that pregnant women get twice as much iron as women who are not pregnant. Pregnant women can get more iron from eating more iron rich foods, supplements, or from both and are advised that medical care during pregnancy should include screening for anaemia. The RDA for pregnant women is fixed at 30mg per day (WHO 2003:6).

2.6.3 Zinc

Pregnant women who eat a normal diet adequate in protein are not likely to lack zinc and the required daily allowance (RDA) of zinc for pregnant women has been set at 11mg. Zinc is absorbed according to body need and is important for the following functions:

- normal growth and sexual maturation

- as part of an enzyme that transfers carbon dioxide from the tissues and the lungs.
- production of insulin by the pancreas

  synthesis of protein and normal sensitivity to taste (Institute of Medicine 2003:4).

2.6.3.1 Functions of zinc

A committee formed to investigate the nutritional status and weight gain during pregnancy published its results in the Institute of Medicine Press of Washington DC: it found out that deficiency of zinc leads to diminished sensitivity to taste, and decrease in odour sensitivity. The publication stated that wound healing following surgery is also prompt when supplements are given to depleted patients especially pregnant women. The committee found out that zinc is essential for many functions, including growth and neurobehavioural development, immune and sensory function, reproduction, antioxidant protection and membrane stabilization. According to the publication zinc requirements increase in pregnancy even more so for pregnant and adolescents, who are still growing (Institute of Medicine 2003: 3).

2.6.3.2 Zinc deficiency

Zinc deficiency in pregnancy is associated with increased risk of congenital abnormality (including neural tube defects), low birth weight and other complications of pregnancy and delivery, such as impaired development and premature delivery. Low zinc intakes in pregnancy may contribute to increased infection, reduction of the uterus and decreased maternal blood volume following childbirth (King 2003:1732). Calcium, Iron, Fluoride and Zinc are discussed because they are the minerals most needed by pregnant women who are the subject of this study.

2.6.4 Fluoride

Fluorides exist in compounds and that minute amounts enter into the complex calcium salts that form tooth enamel. Fluoride may also be useful in maintaining bone structure. Even a lesser incidence of osteoporosis (soft bones) has been observed in persons living in areas with fluoridated water (Robinson 2000:89).

Table 4: DRI of minerals for pregnant women 31-50 years old (Institute of Medicine 2003:4)

MINERALS	EAR	RDA	UL	AI
Iron	22mg/day	30mg/day	45mg/day	27mg/day
Calcium	*	*1200mg	2500mg/day	1000mg/day
Magnesium	*	360mg/day	350mg/day	360mg/day
Phosphorus	580mg/day	700mg/day	3.5g/day	700mg/day
Iodine	160μg/day	220μg/day	1100μg/day	220μg/day
Zinc	9.5mg/day	11mg/day	40mg/day	11mg/day
Selenium	49μg/day	60μg/day	400μg/day	400μg/day
Chromium	*	*	*	30μg/day
Fluoride	*	*	10mg/day	3.1mg/day

RDA = Recommended Dietary Allowances AI = Adequate Intake EAR = Estimated Average Requirement * = Not determined UL = Tolerable Upper Intake Level

2.7 EFFECTS OF NUTRITIONAL DEPRIVATION

2.7.1 Hypothermia

In many poor communities there is little doubt that care practices with regard to drying, wrapping and bathing infants in the first hours after birth make neonatal hypothermia a common phenomenon. During transfer to hospital infants if not kept warm are also more likely to be hypothermic on arrival. Continuous ambulatory monitoring of LBW term infants born in the winter months and routinely managed in a post-natal ward in Kathmandu (a suburb in Mozambique) revealed that all infants studied were hypothermic in the first 12 hours and showed significantly increased cold stress (Platkin 2005:17).

2.7.2 Neonatal hypoglycaemia and hyper-bilirubinemia

Metabolic adaptation in the immediate postnatal period is accompanied by increased risk of hypoglycemia. A study in Netherlands found that neonatal hypoglycemia was common in apparently healthy infants, especially among those who were LBW. There is a pressing need for randomized controlled trials of multiple micronutrient supplementations in pregnant mothers who are malnourished, in which outcomes for mothers and their infants, both short and long term, should be monitored closely. Micronutrient supplementation in pregnancy is potentially a highly cost effective intervention that could be scaled up rapidly even in the poorest communities. However, good clinical science demands that the effects of such an intervention be thoroughly and rigorously evaluated before large-scale programmes are established (Anthony, Costello, Mwansambo & David 2007:553).

2.7.3 High maternal mortality

In developing countries, maternal mortality accounts for about 25% of deaths in women of child bearing age, compared with 1% in the US. The World Health Organization has estimated that 250 women die every four hours due to problems associated with childbirth and high maternal mortality in India and Pakistan. This is a reflection of women's under nutrition, and poor health status. Several common causes of maternal deaths are related to malnutrition, particularly to anaemia. Twenty five to thirty (25-30) percent of babies born to Indian women are below 2500 grams, an indication that low birth weight is a significant factor underlying their infant mortality rates. In a study undertaken with 10,000 prenatal deaths, 75% were associated with weights less than 2500 grams. The study revealed a higher mortality of females (904 per 1000) in Pakistan and India due to poor nutritional status in women (Chartter and Julian 2003:7).

2.7.4 Diabetes

At no other time is blood glucose control as crucial as when a woman with diabetes is pregnant or planning to get pregnant (Reader, 2006:8). Counting food, testing blood glucose levels, and adjusting insulin doses becomes a way of life. Reader (2006) is of the opinion that carbohydrate counting can be a useful way to intensify control for pregnant women with type 1 diabetes, and it can be an easy way to learn food management for women with gestational diabetes mellitus (GDM). Counting carbohydrates does not provide a specific framework for calories, protein, fat, or the elements of a nutritionally balanced diet that are crucial during pregnancy. It is therefore recommended that pregnant women's carbohydrate choices should come from milk, fruit, and from starch (Reader 2006:8).

2.7.5 Tips for common pregnancy disorders

Pregnant women are often cautioned to take care of disorders which become easily associated with the pregnancy period. For example, Thomas (2002:36) advises pregnant women to avoid offending foods (and their odour) when experiencing nausea and heartburn which can easily occur. Many pregnant women find that spicy, fatty foods can increase problems with pregnancy especially nausea and heartburn. Frequent small meals are often better tolerated and pregnant women who eat dry crackers before rising from bed in the morning are able to control nausea. Nausea and vomiting usually subside by the end of the first trimester, and therefore have no significant impact on the final weight gain in most pregnancies. Pregnant women expecting twins or triplets or who enter pregnancy underweight need more energy to support adequate weight gain in pregnancy. Additional servings of foods with added fats in the form of oil and salad dressing are needed to increase energy intake. Pregnant women who are obese may choose lower kilojoule foods (Thomas 2002:36).

Vomiting during pregnancy can result in dehydration. Therefore pregnant women are advised to seek immediate medical intervention. Increased consumption of whole grains, fruits and vegetables, as well as increased fluid intake and physical activity are recommended when constipation occurs. The only real way for a pregnant woman to avoid lack of vitamins is to keep track of what is eaten over a period of time and go over the records with a registered dietician. (MOH 2003:13).

Children born to mothers who are nutrient deficient during their pregnancies are less active than the children of nutrient sufficient mothers (Kolb-Murray *et al.* Board, Susman and Shibley 2006:11). Children may be missing out on exploring their environment and, consequently, miss out on opportunities for development. New mothers who are mildly nutrientdeficient are less emotionally available or in tune with their babies and there is evidence that maternal nutrition affects the physical health and development of the child. (Kolb-Murray *et al* 2006: 11).

2.8 ACCEPTED WEIGHT GAIN DURING PREGNANCY

Gestational weight gain is weight gained between conception and delivery and recommended weight gain ranges are based on pre-pregnancy BMI. Adolescents should strive for gains at the upper end of the recommended range. Women who do not gain enough weight during pregnancy may deliver a low birth weight baby. The lowest risk of mortality is associated with birth weights of 3500g to 4000g and women with multiple gestation are at higher risk of bearing pre-term babies of low birth weight (Ladipoo 2001:91).

Nutrition during the preconception period, as well as throughout a pregnancy, has a major impact on pregnancy outcome says Ladipoo. Pre-pregnancy BMI, folic acid, iron and socioeconomic status are important and that pre-pregnancy BMI is an important factor in predicting pregnancy outcome, since both low pre-pregnancy and high pre-pregnancy BMI are associated with increased risk for a negative pregnancy outcome (Ladipoo 2001:92). There is evidence which shows that low maternal weight gain during pregnancy results in low birth weight babies, especially in undernourished women (Galloway 2002:3). Also, women who gain too much weight are likely to be overweight after birth of the baby (Johnson 2006:1).

There is a whole list of things pregnant women should not eat, which includes mercury-laden fish, sushi and anything un-pasteurised but there are entire books devoted to what pregnant women should eat, how much should be eaten and how much weight to gain (Johnson 2006:1).

Smoking makes pregnant women vulnerable to delivering more than one and a half times low-birth weight babies compared to mothers who do not smoke, and gaining just enough weight during pregnancy could reduce the rate of low-weight births by 20%. A study by Johnson has found out that nearly 40% of pregnant women gain more weight than the recommended amount, but more than 20% do not pack on enough kilograms. A healthy diet including at least 80 grams of high-quality protein and lots of green leafy vegetables results in a wide range of normal pregnancy weight gain (Gray 2000:49).

Gestational diabetes is associated with high pre-pregnancy body mass index (BMI) and excess pregnancy weight gain and that infants of gestational-diabetic mothers are usually born large for gestational age and are at higher risk for caesarean delivery and hypoglycaemia postpartum (M.O.H. 2003: 36) Table 6 below shows the weight gain recommended for pregnant women(IoM 2003:4).

Table 5: Recommended weight gain during pregnancy (Institute of Medicine 2003:4)

Weight (prior to pregnancy)	Recommended weight gain (kg)
Average weight	13 – 17
Underweight	14 – 20
Overweight	7 – 12
Weight (prior to pregnancy)	Recommended weight gain (kg)
Adolescents	15 – 23
Average weight, twins	17 – 23

2.8.1 Factors that affect birth weight

There are a number of factors that are known to affect birth weight. A study comparing mean birth weights of New Zealand's main ethnic groups found that Màori infants were approximately 50g lighter than New Zealand European infants. The study revealed that Tongan and Samoan infants were significantly heavier, and Indian infants were significantly lighter, than infants from all other ethnic groups. The survey further found out that Chinese infants were also significantly lighter, with a mean birth weight 100g less than New Zealand European infants (McCowan and Stewart 2004:432).

Maternal pre-pregnancy weight and height strongly affect birth weight, with weight having the strongest bearing. Kramer in agreement with other writers confirms that one of the strongest predictors of poor pregnancy outcomes include factors such as smoking and stress. Women with a BMI of less than 20 kg/m2 are more likely to deliver a pre-term or low birth weight infant. In practice, thinner women tend to have lighter infants than heavier women, even when gestational weight gain is taken into account. Obese women tend to have heavier infants. (Kramer 2003: 592).

Extremes of maternal age are associated with an increased risk of delivering a low birth weight infant (Ozalp Mete, and Sener 2003:172). Adolescent pregnancy is associated with an increased incidence of low birth weight infants, partly because of low parity and lack of antenatal care (Loto, Ezechi Kalu and 2004: 395). Young maternal age is also associated with low pre-pregnancy BMI and adverse behavioral risk factors (Cogswell and Yip 2003: 1722). Older mothers (above 35 years) also have a higher incidence of low birth weight than do women younger than 35 years; the reasons for this are not known, but may be related to declining placental adequacy with age. In New Zealand, over the last 20 years the number of women giving birth over the age of 30 has increased over the past 20 years, while births among younger women have decreased. In 2002 half of all births were to women 29 years of age or younger (New Zealand Health Information Service 2004:10).

Maternal medical conditions (eg, hypertension) may restrict foetal growth and cause urinary tract infections and pre-term births. There is a higher incidence of low birth weight infants born to mothers who have previously had a low birth weight infant or spontaneous abortion (Zhang and Klebanoff 2004: 754).There is also an intergenerational effect, women who were themselves of low birth weight are more likely to have a low birth weight child (and even grandchild) This may be because of a metabolic adjustment to assure a foetal weight that is proportional to maternal size (Alberman Emanuel and Filakti 2002: 134).

Antenatal care has a positive effect on the outcome of pregnancy, particularly if it is started in early pregnancy and if there is good compliance with recommendations (Blondel Dutilh and Delour 2001: 191). Early antenatal care can be instrumental in identifying risk factors and determining appropriate intervention or monitoring of the pregnancy. Regular contact with the maternity clinic and monitoring of the progress of the pregnancy (including determination of pre-pregnancy weight, height and BMI and iron status) are recommended for all pregnant women. (Blondel *et al* 2001:191).

Male infants are slightly heavier than females (Catalano and Kirwan 2001: 71). Parity also influences birth weight and first-born as infants tend to be slightly lighter than second and subsequent siblings (Robinson 2000: 81). Multiple births are usually associated with higher rates of low birth weight, due to either or both growth restriction or pre-term birth or both. In studies conducted in a range of countries, the average birth weight of twins ranged from 2300 to 2600g, and for triplets the average weight was 1800g (Brown Murtaugh and Jacobs 2000: 205).

The socioeconomic status of the mother is associated with birth weight. Rates of low birth weight infants are higher in areas with a higher level of socioeconomic deprivation (Neilsen 2003: 234). Birth weight is also related to income level and accessibility to health care, education and housing (Kramer Seguin and Lydon 2003: 194). Maternal stressors are associated with low birth weight, both growth restriction and pre-term birth. These stressors are perceived stress, chronic and acute life-event stress, physical abuse, strenuous physical work, work-related stress, and pregnancy-related anxiety. Poor nutrition adversely affects birth weight because it affects pre-pregnancy BMI and nutritional status and gestational weight gain (Hobel and Culhane 2003: 1709).

High alcohol consumption during pregnancy is associated with a cluster of symptoms classified as foetal alcohol syndrome (FAS). One of the most consistent features of full FAS is intrauterine and post-natal growth retardation. Cigarette smoking (or exposure to environmental or second-hand tobacco smoke) is probably the most important single factor influencing the incidence of low birth weight infants in developed countries (Chiriboga 2003: 267). The birth weight of infants born to mothers who smoke in pregnancy is, on average, 150–300 g less than the birth weight of those born to mothers who do not smoke.

An important contributing factor to the higher incidence of low birth weight infants born to Màori women is the high proportion of Màori women who smoke during pregnancy (Ministry of Health 2003: 90).
Cigarette and alcohol contain illicit drugs which can cross the placenta and enter the foetal blood and the consequences include pre-term birth and low birth weight, birth defects, growth restriction, small head size, impaired neurodevelopment, poor motor skills, learning disabilities, behavioral problems, increased risk of infection and sudden infant death syndrome. The use of illicit drugs could increase the risk of miscarriage, pre-term labour and placental abruption. Birth weight is reduced by high caffeine consumption; however this is unlikely to be of clinical importance except in women consuming more than 600 mg of caffeine per day (Bracken, Triche and Belanger 2003: 456).

2.8.2 Recommendation for improving poor nutrition during pregnancy

In a recent review, of prenatal nutrition in developing countries, including strategies, prospects and challenges, it was found that female under nutrition was enormous due to poor social, economic, health and development implications (Mora and Nestel 2002:92). Adequate nutrition of women particularly before and during pregnancy should be secured and remain an important goal for developing countries. The following service delivery are recommended for pregnant women in developing countries:

- Provision of iron and folate supplements during pregnancy
- Monitoring of pregnancy weight gain
- Provision of anti-malarials and other micro nutrient supplements when appropriate
- Provision of prompt diagnosis and treatment of illness and
- Provision of supplementary food to at-risk and undernourished women.

Table 6: Nutrition guidelines for pregnant women (Ministry of Health Wellington New Zealand 2003:29)

Advice	Food group	Nutrients provided
At least five servings of vegetables and two servings of fruit per day	Vegetables including fresh, frozen, canned or Dried	Carbohydrates, dietary fibre, vitamins especially folate, vitamin A, (yellow and green vegetables) and vitamin C (dark green vegetables and most fruits, potatoes) Minerals magnesium and Potassium
At least six servings per day choose whole grain	Bread and cereal (includes breakfast cereals, bread, grains, rice and pasta	Protein, carbohydrate, dietary fibre vitamin B group (except B12), vitamin E rich in wheat germ. Minerals magnesium, calcium, iron, zinc and selenium (whole grain products)
At least three servings per day (choose low fat options)	Milk and milk products (including cheese, yoghurt and ice cream)	Protein, fats: higher proportion of saturated than poly saturated, especially in full fat products. Vitamin riboflavin, B 12, A, D, Minerals – calcium, phosphorus, zinc and iodine
At least two servings per/ day	Lean meat, chicken, seafood, eggs, nuts, seeds and legumes	Protein, Fat: both visible and marbled in meat(mostly saturated fat) mostly unsaturated fats in sea food, nuts and seeds) Carbohydrates: mainly legumes (dried peas and beans).Vitamins: B12, niacin and thiamine Minerals: iron, zinc, magnesium, copper, potassium, phosphorus and selenium.

2.9 NUTRITION GUIDELINES FOR HEALTHY PREGNANCY IN NEW ZEALAND

Some of the guidelines on nutrition for pregnant women include the following:

- Maintain a healthy body weight by eating well and by daily physical activity.
- Eat well by including a variety of nutritious foods from each of the four major food groups each day.
- Eat plenty of vegetables and fruits. Foods high in vitamin C help iron absorption.
- Eat plenty of breads and cereals, preferably wholegrain.
- Have milk and milk products in your diet, preferably reduced or low-fat options. include lean meat, poultry, seafood, eggs, nuts, seeds or legumes. Care should be taken to reduce the use of fatty cuts of meat, salt and saturated fat products
- Prepare foods or choose pre-prepared foods, drinks and snacks with minimal added fat, especially saturated fat that are low in salt; if using salt, choose iodized salt with little added sugar; limit your intake of high-sugar foods.
- Drink plenty of liquids each day, especially water.
- It is best not to drink alcohol during pregnancy.
- Purchase, prepare, cook and store food to ensure food safety.
- It is important to keep physically active during pregnancy and breastfeeding to help manage weight gain.
- Pregnant women and their families should be referred to the appropriate agencies to ensure the family is receiving all the financial assistance it is entitled to.
- Pregnant women should not eat raw or under-cooked meat – meat should be cooked until the juices run clear (no blood present).Cross-contamination of other foods with raw or under-cooked meat should be avoided. Food should be protected against exposure to cat litter, contaminated soil, and foods exposed to contaminated soil. Wash hands with soap and water after exposure to cats, soil, sand, raw meat or unwashed vegetables, and gloves should be worn when gardening.

2.10 ADDRESSING MALNUTRITION IN PREGNANT WOMEN

2.10.1 Supplementation

Supplementation can be defined as a process by means of which food nutrients are delivered to the needy to enhance low levels of nutrients and to correct defects. Vitamin and mineral supplements are delivered through a variety of health delivery approaches and are given to pregnant women (especially in their first and second trimesters) and recommended for treating children who have measles, severe malnutrition or prolonged diarrhoea. Supplementation maintains adequate nutrient levels and ensures that immune functions are not damaged (USAID: 2002: 2).

Research has led to the inclusion of vitamin A supplementation as a major component of USAID pregnant women and child survival programmes. In the early-1990s, the United Nations Children's Fund (UNICEF), USAID, the Canadian Micronutrient Initiative (MI) and other donors began integrating vitamin A supplementation with national polio immunization days (NIDs). This led to widespread supplementation of pregnant women and children (six months to approximately six years of age) in over 40 countries. Recognizing that NIDs are being phased out as large geographic areas became polio free, USAID, began to help countries establish and monitor programmes to distribute vitamin A independently on NIDs. USAID developed an alternative delivery approach to vitamin A supplementation through NIDS and established the Child Health Week approach when vitamin A distribution was presented as a package of preventive services designed to improve pregnant women and child survival through periodic outreach and facility-based promotions (UNICEF 2002:4).

Fifteen out of a total of approximately twenty five vitamin A deficient (VAD) countries are now carrying out semi-annual vitamin A supplementation, nine of them national in scope. Other countries have linked vitamin A supplementation to their immunization programmes as well as to their child health service delivery approaches. In 2002 the UN Special Session on pregnant women and children reported that vitamin A supplementation with a 70% minimum coverage of pregnant women and children under 5 was raised from 11 countries in 1996 to 43 countries in 1999. Innovative approaches have been applied to increase the coverage and utilization of iron for women and children, through iron supplementation approaches. A multi-sect-oral 'Anaemia Control Programme' was launched in Ghana, combining resources and interventions in malaria, reproductive health, media and environmental health (USAID 2002: 2).

The composition of multiple micronutrient supplements for pregnant women, designed to provide the daily recommended intake of each nutrient is as follows: Vitamin A 800μg , Vitamin D 5.0 μg ,Vitamin E 15.0mg,Thiamine (vitamin B1) 1.4 mg Riboflavin (vitamin B2) 1.4 mg Niacin (vitamin B3) 18.0 mg Vitamin B6 1.9 mg Vitamin B12 2.6 μg Folic acid 400. μg Iron 30 mg, Zinc 15 mg, Copper 1.15 mg, Selenium 30μg and Iodine 220 μg (Trupin 2005:1).

A recent publication of the Regional Centre for Quality Health Care at Makerere University in Uganda has proposed five essential health sector actions to be provided through contacts with women during antenatal child health visits to improve maternal nutrition. (Mora 2002:91).

2.10.1.1 Folic acid supplementation

Folic acid has been found useful in lowering blood pressure levels thereby reducing the incidence of maternal mortality and heart disease. British researchers have now addressed the question of how much folic acid (in supplement form) is needed to achieve the maximum results. The clinical trial involved 151 patients with heart disease who were randomized to receive 0.2 mg, 0.4 mg, 0.6 mg, 0.8 mg, 1 mg or a placebo daily for a three-month period. The participants' blood levels of folate were measured before the start of supplementation, and at the end of the supplementation period of three months. A maximum median reduction in homocysteine levels (23%) was observed at a supplementation level of 0.8 mg/day. The currently recommended daily intake of 400 micrograms per day achieved only a 10% reduction in homocysteine levels. Homocysteine levels returned to their pre-trial levels after three months without supplementation indicating that folic acid supplementation must be continuous and indefinite if homocysteine levels are to be kept in check (Queenan 2003: 14).

2.10.1.2 Dietary folate equivalents and folic acid supplementation

The RDI for intake of dietary folate equivalents (DFEs) for pregnant women for the entire duration of their pregnancy is 600 μg RDA per day. This does not include the folic acid tablet recommended to reduce the risk of non transmitted disease (NTD) by the ministry of health of New Zealand (NHMRC 2006). The ministry of health in New Zealand recommends that all women planning pregnancy, or who are in the early stages of pregnancy, take an 800 μg (0.8mg) folic acid tablet daily for at least four weeks before, and 12 weeks after, conception to reduce the risk of NTDs. Women at high risk of a pregnancy affected by NTDs are recommended to take a 5000 μg (5 mg) folic acid tablet for the same period of time. According to the ministry of health in New Zealand women at high risk are those who:

- have previously had an NTD-affected pregnancy
- have a family history of NTD, or whose partner had a family history
- are affected by NTD themselves, or whose partner is affected by NTD
- are on insulin treatment for diabetes
- are taking medications known to affect folate metabolism such as anti-convulsants, infertility treatment, and vitamin A analogues used to treat tumor.

Folic acid tablets are registered medicines which are available over the counter from pharmacies, either as 0.8 mg (800 μg) tablets or 5 mg (5000 μg) tablets. Supplementing with 400 μg (0.4mg) is sufficient to reduce the risk of NTDs, but the only folic acid tablets currently available as registered medicines in New Zealand contain 800 μg (0.8 mg) or 5000 μg (5 mg) It is advised that women take only folic acid tablets that are registered as medicines to reduce the occurrence of NTDs The UL for folic acid for pregnant women aged 14–18 years is 800 μg per day. The UL for folic acid for pregnant women aged 19–50 years is 1000 μg per day. This value is based on limited evidence of the effects on people with vitamin B12 deficiency. As vitamin B12 deficiency is usually not a problem in women of childbearing age, women at high risk of a pregnancy affected by NTD can safely take the 5 mg tablet (NHMRC 2006: 12).

2.10.1.3 Calcium supplementation

Calcium supplementation of pregnant women with low calcium intake reduces preeclampsia and preterm delivery. Randomly selected women from populations with dietary calcium < 600 mg/d. were recruited before gestational week 20 and received supplements (1.5 g calcium/d or a placebo) throughout pregnancy. The groups comprised 8325 women. Calcium supplementation was associated with a non-statistically significant small reduction in preeclampsia (4.1% vs 4.5%) that was evident by 35 weeks of gestation (1.2% vs 2.8%; P = .04). Eclampsia (risk ratio, 0.68: 95% CI, 0.48-0.97) and severe gestational hypertension (risk ratio, 0.71; 95% CI, 0.61-0.82) were significantly lower in the calcium group.
Overall, there was a reduction in the severe preeclamptic complications index (risk ratio, 0.76; 95% CI, 0.66-0.89; life-table analysis, log rank test; P = .04). The severe maternal morbidity and mortality index was also reduced in the supplementation group (risk ratio, 0.80; 95% CI, 0.70-0.91). Preterm delivery (the neonatal primary outcome) and early preterm delivery tended to be reduced among women who were < or = 20 years of age (risk ratio, 0.82; 95% CI, 0.67-1.01; risk ratio, 0.64; 95% CI, 0.42-0.98, respectively). The neonatal mortality rate was lower (risk ratio, 0.70; 95% CI, 0.56-0.88) in the calcium group. A 1.5g calcium/day supplement did not prevent preeclampsia but did reduce its severity, while maternal morbidity, and neonatal mortality, were secondary outcomes. (Villar Abdel Merialdi Mathai Zavaleta Purwar Hofmeyr Nguyen Campódonico and Landoulsi 2007: 639).

2.10.1.4 Iron supplementation

There is currently little evidence from published clinical research to suggest that routine iron supplementation during pregnancy is beneficial in improving clinical outcomes for the pregnant mother or foetus. Evidence available is insufficient to recommend for or against routine iron supplementation during pregnancy. Although observational data suggest that pregnant women with anaemia (haemoglobin less than 100 g/L) are at increased risk of preterm birth, low birth weight, or other adverse outcomes, it is unclear from such evidence whether anaemia is responsible for these outcomes and whether they can be prevented

through iron supplementation. It is also unclear whether iron supplementation during pregnancy can reduce the incidence of iron deficiency in infants. Although iron supplementation can improve maternal haematologic indices, evidence from controlled clinical trials evidence has failed to prove that iron supplementation changes the hematologic indices outcomes of the mother or newborn (Feightner 2003:5).
Iron supplementation programmes are being scaled up in India by actively engaging women health providers who are themselves anaemic. USAID is also collaborating with the World Health Organization (WHO) and UNICEF in developing an introductory approach for delivery of zinc supplements for treatment of acute diarrhoea. Start-up programmes in zinc supplementation have begun in three countries, adhering to clinical guidelines for health workers developed by USAID (UNICEF/UNU/WHO 2006: 4).

2.10.1.5 Vitamin and mineral supplementation

Toxemia in pregnancy is characterized by a combination of at least two symptoms, hypertension edema and protein uria. The dietary intakes of young pregnant women attending a Maternal and Infant Care Program at Tuskegee Institute were evaluated for selected vitamins and minerals. Women with toxemia were identified, and women without toxemia served as controls. The toxemia group generally consumed lesser amounts of vitamins and minerals than the controls. However, both groups were deficient (less than two-thirds RDA) in calcium, magnesium, vitamin B6, vitamin B12, and thiamin. Milk, meat, and grains supplied an appreciable proportion of each vitamin except vitamin A, which was found primarily in the two vegetable groups. Meat and grains contained the greatest quantities of minerals, but milk provided a relatively good proportion of potassium, calcium, magnesium, and phosphorus. Anaemia was not related to the incidence of toxemia. Women exhibiting anaemia consumed smaller amounts of vitamins than did women without anaemia (Lu, Cook, Javia, Kirmani, Liu, Madika, Omasayie, Patel, Reddy, Walker, Williams and Chung 1998:477).

Table 7 describes the advantages and disadvantages of different forms of supplementation (Saul 2004: 8).

Table 7: Advantages and disadvantages of types of supplementations (Saul 2004:8)

Type of supplementation	Advantages	Disadvantages
Tablets or capsules	Excellent shelf life, easy to carry and easy to use	Ingredients sometimes bother stomach
Chewable (supplemented gums)	Tasty	Relatively expensive
Powder with supplement (to be dissolved in water)	Cheap, pure, easiest oral –dose way to body saturation	
Liquids with supplements	Convenient	Potency quickly diminishes after opening
Injections meant to supplement nutritional situations	Best possible absorption. Ideal when sick	Needs a qualified practitioner to give them
Intra nasal (direct through the nostrils)	Excellent absorption	May irritate sensitive membranes
Healthy foods	Cost effective and natural	Not much fibre
Supplemented processed foods	Better than unfortified foods	Loaded with sugar

2.10.2 Food fortification

The term “fortification” is considered to be the most appropriate to describe the process where by nutrients are added to food to maintain or improve the nutritional quality of individual foods or the total diet of a group, a community or a population, to correct specific nutritional deficiencies(FAO/WHO 2005:350). Fortification of food is a convenient, inexpensive, safe and easy way to eliminate childbirth disorders, and wide spread micro nutrient deficiencies. The concept of food fortification with nutrients to prevent deficiencies of vitamins and trace of elements was documented over fifty years ago (Blum 2004:371).

2.10.2.1 Global fortification

Research has demonstrated that foetal death, blindness, anaemia, mental retardation and many common infections that kill the young and the weak are prevalent in the world especially the developing world simply because individuals in this part of the world lack adequate essential vitamins and minerals in their diets. One of the most successful programmes has been the addition of iodine to salt to prevent mental retardation and IQ loss. Some 70% of all salt now consumed worldwide is iodized. In the United States and other industrialized countries, people don't even think about the fact that staple foods are fortified with essential vitamins and minerals. Individuals benefit from such programmes (fortification) with every slice of bread eaten and with every shake of salt. This is not so in the poorer countries. By contributing to the reduction of micronutrient deficiencies through fortification, the Global Alliance for Improved Nutrition (GAIN) aims to decrease child and maternal morbidity and mortality, lower health care costs, improve productivity and promote the ability of populations to achieve their physical and intellectual potential (GAIN 2005: 7).

The major aim of food fortification is to reduce the risk of women giving birth to babies with neural tube defects (spina bifida). Food fortification would theoretically supplement (100 micrograms) of folic acid per day. Canada and the United States of America have issued several reports which show that fortification of popular foods has been effective in reducing NTD (Queenan, 2003:14). Because, of micronutrient intervention, fortification of margarine with vitamins is mandatory. Some bread manufacturers in South Africa are fortifying their bread with iron and B- vitamins. The U.S. government has mandated the fortification of all cereal grains with 0.14 mg (140 micrograms) of folic acid per 100 grams of grain. Canada and the United States of America implemented a policy of fortification of cereal grains and flour with folate as far back as 1990 (Folic Acid Consultations Submissions, Ireland).

2.10.2.2 Fortification in Africa

In African countries like, Nigeria, Ghana, Madagascar and South Africa, more than 80% of current salt production is iodized. As a result, about 12 million infants born in 1996 were spared the consequences of iodine deficiency. The number of babies born cretin has been reduced by half from about 120000 in 1990 to less than 55000 (De Hoop 2005:100). Fortification technology represents an opportunity in developing countries. Historically, food fortification has been renewed and used as an effective health technique to virtually eradicate such adverse effects. Fortification is a potentially attractive approach that requires no conscious involvement by the customer; the customers may not even know that they are eating a food fortified with nutrients. There is a long history of food fortification although consumer acceptability varies greatly around the world. In some countries there are laws requiring some foods to be fortified. Iodized salt has had a beneficial effect on the prevalence of goitre in many countries (Gibley *et al* 2004:20-21).

Once the target of fortification is to increase intake substantially it may be difficult to construct a diet to meet this level, without altering the whole dietary pattern. Particularly if the target group is a low income one and is unlikely to achieve the required changes required, it may be worth considering the possibility of fortifying key foods to achieve the desired change. There is no point fortifying foods that are too expensive or rarely eaten by that target group. If fortification is considered, it is necessary to ensure that no adverse effects of excess consumption occur in groups which consume a lot of the fortified foods. One of the concerns with folate fortification has been the possibility of masking vitamin B12 deficiency especially amongst pregnant women and the elderly.

Table 8: Fortification levels in some cereals (per kg of cereal) (World Bank, 2003: 660)

Fortificant	**Maize/ sorghum**	**Wheat flour**	**Bulgar wheat crushed) wheat**
Thiamin (Vit. B1)	4.9mg	5.7mg	3.3mg
Riboflavin(Vit.B2)	2.6mg	4.0mg	2.2mg
Niacin (Vit.B3)	31mg	46mg	_
Iron	26mg	37mg	11mg
Vit A	2.34ug	2.34 ug	2.34ug

2.10.2.3 Fortification in South Africa

Most South Africans do not have enough money to eat enough of a variety of foods to provide all the micronutrients they need. Therefore the only way that they can get extra micronutrients is if they eat foods that have been fortified. Presently, all maize meal and white and brown bread flour (and bread baked with this flour) are fortified with micronutrients (vitamin A, thiamin, riboflavin, niacin, pyridoxine, folic acid, iron and zinc). Global Alliance for Improved Nutrition' (GAIN 2005: 7) has found out that food fortification is one of strategies that could be used by the Department of Health in South Africa to prevent and control micronutrients deficiencies. GAIN approved South Africa's proposal for a 3-year $2.8 million grant for delivering fortified foods to 45 million South African consumers in 6-18 months.

Before then more than 30 million individuals were at risk of micronutrient deficiency. By fortifying both maize and wheat flour, the South African government and its partners in industry now provide essential vitamins and minerals to all strata of society, both urban and rural. A major factor in the programme is the desperate need of South African pregnant women and children, who will, through fortified foods, receive almost half of their nutrient requirement in addition to other essential vitamins and minerals such as iron and zinc. The proposal clearly demonstrates the country's commitment to a national food fortification strategy, through the creation of the multi-stakeholder National Food Fortification Task Group (NFFTG). The South African government has mandated the fortification of all cereal grains with 0.14 mg (140 micrograms) of folic acid per 100 grams of grain as established by National Food Fortification Programme. The first compulsory fortified product introduced in South Africa was iodised salt. Sasko introduced fortification of white, brown and whole wheat bread with thiamine, riboflavin, niacin, folic acid, pyridoxine and calcium in 1994. Three vehicles for food fortification were identified namely, sugar, maize meal and wheat flour. The food fortification regulations are published in terms of Act of foodstuffs, cosmetics and disinfectants in the Government Gazette. It became mandatory by April 2003, to fortify maize meal, wheat flour with vitamins, micronutrients and mineral salts (DoH 2003: 8).

Table 9: Fortified food vehicle standards in South Africa (D0H, 2003:8)

Fortificant	Unit	Wheat flour for bread	Maize foodstuff	Unsifted maize meal
Vitamin A	IU/kg	5400.00	6400.00	64.00
Thiamin	mg/kg	3.60	3.85	3.85
Riboflavin	mg/kg	2.00	1.85	1.85
Niacin	mg/kg	31.00	28.50	28.50
Folic acid	mg/kg	1.50	1.50	1.50
Pyridoxine	mg/kg	3.20	3.20	3.20
Iron	mg/kg	43.00	37.00	14.00
Zinc	mg/kg	20.00	18.50	18.50

Table 10: Fortification micronutrient mix specifications of the D0H in South Africa (2003:8)

Fortificants	Wheat Flour (g/kg)	Maize meal (g/kg)	Unsifted maize (g/kg)
VitaminA Palmitate 250 000 IUg	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	7.15g
Pyridoxine HCL	16.24g	19.32g	19.32g
Electronic iron	178.57g	178.57g	89.28g
Zinc oxide (min. activity	93.40g	93.40g	93.40g
Calcium carbonate (min. activity	To complete 1000g	To complete 1000g	To complete 1000g

The dosage of 200g of micro-nutrient mix per ton of wheat or maize is necessary to cover the minimum fortification levels (D0H 2003:9). The stipulated minimum levels of fortificants in fortified foodstuffs are final and should not be lower than the levels shown in the table above. Table 10 above displays the micronutrient mix composition and should be used. The Food Chemicals Codex (FCC) has set standards for fortificants (independent or mixed with diluent) and should be followed accordingly. At the point of manufacturing or importation the fortification standards should meet the minimum levels in wheat flour and dry maize meal when analysed (D0H 2003:9).

2.10.2.4 Advantages of fortification

Fortification has several advantages and its success has been recognized in several countries It is socially acceptable. Dietary habits of consumers need not change and fortification does not place much burden on the health sector. The fortified food reaches the target group quickly (pregnant women in the case of this study) because foods used are normally available and are widely consumed. Fortification increases the nutrient intake of many (more especially pregnant women) and other people who are at risk within the population. Fortification is effective the effect of fortification is both fast and broad. The ultimate impact on the micronutrient status of the population can be detected (USAID 2002).
The effect of the micronutrient intake is immediate- as early as in three months. Fortification brings a high return on investment. The rate of return, in terms of benefit per unit of investment, is greater than with many other nutrition interventions. It ranges between R42 ($6) and R350 ($50) per R7 ($1) invested. Behavioural changes are not required. A major advantage of fortification is that it does not require significant changes in feeding patterns. Information to the consumer is important when choices are available to the population (for example between iodised and non iodised salt, fortified and non-fortified cereals). Social marketing will be effective to inform the consumer about choices and the advantages of fortified foods when options are available. Fortification is socially acceptable and politically attractive and is firmly established in developed countries. Because of its high visibility as a staple food that is consumed regularly by the majority of the population, high population coverage can be achieved. Constant amounts of food fortification are the safest strategy, as the added nutrient provided in the diet is low, cconsistent delivery and thus maximizes benefit. Fortification requires minimal behaviour change and enhances health and nutrition

strategies. It is cost effective since it transfers costs of protecting health to sectors otherwise not involved (Neilsen 2002:36).

2.10.2.5 Disadvantages of food fortification

Micronutrient food fortification is not yet widely implemented in developing countries for various reasons. The persistent survival of numerous beliefs and practices is a contributory factor. Other disadvantages include the reluctance of governments and industry to commit themselves, the difficulty in identifying suitable vehicles, and the failure to introduce efficient monitoring. There is the risk of the addition of excess nutrients and of nutrient imbalances or deficits, for example, in a population where both vitamin B12 and folic acid deficiencies are problems related to anaemia. If fortification deals with folic acid only, then this can mask the vitamin B12 deficiency, and in this case, may have serious consequences to health (World Bank 2003a:660).

2.10.2.6 Fortified foods

Nutrients and the types of foods to which they may be added have different specifications. The Food Standards Code specifies the permitted forms of the nutrients and the levels that may be claimed. The addition of nutrients to a food must be identified in the ingredient list. The nutrients may also be included on the nutrition information panel (NIP), but this is not required unless a claim is made. The level of nutrient present as stated on the NIP does not take into account the bioavailability of the nutrient. Allowed levels of nutrients in fortified foods are determined taking into account the potential for toxicity among high consumers. Because most fortification is voluntary in New Zealand, consumers must read the labels to be sure they are choosing a fortified product. For example, not all milk substitutes are fortified to be nutritionally similar to cow's milk, and not all margarine is fortified with vitamin D. Some nutrients are added to improve the dietary intakes of individuals (such as iodized salt and calcium-fortified milk), or to obtain nutritional equivalence for a substitute food (such as vitamin A fortification of margarine to the same level as in butter). Fortified foods that may be nutritionally useful in the diet of some pregnant women include folic acid- and iron-fortified breakfast cereals and wholegrain breads, folic acid-fortified fruit juice, iodized salt, if using salt, margarine fortified with vitamins A and D and soy milk or rice milk fortified with calcium, vitamin A, riboflavin and vitamin B12 (FSANZ 2002).

2.10.3 Nutrition education programmes (NEP)

Nutrition education is designed to assist limited resource audiences in acquiring the knowledge, skills, attitude and charged behaviour necessary for nutritionally sound diets, and to contribute to their personal development (USDA 2006:2) Equally important is the use of communication and education activities to motivate changes in behaviour that increase consumption of beneficial foods, increase food production and improve feeding practice in pregnant women, infants and growing children.

2.10.3.1 The nature of nutrition education programmes (NEP)

NEP is 'that group of communication activities aimed at achieving a voluntary change in nutrition related behaviour to improve the nutritional status of a population'. Education activities can include information processes, designed to inform through print and broadcast (radio and TV) channels, group discussions/ home visits, training and counselling. Each channel has its own strengths and weaknesses. Channels chosen should suit the types of the population being educated (Andrien 2001:2).

2.10.3.2 Issues for nutrition education programmes

There is less evidence available about the feasibility of reproducing positive results routinely and on large scale. Given the limited resources available to most countries, nutrition education must have impact on large sections of the population in a cost effective way. The following have been identified as important for affordability and effectiveness, particularly for large- scale programmes.

- Programmes need a clear institutional framework and government commitment (Cerqueira and Olsen 2005:8).
- Appropriate targeting can reduce cost (Berg 2001:12).

- Programmes must have sufficient time to allow for detailed planning, consultation and field testing of education resources.
- Community participation results in effective education and successful programmes (Cerqueira and Olsen 2005:8).

2.10.3.3 Strategy

There is a trend towards the increased use of locally available mass media, the adoption of more participatory approaches and inclusion of all aspects of a programme. Define objectives by targeting the most vulnerable and making sure the intervention reach that group. Develop and implement programme effectively. Evaluate to judge whether the goal was achieved. Nutritional education assists care givers to make better choices and allows for better use of food resources. It improves living standards of beneficiaries and provides advice to communities (Archterberg 2003: 22).

2.10.3.4. Disadvantages

There is the need for structure, support and funding. Community participation may change during education presentation. Some participants may find it time wasting. It's important therefore, to keep communities interested and request their involvement and resource to prevent loss of interest and participation. (Cerqueira and Olsen 2005:8).

2.10.4 Food diversification

Food diversification is a strategy designed to reduce exposure to risk by combining a variety of investments. The diversification of the diet to increase the consumption of iron, vitamin A and other micronutrients on a daily or continuing basis is a practical, long-term measure to eliminate and prevent micronutrient deficiencies. Activities that improve production, availability and access to micronutrient-rich and locally produced foods are a major focus of this type of intervention (Heleigh 2006:3).

Many dietary diversification activities operate at the community level where they are more likely to be sustainable and cause enduring behaviour change in macro and micronutrient consumption. Food diversifying involves transforming traditional food items into enriched food mixes for poor communities (USAID 2005: 8).

2.10.4.1. Advantages of food diversification

Food diversification ensures better choices and consumption of naturally rich food sources. It is cost effective, sustainable and income generating. Food diversification is feasible to implement and culturally acceptable. It promotes self reliance and community participation and builds alliances among government, consumer groups, the food industry and other organizations to achieve the shared goals of preventing micronutrient malnutrition (FAO 2002:11).

2.10.4.2 Disadvantages of food diversification

Food diversification needs support from local government or non –governmental organisations to overcome cost constraints. It is a long term food based solutions to micronutrient deficiency (FAO 2002:11).

2.10.4.3 Strategies to accomplish when diversifying food

Community or home vegetable and fruit gardens are projects that can lead to increased production and consumption of nutrient rich foods. The success of projects requires good knowledge and understanding of local conditions as well as involving women in the community. Production of fish, poultry and small animals (rabbit, pigs and guinea pigs) are excellent sources of highly bio-available essential micronutrients. The production of animal foods at local level may permit communities to access foods that would otherwise not be available owing to high costs resulting from post - harvest losses. Improvement of food nutrient levels in soil and plants will result in more nutrient-rich harvests. Implementation of large scale commercial vegetable and fruit production with the objective of providing nutrient -dense foods is yet another alternative. Optimising nutrient intake through specific food product development, for example food multi-mixes is also recommended (FAO 2002:11).

2.11 FOOD MULTI-MIX SUPPLEMENT

A multi-mix is a combination of more than two ingredients. It was discovered by Gokaldas in 1974 and Cauera and Hofvander in1981. Since 1990, Amuna, Zotor, Yewfik have also been working on it to improve the formulation of multi-mixes. The health of pregnant women, and people suffering from malnutrition in the developing world could be improved by the University of Greenwich project to develop nutritious, low-cost foods (FMM). The technology can also be used to help people with diabetes in the UK (Amuna, Zotor, Yewfik 2004:129). Tests have shown that whilst foods provided by the Food and Agriculture Organization as part of the World Food Programme are energy-rich, the food mixes more complete diet with longer lasting benefits (Amuna, Zotor & Tewfik 2004:129).developed at the University of Greenwich have a higher mineral and vitamin content for a

According to Amuna, Zotor Yewfik (2004) the FMM project has been designed to utilise affordable foods that are culturally acceptable to the subject group. Processing methods are being examined to avoid over cooking and loss of food nutrients. Affordable nutrient-dense food multi-mixes will significantly improve the nutritional status of malnourished pregnant women, and reduce negative effects associated with pregnancy and birth. In the absence of good nutritional support, drugs alone will not produce the best outcomes for the malnourished (Amuna, Zotor & Yewfik 2004:129).

2.12 CONCLUSION

Nutrients have many functions in the body, especially in pregnant women who happen to be feeding a foetus as well. Therefore it is very important that recommended daily allowances (RDA) and the extras required by pregnant women be fully met to yield excellent results for both baby and mother. It is essential at all stages of pregnancy that, diet contains all the required nutrients in the right quantity. This chapter started with the description of the various nutrients. Macronutrients and the micronutrients (vitamins and mineral salts) were discussed. Strategies employed to address malnutrition especially in pregnant women were also discussed. These included supplementation, fortification, nutrition education programmes and food diversification, including food multi- mixes. The major objective of this study was the development of a food multi-mix supplement meant to supply about 20 –

25% percent of the required RDA of nutrients set by World Health Organization for pregnant women. The FMM supplement is nutrient-dense, affordable and culturally acceptable food, and can be used to correct maternal malnutrition to avoid mishaps in child delivery. A flow diagram depicting the process of the multi-mix formation is shown in Figure 2. FMM is the strategies that will be focused in this study and will be discussed further in chapter three.

CHAPTER 3

LITERATURE REVIEW: Food product development

3.1 INTRODUCTION

Development of a food multi-mix supplement was the strategy adopted for this study. The formulation was based on food development principles. In this chapter the theoretical basis for the methods employed in this study is described. In the introduction, the fact that household insecurity and limited access to good quality and nutrient-dense foods continue to have a negative impact on expectant mothers in Sub-Saharan Africa is highlighted. Chemical analysis of food in general is discussed and analysis of the food multi-mix supplement is described in detail. Analysis of macronutrients, protein, fat, ash, moisture and fibre is also described. Carbohydrate and energy content derived using data gained from the analytical procedures are stated. Determination of mineral content by atomic absorption spectrometry (AAS) and/or inductively coupled plasma-mass spectrometry (ICP-MS) is also described.

The well-being of pregnant women, and the foetus, depends on the correct intake of recommended micro- and macronutrients. A woman whose diet is deficient during pregnancy, is likely to give birth to a baby of low birth weight (USAID 2002:2).Household food insecurity and limited access to good quality, nutrient-dense and affordable food, in Sub-Saharan Africa has negative impact on different population groups, like pregnant women. The development of a suitable food multi-mix supplement can provide sufficient nutrients in the daily composite diets of the needy. In many food-insecure countries, pregnant mothers, infants, school children and the elderly continue to develop their own coping mechanisms to deal with chronic hunger, the result of which is under-nutrition, poor birth outcomes, childhood malnutrition and increased susceptibility to ill health. (Amuna *et al* 2004).

3.2 PRODUCT DEVELOPMENT

The purpose of this study was to develop a cost effective, nutrient –dense and culturally familiar product -a food multi-mix (FMM) supplement to improve the RDA of pregnant women in the Vaal region by about 20-25% as stated in the objectives of the study. According to Heleigh (2006:2) product development is the process of designing, creating and marketing a product. The product can either be one that is new to the market place or one that has been improved. All product development goes through a similar planning process (Heleigh 2006:2).

3.2.1 Procedures for developing a product

Steward-Knox and Mitchell (2003:58) proposed the following procedure in developing a product.

- use of the product (for example as a food supplement in the case of (FMM supplement)
- method of preparation
- minimum or maximum nutrient content
- expected shelf life
- type of storage
- target group and
- cost

After the development of every product, the target group should test the acceptance of the product through sensory evaluation. Details required from the target group should include purpose of design, whether the product fulfils the purpose for which it was designed, whether it meets the needs of the target group, whether it is easy to prepare and store and if it is affordable and safe for consumption. To ensure quality control, recipes and quantities of ingredients must be followed for each product (Rudder, Ainsworth and Holgate 2001:658 & Steward-Knox and Mitchell 2003:59- 62).

3.2.1.1 Characteristics and steps in product development

The steps in product development start with idea generation. The idea is screened and the concept development tested. After testing, the marketing strategy is developed and business analysis made. Test marketing is then followed by the final stage of commercialisation. Screening includes methods such as brain storming sessions amongst personnel, gathering of information from various sources such as customers, competitors and trade journals. The screening of ideas is used to identify good ideas and eliminate poor ones. Development and testing of the concept involves taking the promising idea to a more concrete level and defining parameters for the product defined (Rudder *et al* 2001: 657).
The marketing strategy development stage allows for a detailed strategy to be developed that will address the target market, the planned product positioning, sale and market share. During the business analysis stage, factors such as review of sales, cost and profit projection are undertaken. Product development involves the production of the physical product. Test marketing is deemed suitable for products that have passed through the previous stages. Commercialisation according to Rudder et al, is seen as the stage in which the new product is launched (Rudder *et al.* 2001: 659).

3.2.1.2 Categorization of launched products

During launching, products are categorized according to their type; new to the world products (10%), new product lines (20%), additions to existing line (26%), improvement to existing product line (26%), repositioning of existing products (7%), and cost reduction: new products that provide similar performance at lower cost (11%)(Rudder *et al.* 2001: 663).

3.3 CHEMICAL ANALYSIS OF FOOD

The chemical composition of food is of utmost importance from many standpoints including nutrition and health, toxicology and safety, and stability of microbiological, chemical or physical changes. Analysis of these food components is required to provide the correct nutritional information to the customer. The methodology used will depend on the particular component and nature of the product being analysed, the purpose of the analysis and the available resources. The principles of important analytical techniques, include, spectroscopy, titration, potentiometer electrophoresis and chromatography (Neilsen 2004:234).

3.3.1 Instrumentation

An AAS (Video 11AA AE Spectrometer) was used for the analysis of dried foods. It contained a source of radiation whose wavelengths were exactly the same as those required to excite the atoms in the flame. A hollow cathode was used to produce a high intensity of radiation similar to that which absorbs the element to be determined.

3.3.2 Nutrient analyses

The procedure included analyses of minerals in the multi-mix supplement. The content was determined by Atomic Absorption Spectroscopy (AAS). This was to determine whether the intended bio-available target was being met. Instruments used included Atomic Absorbance Spectroscopy (AAS), hollow cathode and a chopper which was used to produce signals that distinguished hollow cathode radiation from flame radiation.

During protein thermal digestion, sample (concentrated (10ml) nitric acid heated at 140-90degrees centigrade for 90minutes releases the minerals bound up in a (1.0g) FMM sample. The AAS determines the mineral content in the digest and diluted sample by heating the sample to vaporize and atomize the minerals. Bumping crystals are added during digestion to avoid boiling over. Light of suitable wavelength for a particular element is shone through the flame, and some of this light is absorbed by the atoms of the sample. Measurements are made separately for each element in order to achieve a complete analysis of the sample.

3.3.3 Limitation of the atomic absorbance spectroscopy

Some of the limitations include, the ability to determine only one element at a time, the use of distilled water only, fluctuations from the gas supply sometimes causing hindrance to accurate results and further dilution of the solution to stabilize the mineral content.

3.3.4 Calculation of mineral content

The following formula was used to calculate the Ppm

Ppm = Concentration * Dilution factor/1000

For example a material with a known content of 208/100g food gave a reading of 0.062 after 1/10 dilution

Ppm = 0.062 *1/10

=1/10*0.062

= 0.0062

3.3.5 Kjeldahl protein analysis

The food sample is heated in sulphuric acid and digested using copper sulphate as a catalyst until the carbon and hydrogen are oxidised and the protein nitrogen reduced and transformed into a green solution, called ammonium sulphate. The nitrogen content of the FMM can then be quantified using the modified Berthelot reaction, where an intense blue dye is formed in the presence of ammonia, which absorbs light in the region of 630 -650nm.Visible spectral measurements can then be used for quantitative analysis as the amount of radiation transmitted by a solution depends on its concentration and path length. Protein content is analysed using the modified Berthelot method.

The procedure was a reaction between hypochlorite and ammonia in the presence of a phenol source at approximately pH 11.5. The product is a dye that absorbs light in the region of 630 – 720 nm. In the analysis, an organo-chlorine compound, is used, which hydrolyses compounds quantitatively to yield a more stable hypochlorite source. A sodium catalyst is used to accelerate dye formation and stabilise the indophenols thereby allowing the reaction to proceed with less dependence on pH (Amuna *et al*, 2004).

Table 11: Composition of standard solutions used for plotting protein calibration curve

Tube number	[N] ppm	10 ppm standard nitrogen	1% 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

3.3.6 Sample digestion

Each sample, a blank and 3 reference material (CRM 381, Wheatex 1500 & Wheatex 2240) were prepared for analysis by thermal digestion in sulphuric acid. Next 0.5g of the samples were weighed accurately to 4 decimal places using an analytical balance and placed in a 2.5 by 30cm boiling tube. 0.2 g cupric sulphate pentahydrate and anti-bumping crystals are added to the tubes. Also added was10ml of concentrated sulphuric acid (98%) was also added and the tubes placed into the standard thermal heating block and held at 400° C for 180 minutes or until the digest had turned green in colour. Sulphuric acid was added to the 10ml mark throughout the digest to make up for evaporation. This was carried out in a flow hood as nitrous oxide gas was created. The digests were then cooled and transferred to a 250ml volumetric flask and made up to volume with distilled water. Prior to analysis a further 1:100 dilution of the digest was carried out using 1% sulphuric acid solution for dilution.

3.3.7 Analysis of sample digest

Solution 1 was made up using 240g/L sodium salicylate, 1.4g/L sodium nitroprusside and 130g/L trisodium citrate dissolved in water. Solution 2 was made up using 50g/L sodium hydroxide and 40g/L sodium dichloroisocynurate dissolved in water. Both solution 1 and 2 were wrapped in foil as they were light sensitive. Next 2 mls of the sample and reference digests were placed into 4 ml plastic macro cuvettes. 1 ml of solution 2 and 1 ml of solution 1 being added in that order. The samples were then incubated at room temperature in the dark for 20 minutes and read at 650nm using the spectrophotometer.

3.3.8 Calculation of protein content

A quadratic equation determined from the standard curve (from the standard nitrogen stock solutions) was used to determine the nitrogen content of the samples at 650ml. The following calculation is used to calculate the protein content of the samples protein/100g = (experimental ppm/10000) x 6.25.The nitrogen content had to be multiplied by the factor 6.5 to arrive at the protein content.

3.3.9 Fat analysis by hydrolysis method

3.3.9.1 Principle

The dietary fat analysis method utilizes the organic solvents petroleum ether and hexane to break bonds between lipids and other compounds so that the free lipids can be solubilized and fat extracted using alcohol and ether mixes. Materials for fat analysis include oven (hot box), analytic balance, 100ml conical flasks, 10ml measuring cylinder, 25ml volumetric flask, 50ml beakers, and plastic 3ml pipettes. Reagents consisted of absolute ethanol, concentrated HCL (37%), ethyl alcohol, diethyl-ether and petroleum ether, a blank was also used to standardize results.

3.3.9.2 Procedure for fat analysis

Two (2) grams of the samples and reference materials were weighed to 2 decimal places using an analytical balance and placed into 100ml conical flask. 2 Next 2ml of absolute ethanol and 10 ml concentrated HCL (37%) were added to the conical flask and placed into a water bath at 70 – 80°C for 40 minutes with continual agitation of the sample to prevent lumping. Using a 10 ml measuring cylinder, 10ml ethyl alcohol was added using 10 ml measuring cylinder and the samples allowed to cool. Once cooled, 25ml diethyl ether was measured using a volumetric flask and added to the samples which were well shaken for at least 1 minute. Finally, 25 ml petroleum ether was added to each sample and shaken for a further minute then left to stand until the upper layer to became clear of greenish colour.
A clean plastic 1 ml pipette was then used to extract the top ether-fat layer, weighed and dried in 50ml beakers. 15 ml 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 again 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.

3.3.9.3 Calculation of fat content

The weight of the clean dried beaker 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 percentage of fat of the sample was then 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)

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

3.3.10 Direct method of ash analysis

The ash content was derived by weighing the dry residue of organic materials and are heated at temperatures of 550°C whereby organic matter is burnt off leaving the inorganic ash fraction. Materials for Ash Analysis include, a six placed hot plate, muffle furnace, analytical balance and Silica crucibles (Amuna, Zotor & Tewfik 2004: 137).

3.3.10.1 Procedure for ash analysis

Each labelled silica 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 furnace preheated to 550^0c. The samples were left in the furnace for up to 3 hours until white/grey. The crucible was weighed accurately when cooled.

3.3.10.2 Calculation of ash content

The formula for calculating ash is $wt_1 - wt_2$. Weight one (wt_1) is the weight of crucible and sample before ashing (g) Weight two (wt_2) is the weight of crucible and sample after ashing (g).

Wts is the weight of sample (g) and percentage of ash was weight of ash multiplied by one hundred to arrive at the percentage.

3.3.11 Determination of moisture content

3.3.11.1 Principle

Moisture content is 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 also to include any moisture loss calculated in food roasting prior to FMM formulation. The moisture content of a food can affect the stability of its nutrients and its shelf life. Materials for moisture analysis include oven, analytical balance, thermometer and aluminium weighing boat.

3.3.11.2 Procedure for moisture analysis

Aluminium boats and 2.5g of each sample are weighed accurately to 4 decimal places. The samples are placed in a preheated oven at 105° C for 5 hours. The samples are then weighed after cooling.

Moisture content of a sample is calculated with the following formula;

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)

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

3.3.12 Derivation of carbohydrate content

Total carbohydrate content of the samples can derived by subtracting the weights of protein, fat, ash and moisture, derived analytically, from a known amount of the sample. Total Carbohydrate = 100% - (%protein + % fat + % ash + % moisture). For this calculation to work, the numbers derived for each nutrient analysed chemically must be accurate.

3.3.12.1 Derivation of energy equivalent of food multi-mixes

An estimate of the energy equivalent in each sample is derived using the formula below. This assumes that 1 g of carbohydrate or protein is equal to 16.8 kJ and 1g of fat equal to 37.8 kJ. Energy (kJ/100g) = (protein (g) x 16.8) + (Carbohydrate (g) x 16.8) + (fat (g) x 37.8) with carbohydrate, the values used for energy calculation must be as accurate as possible to get a better estimate.

3.4 SHELF LIFE DETERMINATION OF FOOD

Shelf life is the time when a product becomes unacceptable to consumers under a given storage condition. Consumer acceptability is usually determined by means of 'consumer tests' using a large number of untrained testers in which samples with various ages are tested together (Fritsch, Hofland and Vickers 2000: 425). This is accomplished by using samples of the product manufactured at different times or by freezing aged samples to stop deterioration. Another technique used in industry for shelf life determination is team judgement. It is frequently applied in the early stages of product development, where prototypes are evaluated during the storage by a team familiar with the product.

The use of correlation between trained panel evaluation and consumer response has been reported in the literature (Fritsch, et al 2000:425). First a team trained to recognize deteriorating attributes qualifies change in their intensity during storage. Samples are frozen and then used in a second test where consumers' responses are correlated with those of the trained panel to determine the limits for the intensity of deteriorating attributes in the product at the end of consumer shelf life (Cardelli 2000:34).

3.4.1 Process of food deterioration

The principal mechanisms involved in the deterioration of foods are microbiological spoilage which sometimes accompanied the pathogen development, chemical and enzymatic activity causing lipid breakdown colour flavour and texture changes.moisture and/or other vapour migration producing changes in texture, water activity and flavour (Cardelli 2002: 34).

Formulation and processing variables which affect these mechanisms and can be used to control deterioration include moisture and water activity, pH, heat treatments, emulsifier systems preservatives and additives and packaging.

3.4.2 Importance of moisture and water activity during shelf life

The work on shelf life determination elaborates extensively the importance of water and moisture activity. Water has been called the universal solvent because it is a requirement for growth and metabolism of microbes and the support of many chemical reactions which occur in food products. Water occurs in food systems in both the free and bound states. Free water is just that, free from chemical reactions to support microbiological growth and to act as a transporting medium for compounds. In the bound state, water is not available to participate in these reactions as it is tied up by water soluble compounds such us sugar, salt, gums etc (osmotic binding) and by the surface effects of the substrate (matrix binding).

These water- binding effects reduce the vapour pressure of the water over the food substrate according to Raoult's law. By comparing this vapour pressure, with that of pure water, at the same temperature; one establishes a ratio, which is called water activity an Aw) which by definition is for pure water. A one moll solution of sugar, has an Aw of 0.98 and a one moll sodium chloride solution has an Aw of 0.9669. A saturated sodium chloride solution has an Aw of 0.755.Thus the Nacl solution in closed container will develop an equilibrium relative humidity (ERH) in the headspace of 75.5%. Therefore the equation, Aw =ERH/100 as explained by Cardelli means Aw (pure water) is equal to the equilibrium relative humidity of a food product- divided by one hundred.

The ERH of food products is defined as that relative humidity of air surrounding the food at which the product neither gains nor loses its natural moisture; that is it is in equilibrium with its environment .At relative humidity above ERH, the product will gain moisture and at humidity below that level, it will loose moisture. A food with an (aw) of 0.6 will loose moisture at relative humidity's below 60% and gain moisture over 60%. The ERH is a valuable tool for food product and packaging development as it is an indicator of what chemical reaction may occur during distribution and how much packaging protection should be designed for the product to give it the required shelf life. Without the protection, of a package, the moisture of any food, changes in direct proportion to the relative humidity. The rate at which the gain or loss of moisture occurs depends on the make up of the product for example its hygroscopicity, the temperature and the atmospheric pressure. In packaged products, the changes are relatively slow, but at times a significant change can occur within a short period (Cardelli 2000:34.)

3.4.3 Equilibrium moisture condition

When food is exposed to a constant humidity, it will equilibrate at a final moisture content called its equilibrium moisture (Cardelli 2000:35). By exposing the product to a range of relative humidity, one can develop micro-moisture equilibrium curve. This test is accomplished by placing a known weight the product in a metal dish inside of a glass jar containing a saturated salt solution .Various saturated salt solution equilibrate at certain relative humidities. The sample dishes are weighed back at various times, until they reach equilibrium. The moisture value is then calculated and the texture of the sample is noted for reference (see table below).

Table 12: Equilibrium moisture condition of a cereal (Cardelli 2002:35)

%RH	%H20	TEXTURE
0.0	1.54	CRISP
11.1	2.27	CRISP
22.9	3.18	CRISP
32.9	4.59	SOFT
43.9	6.55	SOGGY
53.5	8.27	SOGGY
64.8	11.43	RUBBERY
75.5	15.88	MOULDY
86.5	23.69	MOULDY

If the RH is divided by 100 to obtain the water activity, a moisture absorption isotherm (moisture content versus water activity) is produced. From such a curve, one can see that the breakfast cereal with a moisture content of 3.18 would have an Aw of about 0.2 and would support mould growth at an Aw of 0.7555.If this cereal were left in an open package during winter, the texture would remain crisp because the RH is normally below 25%. The flavour may change, insects may invade it but the texture will remain crisp (Cardelli 2002:35).

3.4.4 Testing equilibrium moisture effects

Food products may lose quality if the moisture level changes from the equilibrium moisture in the distribution chain. The rate of moisture change can be monitored by changes in the package weight which occur during storage in appropriate temperature and humidity environments. For products that suffer quality losses in high humidity, the packages are stored in a 'weather room'. This room is kept at constant 65% RH with temperature cycling on day /night bases between 32 °C and 23 °C.

3.4.5 Microbiology and the shelf life of refrigerated products

Shelf life of food products is most familiar to consumers through the open dating used on refrigerated goods. The shelf life of these types of products is affected for the most part by their microbiological status. These products pose the highest food safety risk and have the shortest shelf life, because they are most susceptible to microbiological deterioration and the growth of pathogenic organisms. Bacteria need moisture and the correct pH, and right temperature, nutrients and time to grow. If these conditions are controlled, bacteria growth is prevented.

Once developed the shelf life of a product can be determined in real time at the various temperatures which may be encountered during storage and distribution. Growth of yeast and mould, spoilage pathogenic bacteria, etc can be monitored by microbiological methods. Another means of ensuring the product will have an adequate shelf life is to challenge the product with inoculi of various spoilage organisms. Listeria monocytogenes grow under refrigerated conditions. Microbiological shelf life determinations can be accomplished in real time and are therefore accurate.

3.4.6 Chemical deterioration

Chemically based deterioration of packaged food products can be classified into three; oxidation of lipids, enzymatic degradation and non –enzymatic browning All three can occur simultaneously in food and are accelerated by increasing storage temperature (Cardelli 2002:37).

3.4.7 Lipids and shelf life testing

One of the principal methods of predicting the shelf life of processed food products is to monitor the level of lipids degradation products in foods stored at elevated temperatures (Cardelli:2002:37).

3.4.8 Fat oxidation and hydrolysis

Each particular fat has its own unique combination of fatty acids and therefore its own physical and chemical properties. Saturated fatty acids are very stable because they contain no double bonds between the carbon atoms in the chain. Unsaturated fats are subject to a variety of reactors. Monounsaturated fatty acids have one double bond while polyunsaturated have up to six double bonds and are the least stable. These double bonds are the most reactive sites on the fatty acids chain and are easily attacked by oxygen, hydrogen, and enzymes. Each of these attackers produces different results. When hydrogen reacts with the double bond, it eliminates the bond. This process, called hydrogenation produces a more saturated and more stable fat, with a higher melting point.

3.4.9 Kinetics of shelf life testing

The prediction of shelf life for food products is based on the application of the principles of temperature dependent chemical reaction kinetics. These reaction rates depend on product composition as well as on environmental factors like temperature, humidity, atmosphere etc. Lapuza has reported that, quality loss follows the equation dQ = K(QA)n dQ/dt is the change in the measurable quality factor A times K is the rate constant in appropriate units and n is the order of chemical reaction of the quality factor. The order of reaction for most quality attributes in food producers is either zero, first, or second. In zero order reactions, the rate of loss of the quality factor is constant and the resulting curve will be linear on a linear graph. First order reactions are not linear but are dependent on the time. Typical first order reactions are rancidity, microbial growth, microbial growth and death, microbial production products, vitamin losses in dried food and loss of protein quality (Lapuza 2001:18).

3.4.10 Typical shelf life design

The first step in setting a shelf life study is to select one of the degradation reactions which are expected to occur in the product at typical storage temperatures, can be measured and used as an index of quality loss. These could include lipid oxidation, vitamin loss of moisture etc means the more accurate the analysis, the more precise the shelf life prediction. (Lapuza 2002: 20).

3.4.11 Guidelines for storage studies involving fat dehydration

Peroxide values or free acid tests should not be conducted with products which have less than 2.5% fat as the fat extraction process necessary to obtain enough fat is too rigorous and may end up producing artificially high results. For samples with 2.5-10% fat, PV or FFA should not be used. A fat acidity test which utilises a Soxlet type could be selected and extraction followed by the base titration. Samples with more than 10% fat FFA, may yield good results. For the Pv test to be effective on food products, the sample history needs to be known.

Next, select the package that you want to protect, the product in the distribution channels. Storage temperature conditions should then be chosen which fit the product and give reliable results in a reasonable amount of time. Common temperatures used would be 20, 30, 40, and 55°C. At least two temperatures are required with three or four preferred for more accurate predictions.

The frequency of the analytical testing is the next important decision. The higher the storage temperature, the more frequent should be the testing. Weekly tests are common for most products.

Lapuza, (2002:20) has developed the equation FZ =f1*Q10 4/10 for testing frequency where fl is the time between tests at higher temperatures f2 at the lower temperatures and 'delta' is the difference in degrees centigrade between the two. For a product with a Q10 of 2 tested each week, at 30° C the frequency at 20° would be F2 =1*210/10 ° F2 = 2 weeks. The results should be plotted as they are developed in order to ensure the experimental design is working properly and document all data.

3.5 RECIPE DEVELOPMENT

Schuster (2001: 67) developed criteria for recipe development. Schuster states that low- cost readily available ingredients and basic equipment and appliances be used and recipes be easy to read and be successfully tested by minimum of three people. Fat and sodium in recipes should be reduced, and recipe made to fit into a menu for a meal and should include formal selected ingredients (Schuster 2001: 67).

Miller, Burgress and Mason (2001: 67) in a cook book developed for emergency, feeding programmes, specified that, recipes must be nutritious, have a limited number of ingredients and should be flexible so that they can be used with fresh, frozen or canned food varieties. Recipes should be tested for clarity of instructions and taste acceptance and for ease of preparation Miller (2001:67). The American Association of Family and Consumer Science in addition to previously mentioned criteria, mentions that recipe standardization guidelines be followed, to ensure correct amounts of ingredients, pan sizes and consistency. (AAFCS 2001: 56).

Table 13: Check list for evaluation of recipes (AAFCS 2001)

Features of standardised Recipes	YES	NO
1.Name of recipe		
Name gives a sufficient description of the major ingredient		
B. Name is appealing		
2. List of ingredients are listed		
A. All ingredients are listed		
B. Ingredients are listed in order in which they are used C. Ingredients are listed as they are measured eg cup chopped onions		
D. Measurements are given in common fraction e.g ½ cup		
E. Ingredients are listed in the easiest units of measurement eg ¼ cup instead of 4 tablespoons		
F. All measurements are spelled out not abbreviated		
G. Weights given instead of measurements when helpful		
H. Sizes of cans or boxes are specified		
I. Brand names avoided		
J. Directions for combining ingredients- clear instructions and simple words are used		
K. Short sentences are used		
L. Simple words are used		

3.6 SENSORY EVALUATION

Sensory evaluation is the science of judging and evaluating the quality of a food by the use of the senses, i.e. taste, smell, sight, touch and hearing. Sensory testing has been developed into a precise, formal, structured methodology that is continually being updated to refine existing techniques. The developed methods serve economic interests and can establish the worth or acceptance of a commodity. Sensory tests offer a course to select the product that optimizes value for money. Sensory evaluation is used as a practical application in product development by aiding in product matching, improvements, and grading. Research is another area where sensory evaluation is frequently used. Evaluation of a product may be needed to determine the effects an experiment had on its subject. Finally, quality control and marketing is yet another application of sensory testing. Simply stated, sensory evaluation is divided into two methods, subjective and objective testing. Subjective tests involve panelists, while objective testing employs the use of lab instruments as well as specialized lab technicians with no involvement of the senses. Both tests are essential in sensory evaluation and necessary in a variety of conditions (Meilgaard Civille and Carr 2002: 5).

One such subjective test is the use of the Hedonic scale method. This rating scale method measures the level of the liking of foods, or any other product where an affective tone is necessary. This test relies on people's ability to communicate their feelings of like or dislike. Hedonic testing is popular because it may be used with untrained people as well as with experienced panel members. A minimum amount of verbal ability is necessary for reliable results. 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 scales accordingly. The advantage 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. A separate scale is provided for each sample in a test session. The scales may be grouped together on a page, or be on separate pages (ASTM 1999: 31.). 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 (O'Mahony 2001: 10).

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 an hedonic scale may be affected by many factors other than the quality of the test samples. Characteristics of the subjects, the test situation, and 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 (ATSM,1999: 30)) 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. According to Civille (2007:29) sensory evaluation has been defined as a scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch, taste, and hearing. The field of sensory evaluation has grown rapidly in the second half of the 20th century, along with the expansion of the processed-end food and consumer products industries. Nevertheless, most importantly consumers are buying sensory properties/performance and sensory consistency. Therefore, sensory evaluation should play an integral part in defining and controlling product quality. Every company committed to quality should support, develop and operate a QC/sensory programme (Amerine, Pangborn and Roesller 1965: 8).

Sensory Science has expanded significantly beyond the "product development phase" (Civille 2007:29). Taste problems are prevalent in pregnant women. Most pregnant women develop increased sensitivity and aversion to bitter taste and this can alter food taste, choices and consumption patterns Duffy, Bartoshuk, Striegel-Moore and Rodin (1998: 809). Taste sensitivity is directly related to the number of taste buds stimulated, implying that, taste disorders are accounted for by changes in the body, which happens to pregnant mothers. Women who are pregnant can therefore express different taste levels for same type of product under same conditions.

3.6.1 Smell

When interpreting smell the reference is odour, which is detected through the nose. Any food item which has an unpleasant smell will be refused immediately. The smell of items during preparation will also affect the individual when eating if the smell is offensive (Daniel 2002: 809 Thomas, 2002: 36).

3.6.2 Flavour and taste

Flavour is a sensory characteristic, which is often understood as taste. Flavour is a complex of sensations. There are four taste sensations involving the taste buds on the tongue; sweet, sour, bitter and salty. Flavour is a blend of aroma and taste. The flavours of some foods when raw are readily perceived as 'natural'. W hen cooked certain non-flavour substances are produced, e.g in cauliflower and cabbage. The tantalizing aroma arising during the baking of bread is an example of flavoured substances produced by heating. The flavour of food should be acceptable so that a product can be consumed, e.g. dried sugar beans are insipid if roasted. Examples of flavour include metallic or fruity, whereas taste may be sweet or sour.

Flavour can be divided into odour received through the nose, taste through the taste buds and oral feel. To be taste blind refers to being unreceptive to certain tastes, which are also affected by concentration. Taste – tired means that eating heavy foods results in the taste buds being unable to classify thoroughly. Some foods may have little or no flavour so an enhancer is added e.g. monosodium glutamate (MSG) (Daniel 2002:809; Thomas 2002:36).

3.6.3 Texture

The texture refers to the feel on the tongue e.g. creamy or smooth. The sensation involved in touch and feel is called the tactile sense. Texture can be explained as being lumpy, granular, sticky or smooth. It also refers to the brittleness and ease of chewing. Five primary characteristics of texture include harness, viscosity, elasticity and adhesiveness. Texture also implies the physical and chemical interaction in the mouth from the initial perception on the palate, the first bite, through mastication and finally swallowing (Daniel 2002:810, Thomas 2002:36).

3.6.4 Appearance

Appearance refers to colour, form and size and is referred to as the appeal to the eye. Texture and appearance refer to the visual perception and colour (Bennion 1999: 69).

3.6.5 Tasting panels

Research has established that, a tasting panel should comprise of 5 to 15 experienced individuals, who check for sensory evaluation, and quality (Carpenter, Lyon & Hasdell 2000:18) Training of judging panels is time consuming and costly but they provide more information and accuracy. Sensory panels use sight, taste, smell, texture and hearing to access foods. The purpose of sensory panels is to indicate preference of products and the potential acceptability of and differentiation between products (Thomas 2002:36).

The requirement of an assessor will be determined ultimately by the type of evaluation completed. The basic requirement for a person taking part in sensory evaluation include availability and willingness to participate, good health, the ability to perform, which implies good knowledge of tasting and understanding of the purpose of the exercise, and they should not chew gum, eat , drink or smoke at least 30 minutes before a sampling session. This ensures a lesser degree of bias (Carpenter *et al*, 2000:18 Thomas 2002:36).

The method of testing is also affected by the qualification of members and the aim of the experimenter. It is important to remember that tasting panels need to be trained in sensory evaluation procedures and that they need to have a sound understanding of the product. Ideally, 80 or more panellists should participate when no form of training is provided and/or none has been received through tertiary studies Thomas (2002:36). Carpenter *et al* (2000:18) suggest a minimum of 70 unqualified assessors. It is advisable to use a comparison of similar samples on the market. If ingredients are substituted, then it is suggested to have the original to compare with the new product (Carpenter *et al* 2000:18, Thomas 2002: 35).

Consumer testing is also relevant, though the experimenter should ensure that preliminary training has been done. Sensory evaluation can be completed by using a hedonic face scale where the images represent the emotions and are related to scores where the highest score registers a liking while the lowest indicates a dislike.

Sensory evaluation should be conducted under condition with no interruption and distraction. The environment should be quiet and comfortable and individual booths should be used to avoid any form of contact or discussion. Uniform lighting is advised and the session should be held away from the preparation area. All samples should be entirely uniform (size, temperature and type of container. (Daniel 2002:811).

It is important that a company budgets for product testing. Companies that invest in continuous product testing, have higher market retention and sales. Product testing will be successful if recipes are standardized and the information obtained is correctly interpreted, when tested within the targeted environment and when there is proper execution of the evaluation process (Thomas 2002:36).

A tried and tested method for sensory analysis includes rating of appearance, odour, texture, taste and flavour. Such ratings indicate acceptability on a scale from excellent to inedible. The true test of food is mass produced food that has been tested and accepted by a sensory panel. The product can be nutritional but not meet the economic criteria of the intended group. If the texture, smell and flavour are good then the product may yet be a success (Daniel, 20002 810, Thomas 2002: 36). Data are collected and analysed directly or with modification. Modification or transformation refers to the combination of categories or groupings of non-numeric data. All data modification and the reasons when appropriate should be reported. Missing data may require special mention in a report. Results are presented within the body of the report and may be summarised in the form of graphs, diagrams, tables or descriptive statistics. Computer programs are available to assist with the capture of sensory data and statistical analyses (Carpenter *et al* 2000:18).

3.7 CONCLUSION

In this chapter, certain aspects of product development were discussed. Chemical analysis of food in general was discussed. Under shelf life determination of food, the importance of moisture and water activity during shelf life determination, equilibrium moisture condition and fat oxidation and hydrolysis were also discussed. Characteristics of standard recipe are provided. The chapter ends with a definition and discussion of sensory evaluation. The two methods of sensory evaluation, subjective and objective testing are explained (Amerine *et al* 1965:8). This chapter provided the theoretical bases for the methods used to develop the food multi-mix for pregnant women in this study.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

In this chapter, the methods used in the study are discussed. The approach employed was to develop a novel food multi-mix (FMM) supplement that was nutrient-dense, financially affordable, and culturally acceptable to pregnant women of the Vaal Region in order to improve their nutritional status. The conceptual framework of this study is depicted in Figure 1 (one).

4.2 STUDY OBJECTIVES

4.2.1 Main objective

The major objective of this project was to develop a food multi-mix supplement that is cost effective, culturally acceptable and nutrient-dense for consumption by pregnant women in the Vaal Region.

4.2.2 Specific objectives of the project

The specific objectives of this project included:

- Formulation and chemical analyses of a food multi-mix supplement (FMM) that was to satisfy the nutrient needs of pregnant women in the Vaal region.
- Determination of the shelf life of the FMM supplement
- Development of two recipes (soup and gravy) incorporating the developed FMM supplement and development of 'recipe leaflets'
- Sensory evaluation to test for consumer acceptability.

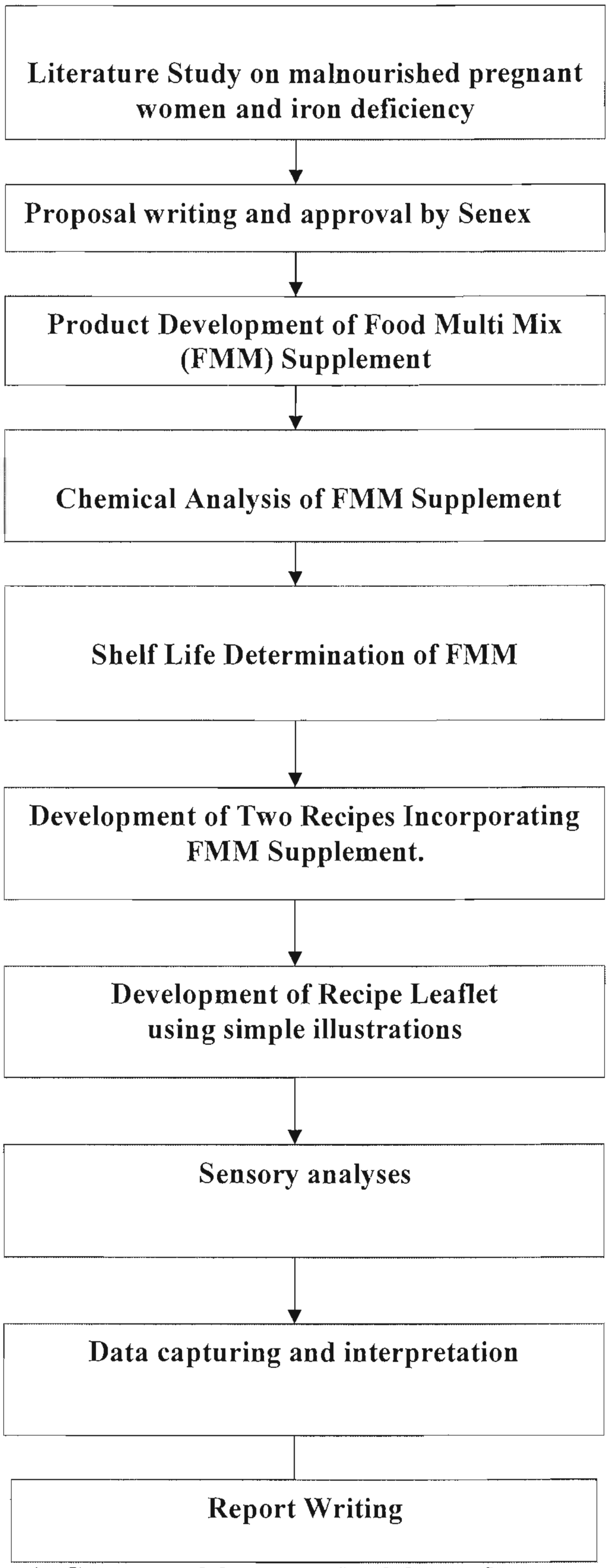

Figure 1: Conceptual framework of the study

4.3 METHODOLOGY

4.3.1 Development of a food multi-mix

The framework in figure 4.2 was used for the development of the multi-mix and each step is described separately.

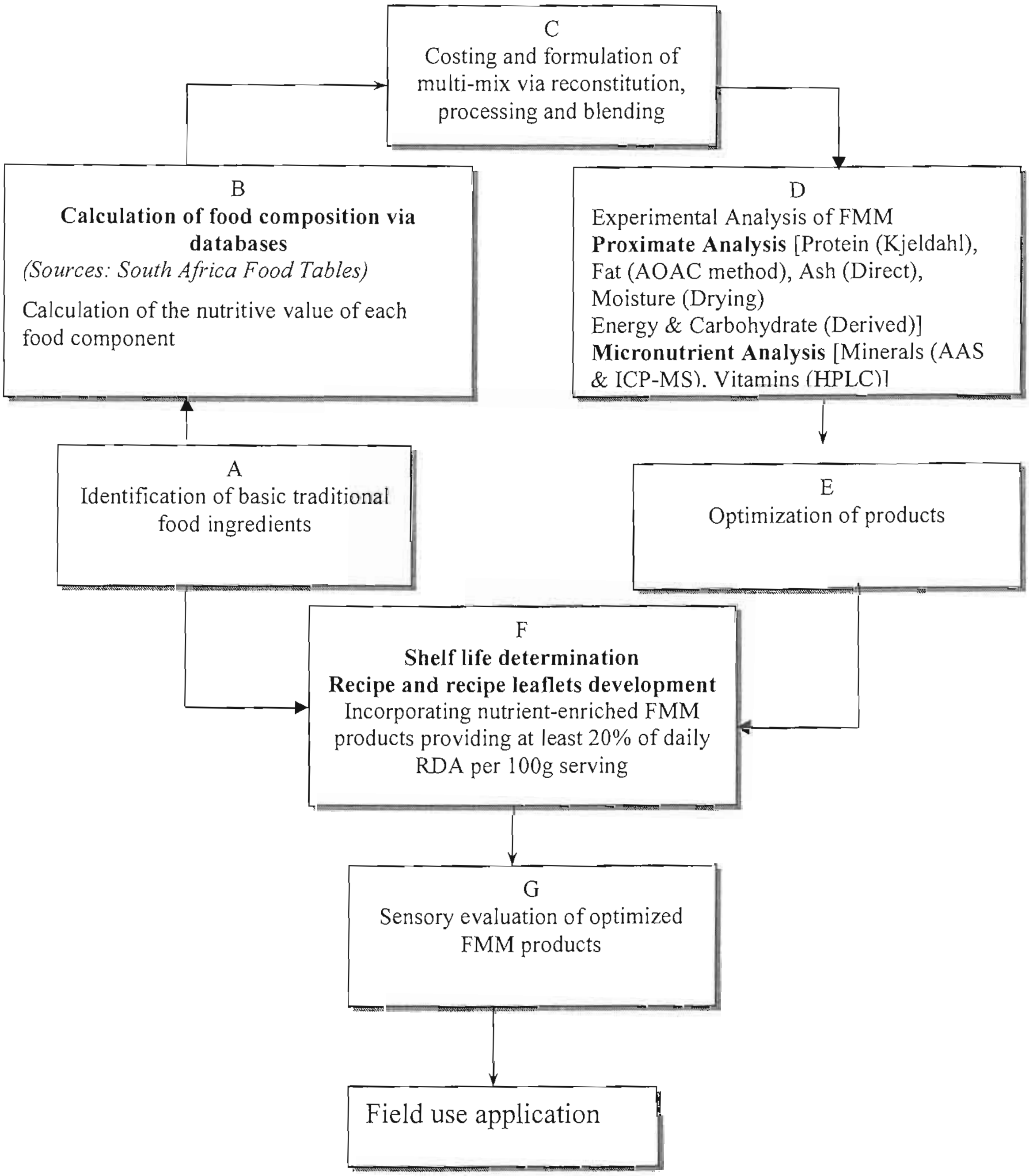

Figure 2: Stages and processes involved in the development of FMM supplements (adapted from Amuna *et al* 2004)

Step 1

4.3.1.1 Identification of basic traditional foods

Basic traditional foods (ingredients that are known and are used by the study community) that are cost effective, nutrient-dense and culturally acceptable were used. Some of the food items were selected from a list of the 20 food stuffs most consumed by pregnant women in the Vaal region which was compiled by Kesa in the year 2001 (see Appendix. C.). During the selection, food items with carbohydrates, protein, vitamins, minerals and fat sources were considered The food items chosen for each multi-mix did not exceed five. This was to avoid overloading of certain nutrients in a particular multi-mix. Twenty food multi-mixes were formulated.

Table 14: Commodities and rationale for inclusion (Amuna, Zotor& Tewfik 2004:129)

Food group/Commodities	Rational for inclusion
Cereal, grains, tubers, roots, Legumes	Major staples and primary carbohydrates sources (including fibre)
Energy- dense and protein-rich foods :e.g. cow peas , soybeans, melon seeds , black-eyed beans ,dried fish	Foods that are locally available and providing reasonable amounts of key macro and micronutrients as well as being complementary to other foods that are nutrient limited
Vegetables , fruits , pulses ,and Nuts	Seasonality, locally accessible and affordable
Vegetable oils ,daily products animal products	Accessibility and affordability
Wide ranging varieties of food choice	Socio –cultural and religious factors that govern food choice
Appropriateness of product	Appearance ,texture ,taste ,digestibility

Step 2

4.3.1.2 Formulation and theoretical calculation of nutrient composition

The nutrient composition of each ingredient and formulated multi mix was calculated using the Dietary Manager® software program which is based on South Africa food composition tables (Langenhoven *et al.* 1991).

Step 3

4.3.1.3 Criteria for food multi-mix formulation

The criteria were to develop a nutrient-dense food multi-mix supplement that was nutrient dense to meet 20% of RDA for protein, energy, iron and folate for pregnant women as these nutrients were found to be lacking in the diets of pregnant women aged between 31-50 years old in the Vaal Region (Kesa 2001). The money that pregnant women were prepared to spend on food, snacks or supplements was R1.75 per day (Kesa 2001) and this amount was thus used as the cost criterion set for the formulation of the FMM supplement. Step 3 further consisted of the preparation of the multi-mix through the drying process and blending into powder form. Cultural acceptability was ensured by choosing ingredients from the Top 20 food items such as maize meal and milk powder mostly consumed by pregnant women (Kesa 2001) as well as sensory analyses, while safety for human consumption was based on microbiological testing. Using the Dietary Manager® twenty FMM supplements were formulated, two were chosen and named FMM C1 and C3 respectively. FMM C1 AND C3 were chosen because they were theoretically found to contain higher quantities of the nutrients carbohydrate, folate, and protein.

Step 4

4.3.1.4 Weighing, drying and grinding of ingredients

Ingredients selected for the various food multi-mixes were accurately weighed before and after drying and differences in pre-mass and after mass weight noted. To test for dryness, ingredients were crushed in the palm, and if dried, crumbled easily. Dried food items were blended into powder form. They were then proportionately mixed together to form the

FMM supplement taking into consideration the estimated ratio proportion of each food item to a 100g of multi-mix supplement. Identified fresh food items were pre weighed and dried in a pre – heated rational oven at accepted temperatures between 95-110°C and the time set depending on the type and quantity of food being dried at one time. Checking for dryness of ingredients was done at 30 minute intervals. To prevent contamination hygienic procedures were followed, such as wearing clean overalls, aprons and hats which prevented hair from falling into food, and well cleaned work-tops utensils and gadgets. The small- scale laboratory of the department of hospitality was the venue used.

Oven, drying racks and storage containers were the basic equipment used. A spatula was used to turn food items intermittently for even drying. Oven drying was used because it was found to be the simplest method and did not require much special equipment was needed.

Step 5

4.3.1.5 Calculation of the index of nutritional quality

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 kJ in a food, meal or diet to be compared with a nutrient standard. INQ is also defined by Bender, (2005). As the ratio between the percentage of the reference intake of each nutrient and the percentage of average requirement for energy provided by the food. Using the formula (Amount of nutrient in 1000 kJ of food divided by the recommended daily allowance of nutrient in 100g of food), the index of nutritional qualities of iron and folate food multi-mix C1 and C3 were calculated.

Step 6

4.3.1.6 Chemical analyses of food multi-mix

FMM supplements C1 AND C3 were then taken to ARC laboratory where results were established for protein, fat, moisture, ash, energy and carbohydrate content of the FMM.

Micronutrients, minerals, and vitamins contents of the FMM were also established by Agriculture Research Centre (ARC).

Experimental chemical analysis of formulated FMM was in the process of being done to establish the nutritional content of the various food items when the AAS machine at the VUT chemical laboratory in use broke down in the process and effective results could not be obtained. FMM supplements were then taken to the ARC where results were established for protein, fat, moisture, ash, energy and carbohydrate content of the FMM. Micronutrients, minerals, and vitamins contents of the FMM were established by the Agricultural Research Centre (ARC) laboratory.

ARC, an accredited laboratory in South Africa used standardised procedures to determine the nutritional content of the formulated FMM. Proximate and micronutrient analysis were made. Minerals were analysed using a state of the art inductively coupled plasma spectrometer (ICP). Vitamins were analysed employing high performance liquid chromatography (HPLC).

Table 15: Methods used to analyse various nutrients

NUTRIENT	METHOD OF ANALYSIS USED
Protein	Kjeldahl analysis
Fat	Hydrolysis
Moisture	Weight 1 – Weight 2
Energy	(Protein (g) /16.8kJ) + (carbohydrate(g) /16.8 kJ +(/37.8 kJ)
Ash	Direct method ash analysis see chapter 3.3.11
Carbohydrate	100%
Minerals	Inductively coupled spectrophotometry
Vitamins	High performance liquid chromatography (HPLC)

Step 7

4.3.1.7 Optimisation

Optimisation of FMM recipes involved re-tuning the composition to further enrich it bearing in mind clinical and/or daily nutrient requirements. Products developed were tested to confirm nutrient composition. The actual and theoretical values had to be compared and ingredients, adjusted to meet the formulation criteria.

Step 8

4.3.1.8 Shelf life testing

The food multi-mix were kept at room temperature (±25°) and analysed on day 0 (12^{th} September 2005, arrival day), day 3 (15^{th} September 2005) day 7 (19 September 2005), day 14 (26 September 2005), day 21 (3^{rd} October 2005) and day 28 (10^{th} October 2005). An aliquot of 10g of sample was removed aseptically from the tube of FMM each time it was analysed. The samples were homogenized in Stomacher 400 (DHK Pty Ltd) with 90ml of diluents (Buffered peptone water).The samples were analysed for Total aerobic plate count on Tryptone soy agar and incubated at 25° 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. Because no instructions were included with the sample, *E.coli* and Coliform analysis were 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 analysed on Rose Bengal agar with Chloramphenicol and incubated at 25°C for 5 days.

Step 9

4.3.1.9 Development of two recipes

The two recipes developed were soup and gravy. Soup and gravy were chosen because they are easy to prepare and are common accompaniments to staples like maize meal, rice and potato. The FMM incorporated in the developed recipes included maize meal and milk which can be found on the list of top twenty food items, commonly consumed by pregnant

women of the Vaal region (Kesa 2001).Other food items on the list include, Mahewu/ Mageu (non-alcoholic fermented maize drink), cold drink squash, apple raw with skin, chicken and beef to mention a few. The NFCS report centred on child eating habits but the report makes clear the fact that fortified maize meal (major component of the FMM and was used in the recipes is inexpensive and has beneficial results). The property of soups and gravies to moisten food is ideal and was considered. Ingredients were added procedures in order not to alter the macro and micro nutrient values of the product (FMM) supplement.
FMM C1 and C3 were incorporated respectively. Basic soup and gravy recipes were adapted to include FMM supplement. Some ingredients removed included, flour and flavourings. The FMM supplement had its own thickening power and the ingredients used had their own natural flavours. The multi-mix was formulated to supplement the diet not to replace any meals. Simple and colourful illustrations in the form of tools like ladles, spoons, water flowing through a tap, and ingredients like onions and tomatoes made recipes reading interesting and easy for subjects to understand.

Step 10

4.3.1.10 Development of recipe leaflet

Simple illustrations in the form of ladles, spoons, water flowing through a tap etc were used in compiling recipe leaflets to make reading and cooking easy for subjects.

Step 11

4.3.1.11 Costing of recipes

Costs of the various recipes (soup and gravy with FMM supplements C1and C3) were calculated with prevailing prices of ingredients used.

Step 12

4.3.1.12 Sensory evaluation of developed recipes

A sensory evaluation for the developed recipes (soup and gravy) was performed to test the acceptability of the products by the target group. Two clinics namely, the Johan Heyns and Sharpeville clinics both in the Vaal region were used. A total of 25 pregnant women (14 in

Johan Heyns clinic and 11 in Sharpeville clinic) participated. Developed (Hedonic scale) facial expression questionnaires (see Annexure E) were developed and used to collect data for analysis to arrive at acceptability level of the products. A pre- acceptability tasting was conducted with 10 ante natal nursing sisters from clinics in the Vaal region and all products tasted were approved for taste, flavour, colour and appearance. Both food multi-mixes C1 and C3 were used separately to prepare the soup and gravy separately and were tested for consumer acceptability. The process of sensory evaluation with the subjects began at the Johan Heyns clinic. Nursing sisters in charge welcomed and introduced the researcher to the pregnant women who had assembled for a routine pre -natal check- up. The pregnant women had already been informed of the sensory analysis procedures. Subjects were confined in one room after their usual pre- natal checks. Meanwhile, products to be evaluated were displayed on a table in another room selected for the purpose. Pregnant women were called in one after the other, to taste the foods displayed. This was to prevent the subjects from influencing each other's true opinions about the foods. The pregnant women were helped by researcher to express their opinions about each particular food tasted on a developed hedonic questionnaire (Annexure E) which were later analysed to detect the acceptability of the various foods by the pregnant women.

4.4 CONCLUSION

In summary this chapter described the steps followed to achieve the goal of the study. First a food multi-mix supplement was developed according to formulated criteria to address the state of maternal malnutrition in the Vaal region. South African food tables were used to calculate the nutritional values of food chosen. Food items selected were dried and ground into powder form. This was done under hygienic conditions to avoid contamination. Chemical analyses and the shelf life of the product were successfully determined by the ARC laboratory in South Africa as a result of the equipment at VUT laboratory breaking down during analyses and product had to be taken to ARC. Two recipes (soup and gravy) were developed using the basic soup and gravy methods and incorporating the developed food multi-mix supplement.

Sensory evaluation was conducted in two clinics (Johan Heyns and Sharpeville) to test the acceptability of the different products. The results of all these stages in the development of the food multi-mix will be described in chapter five.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 INTRODUCTION

This chapter presents the results of the study which will be described for each step of the procedure followed as depicted in figure 4.2.

5.2 CRITERIA FOR MULTI-MIX FORMATION

The main aim of this project was to develop a FMM supplement, meeting the following criteria, for pregnant women in the Vaal region:

* Affordability in that a daily portion should not cost more than R 1.75 because this was found to be the amount of money that pregnant women were prepared to spend daily on food, snacks and supplements per day (Kesa 2001).

* Nutritive value meeting 20% of the RDA for iron, folate, and protein. An interpretation of the iron status of selected pregnant women showed that 50% were anaemic (Kesa 2001). Results of nutrient intake by sampled pregnant women also by Kesa showed 72.8ug which represents 0.3% RDA of folate, 3.8mg of iron which represents 12.6% RDA of Iron and 23g of protein which is 38% RDA.

* Cultural acceptability choosing ingredients familiar to the pregnant women in the area from among the 20 top food items most often consumed by pregnant women of the Vaal region Kesa, (2001) and through sensory testing.

* Safe for human consumption as proved by microbiological testing.

Step 1

5.3 IDENTIFICATION OF BASIC TRADITIONAL FOODS

In step one basic traditional food items (ingredients that are known and are used by the community) that are cost effective, nutrient dense and culturally acceptable were identified and used for the food multi-mix. Some of the food items were selected from the list of 20 top most commonly consumed food items by pregnant women in Vaal region which was compiled by Kesa in the year 2001. During the selection, food items with carbohydrates, protein, vitamins, minerals and fat sources were considered. Food items chosen for FMM supplement C1 included maize meal, (one of the most commonly consumed food items by pregnant women of South Africa (Kesa 2001) which had 0.7mg iron, 8.9g protein and 16μg folate, kidney beans which had 5.9mg iron, 3.20g protein and 370μg folate, peanuts which had 1.8mg iron, 5.17g protein and 126ug folate, pea powder which also had 2.7mg iron, 3.3g protein and 49μg folate. Milk had almost no iron, 33.6g protein and 350μg folate. Food items chosen for FMM supplement C3 included Sorghum, which had 4.5mg of iron, 9.5g protein and no folate, maize meal which had 0.7mg iron, 8.9g protein, and 16μg folate peanuts which had 1.8mg iron, 26.4g protein and 126μ folate and dried onion which had 0.2mg of iron, 1.2g of protein, and 19μ of folate (Institute of Medicine, 2003).

Step 2

5.3.1 Formulation and theoretical calculation of nutrient composition data

In table 17, the nutritional content (iron, carbohydrate, folate and protein) of 20 formulated FMM supplements and their RDA are displayed. FMM C1 and C3 were chosen because they were theoretically found to contain reasonably higher quantities of nutrients (carbohydrate, folate and protein) compared with the others. These meet the nutrient formulation criterion of the FMM. FMM C1 however recorded a low 6.2mg/100g for iron. After costing FMM C1 recorded a low R0.82 and since the food items used are nutrient-dense it therefore meets the nutrient formulation criterion of the FMM. FMM C3 costed an affordable R0.65 and therefore meets the criteria set.

Table16: Multi-mixes formulated and their nutrient content

Multi-mix Codes	Iron RDA 6mg	Carbohydrate RDA 175 g/day	Folate 80 µg per day	Protein RDA 12g/day
C1	**6.2mg**	**60.16g/100g**	**76.5ug/100g**	**19.6g/100**
2	2.4mg/100g	48.05g/100g	8.62ug/100g	10.35g/100g
C3	**15.8mg**	**66.28/100g**	**54.1ug/100g**	**13.78g/100g**
4	2.0mg/100g	54.08g/100g	24.40ug/100g	7.86g/100g
5	7.8mg/100g	46.4g/100g	18.4ug/100g	4.63g/100g
6	3.11mg/100g	29.3g/100g	16.39ug/100g	10.04g/100g
7	2.63mg/100g	27.6/100g	22.2ug/100g	9.03g/100g
8	1.64mg/100g	29. 99g/100g	23.50ug/100g	8.23g/100g
9	3.60mg/100g	21.46g/100g	12.52ug/100g	9.58g/100g
10	1.84mg/100g	40.71g/100g	13.93ug/100g	8.2g/100g
11	4.60mg/100g	27.39g/100g	13.8ug/100g	9.97g/100g
12	6.09mg/100g	47.42g/100g	13.75ug/100g	11.05g/100g
13	1.90mg/100g	25.66g/100g	22.05ug/100g	12.6g/100g
14	3.40mg/100g	23.55g/100g	21.1ug/100g	9.85g/100g
15	2.30mg/100g	29.51g/100g	13.06ug/100g	6.73g/100g
16	5.90mg/100g	54.9g/100g	14.40ug/100g	10.15g/100g
17	7.16mg/100g	20.3g/100g	10.02ug/100g	10.10g/100g
18	0.2mg/100g	10.9g/100g	10.8ug/100g	5.4g/100g
19	2.4mg/100g	33.8g/100g	21.05ug/100g	5.92g/100g
20	5.2mg/100g	17.7g/100g	17.53ug/100	4.45g/100g

Table 17: Multi-mix C1

Ingredients	Quantity Used
Maize meal	30g
Peanut powder	25g
Kidney beans, dried	15g
Pea powder	20g
Dry milk (Non fat)	10g
TOTAL	100g

Table 18: Multi-mix C3

Ingredients	Quantity used
Sorghum	26g
Maize meal	37g
Peanut powder	29g
Onion	8g
Total	100g

In step two the nutritive values were calculated for each food component using the Dietary Manager® data base. South African food tables were also used. Tables 19 and 20 provide lists of ingredients, quantities used and the nutritional value of each food item used in both multi-mixes.

Table number 19: Formulation and theoretical nutrient composition of food items used in the formulation of nutrient-enriched multi-mix C1

Food description	WHT gms	Ener kj	Prot g	CHO g	Fat g	Prot %	CHO %	Fat %	Fib g	Ca (mg)	Fe IRON (mg)	Vit .C (MG)	Fol (ug)	VIT B12 (ug)	VIT A (ug)
RDA	*	10.500	30	175	20	30	45	35	28	1200	30	70	400	2.2	800
Maize meal	30	453	2.79	21.6	1.1	2.8	21.5	2.6	0.6	5.1	0.75	0.9	7.6	0	*
Peanut dry	25	605	5.7	5	11.	5.72	5.0	25.2	0.7	12..2	0.95	0.25	27.5	0	0
Pea dry	15	204	3.3	8	0.1	3.3	8.4	0.4	0.9	13.5	2.7	0	4.95	0	2.25
Kidney beans, dry	20	277	4.4	11.4	0.3	4.4	11.3	0.7	0.9	38	1.64	0.2	36	0	660
Milk powder	10	149	3.5	5.21	0.0	3.5	5.2	0.2	0.03	14.1	0.17	0.4	0.4	0	*
TOTAL	100	1688	19.6	51.21	12.	19.7	51.4	29	3.1	82.9	6.2	1.7	76.5	0.0	662

In Table 19 the nutritional levels of food items used in formulating FMM supplement C1 and their various nutrient contents are displayed. The percentage ratio of each commodity used is also shown as 30g of maize meal, 25g of dry peanut, 15g of pea powder, 20g of kidney beans and 10g dry non-fat milk powder.

Step 3

5.3.2 Cost of FMM C1 and C3

Step three involved costing of food multi-mix supplements, purchasing of food items involved and the preparation of the multi-mix through the drying process and blending into powder. Table 21 depicts the cost of FMM CI. This is considerably lower than the R 1.75 criterion, and since the food items used are nutrient dense and therefore meet the nutrient formulation criterion of the FMM.

Table 20: Formulation and Theoretical nutrient composition of food items used in the formulation of nutrient – enriched multi-mix C2

Food description	W HT Gm s	Ener kcal	Prot g	CHO g	Fat g	Prot %	CH O %	Fat %	Fib g	Ca (mg)	IRON (mg)	Vit .C (MG)	Fol (ug)	VIT B12 (ug)	VIT A (ug)
RDA	*	10.500	30	175	20	30	45	35	28	1200	30	70	400	2.2	800
Sorghum	26	422.1	2.6	20.1	1.1	2.4	18.7	2.2	0.6	3.16	14 .0	0.9	*	0	*
Maize meal	37	562.4	2.8	28.4	1	2.7	26.4	2.0	0.5	8	0.6	0.25	22.8	0	0
Peanut dry	29	703	6.7	5.8	13.1	6..2	5.4	27.2	0.8	8.19	1.1	0.2	18.4	0	0
Onion powder	8	1016.4	0.8	6.4	0.0	0.8	6	0	0.5	1.06	0.02	0.4	13.2	0	*
TOTAL	100	2703	13	60.7	15.1	12.1	56.5	31.5	2.4	20.4	15.8	1.75	54.1	0.0	0

In Table 20, the nutritional content of each food item used sorghum, cornmeal, peanut and onion powder for the formulation of multi-mix C3 is shown. The ratio percentage for each commodity is shown as 26g of sorghum 37g maize meal, 29g peanut dry and 8g onion powder.

Table 21: Cost of food multi-mix C1

Item	Quantity used in FMM	Cost per kg	Cost of quantity used
Maize meal	30g	R6.99	R0.20
Peanut Powder	25g	R6.99	R0.17
Pea powder	15g	R4.99	R0.07
Kidney beans	20g	R6.99	R0 .13
Milk Powder	10g	R24.99	R0.25
Total			**R0.82**

Table 22: Cost of food multi-mix C3

Item	Quantity used in FMMM	Cost per kg	Cost of quantity used
Sorghum	26g	R5.99	R0.16
Maize meal	37g	RR6.99	R0.26
Peanut dry	29g	R6.99	R0.20
Onion powder	8g	R4.25	R0.03
Total			**R0.65**

This FMM meets the cost criterion as it is very affordable at R 0.65 per portion.

Step 4

5.3.3 Weighing, drying and grinding of ingredients

In Table 23 selected food items, temperatures used to roast them, their mass before and after drying and time taken to dry them, are displayed. Milk powder was used as purchased and therefore had no cooking temperature, or cooking time. It was not cooked so it's mass remained the same.

Table 23: Temperatures used to roast food items in an oven

Food Item	Temperature	Pre-weight	After weight	Cooking Time
Maize meal	99degrees C	1.5kg	1.35kg	50minutes
Peanut dry	99degrees C	1.2kg	1.1kg	50minutes
Pea	100degrees C	1.5kg	1.35kg	60minutes
Kidney beans	110degrees C	1.5kg	1.4kg	60minutes
Milk powder	*	*	*	*

Step 5

5.3.4 Results of the index of nutritional quality (INQ)

INQ for Food multi-mix C1 Iron, Folate and Calcium

INQ for Iron in FMM C1

Amount of iron in FMM C1= 4200kJ * 6.2 /100g

RDA for iron in pregnant women= 27mg / day

Therefore 6.2 mg/100g/ 27mg/ day = 0.23

INQ for iron in FMM C1 is 0.23

INQ for Folate in Food multi-mix C1

Amount of folate in FMM C1= 76.5 μ/100g

RDA for folate in pregnant women = 600 μ/day

Therefore 76.5μ/100g / 600μ/day= 0.13

INQ for folate in FMM C1 is 0.13

INQ for FMM C3 Iron, Folate and Calcium

INQ for Iron in food multi-mix C3

Amount of iron in FMM C3 = 15.8mg/100g

RDA for iron in pregnant women =27mg / day

Therefore 15.8mg/100g/27mg/day=0.59

INQ for Folate in food multi-mix C3

Amount of folate in FMM C3 = 54.1μ/100g

RDA for folate in pregnant women = 600 μ/day

Therefore 54.1mg/100g/600μ=0.09

Step 6

5.3.5 Results of the chemical analyses of food multi-mix

In step, six FMM supplements were sent to the ARC laboratory where results were established for protein, fat, moisture, ash, energy and carbohydrate content of the FMM. Micronutrients, minerals, and vitamins contents of the FMM were also established by the ARC laboratory. Results of the laboratory analysis of multi-mix C1and C3 per 100g are as shown in Table 24 below.

Table 24: ARC results of laboratory analysis of multi-mix supplement C1 and C3 per 100g

Analysis	Accreditation Number	Unit	Sample (1) C1	Sample (2) C3
Ash	ASM 048	%	2.65	1.51
Dry matter	ASM 013	%	96.18	96.49
Moisture	ASM	%	.82	3.51
Fat (ether extraction)	ASM 044	%	12.38	14.92
Protein		%	20.99	13.78
Vitamin A		mg/100g	0.09	0.02
Vitamin B1	ASM 025	mg/100g	0.06	0.05
VitaminB2	ASM 025	mg/100g	0.16	0.02
Vitamin C	ASM 057	mg/100g	0.19	0.38
Calcium		mg/100g	204	72
Magnesium		mg/100g	133	120
Copper		mg/100g	0.26	0.18
Iron		mg/100g	4.20	5.75
Zinc		mg/100g	3.80	1.94
Carbohydrat (calculated)		g/100g	60.16	66.28
Energy Folic acid		kj/100g μ/100g	1838 40	1913 26

Table 25: Comparison between ARC experimental results and theoretical results for the critical nutrients in food multi-mix C1

Nutrient	Unit per 100g	RDA for pregnant women	Theoretical results	RDA% of Theoretical Results	Experimental Results	RDA% of experimental results
Protein	G	60	19.6g	32	20.99	35 %
Energy	kJ	10,500	1688kJ	16	1838	18 %
Carbo hydrate	g	175	51.21g	29.2	60.16	34. %
Iron	mg	30	6.2	20.6	4.2	14%
Folate	μg	400	76.5	19.1	40	10 %
Calcium	mg	1200	82.9	6.9	204	17 %

RDA, stands for, recommended daily allowance (IoM, 2003).

The experimental results showed that the protein, energy, carbohydrates and calcium values were actually higher than those calculated theoretically, but the critical nutrients, namely iron and folate, were considerably lower.

Table 26: Comparison between ARC experimental results and theoretical results of food multi-mix C3

Nutrient	Unit per 100g	RDA for pregnant women	Theoretical results	RDA% of Theoretical results	Experimental results	RDA% of experimental Results
Protein	G	60	13	21.6	13.8	23%
Energy	kj/	10.500	2703	25	1913	18.2%
Carbohydrate	g/	175	60.7	34.7	66.28	37.8%
Iron	Mg	30	15.8	52.6	5.7	19%
Folate	μ/	400	54.1	13.5	26	6.5%
Calcium	Mg	1200	20.4	1.7	72	6%

RDA, stands for, recommended daily allowance. Institute of medicine,2003. Washington DC

The experimental results showed that the carbohydrates, protein and calcium values were actually higher than those calculated theoretically, but the critical nutrients, namely iron and folate, were considerably lower.

Step 7

5.3.6 Optimisation

During this step, the C1 formula was adjusted theoretically in order to increase the folate and iron content as the chemical analyses resulted in much lower values.

Table 27: Optimisation for food multi-mix C1 in terms of macronutrients

Food Description	Wht.	Ener.	Prot.	CHO	Fat	Prot.	CHO	Fat
	(g)	KJ	G	g	g	%	%	g%
RDA		10500	60	175	15	20	45	35
Cornmeal 96% extract	25	107.82	2.32	18.5	0.94	2.78	21.5	2.6
Groundnut –dry	25	144.25	5.8	5	11.25	5.72	5	25.2
Pea, dried	20	48.285	4.4	11.2	0.22	3.29	8.4	0.4
Kidney beans	20	65.9	4.4	11.4	0.3	4.38	11.3	0.7
Milk, dry, full cream	10	35.528	3.51	5.21	1.9	3.49	5.2	0.2
Total	100	401.78	20.43	51.31	14.61	19.66	51.4	29

Table 28: Optimisation for food multi-mix C1 in terms of micronutrients

Fibre	Ca	IRON	B1	B2	B3	K	Mg	Vit. C	Fol	Vit B12	Vit A
G	(mg)	(mg)	(mg)	(mg)	(mg)	(mg)	(mg)	(mg)	(µg)	(mg)	(mg)
28	1200	30	1.5	1.6	17	2000	320	70	400	2.2	800
0.57	4.25	0.63	0.09	0.02	0.54	75	*	0.9	6.35	0	*

Table 28 continued

Fibre	Ca	IRON	B1	B2	B3	K	Mg	Vit. C	Fol	Vit B12	Vit A
0.725	30	0.95	0.2	0.04	3.875	170	52.5	0.25	39	0	0
0.855	18	3.6	0.13	0.03	0.45	148.5	5.1	0	6.6	0	2.25
0.88	9.8	1.64	0.07	0.03	0.48	250	30	0.2	36	0	660
0.031	0.0413	0.174	0.09	54.9	170.5	*	*	0.399	0.4	*	*
3.1	62.0913	6.994	0.6	55	175.8	643.5	87.6	1.7	88.35	0	662

This step resulted in theoretically adjusting the iron and folate content to 6.99 mg (26% of RDA) and 88.35 μg (15% of RDA) pregnant women respectively.

Table 29: Optimisation for FMM C3

MULC3	Wht.	Ener.	Prot.	CHO	Fat	Prot.	CHO	Fat	Fibre
	(g)	Kcal	g	g	g	%	%	g%	G
RDA		2500	60	175	20	60	45	35	28
Sorghum	40	142.88	4	29.2	1.12	2.37	15.89	2.09	0.21
Maize meal	15	53.89	1.39	10.8	0.57	2.74	26.9	2.1	0.3
Peanuts-dry	35	123.2	8.05	7	15.75	5.87	4.5	25.6	1
Onion Powder	10	36.8	1	8.02	0.05	0.85	7	0.08	0.57
Total	100	356.77	14.44	55.02	17.49	11.83	54.29	29.87	2.08

Ca	IRON	B1	B2	B3	Mg	Vit. C	Fol	Vit B12	Vit A
(mg)	(mg)	(mg)	(mg)	(mg)	(mg)	(mg)	(μg)	(mg)	(mg)
1200	30	1.5	1.6	17	320	70	400	2.2	800
9.6	4	0.177	0.04	0.6	0	0	5.6	0	*
2.55	0.4	0.068	0.02	0.53	0	0	3.8	0.34	10.6
17.5	1.3	0.23	3.5	3.43	6.3	0.25	38.5	0	0
36.3	0.3	0.33	0.2	0.29	6.4	7.05	16.6	0	0
65.95	6	0.805	3.76	4.85	12.7	7.3	64.5	0.34	10.6

This step resulted in theoretically adjusting the protein, calcium, and vitamins A & C nutrients to 14.44g, 65.9mg, 10.6 mg and 7.3 mg respectively.

Step 8

5.3.7 Shelf life testing of food multi-mix

The FMM (C1 AND C3) were delivered to the ARC- Micro section on Monday the 12th of September 2005 for their shelf lives to be determined. The powders were individually packed safely in tightly covered tubes. The FMM powders were kept at room temperature (±25°) and analysed on day 0 (12th September 2005, arrival day), day 3 (15th September 2005) day 7(19th September 2005), day 14 (26 September 2005), 21 (3rd October 2005) and day 28 (10th October 2005.6.1 Micro-biology tests for shelf life

Table 30: Shelf life results of multi-mix C1 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	360	–	–	40
Day 3	130	<10	<10	10
Day 7	100	<10	<10	50
Day 14	21000	<10	<10	30
Day 21	<1000	<10	<10	75
Day 28	<1000	<10	25	625

Cfu/g = Colony forming units per gram of sample

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

Table 31: Shelf life results of multi-mix C3 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	1770	_	_	280
Day 3	25000	<10	120	<10
Day 7	13175	<10	160	45
Day 14	5500	<10	410	425
Day 21	12250	<10	2405	1100
Day 28	13250	<10	7350	60

Cfu/g = Colony forming units per gram of sample

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

5.3.7.1 Detecting coli-form and *e-coli* count

Very low, but acceptable levels of *E.coli* (Table 30 and 31) were detected for both the multi-mixes throughout the trial. The Coli-form count Table 31 shows for the multi-mix C1 started as <10 cfu/g and remained very low throughout the trial. The Coli-form count for multi-mix C3 started at 120 cfu /g and increased with one log/g to 7350 cfu/g. Table 31 shows the Coli- form count for multi-mix C1and C3 over a period stored at 25°. The total aerobic count for Multi-mix C1 started at 360cfu/g and increased with 2 log/g to 21000 cfu/g on day 14, and then decreased to less than 1000cfu/g. The reason for the counts not having a value on day 21 and 28 is that 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 would 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. The total aerobic count for the Multi-mix C3 started at 1770 cfu/g and increased with one log/g to13250 cfu/g on day 28 (See Table 31 above).

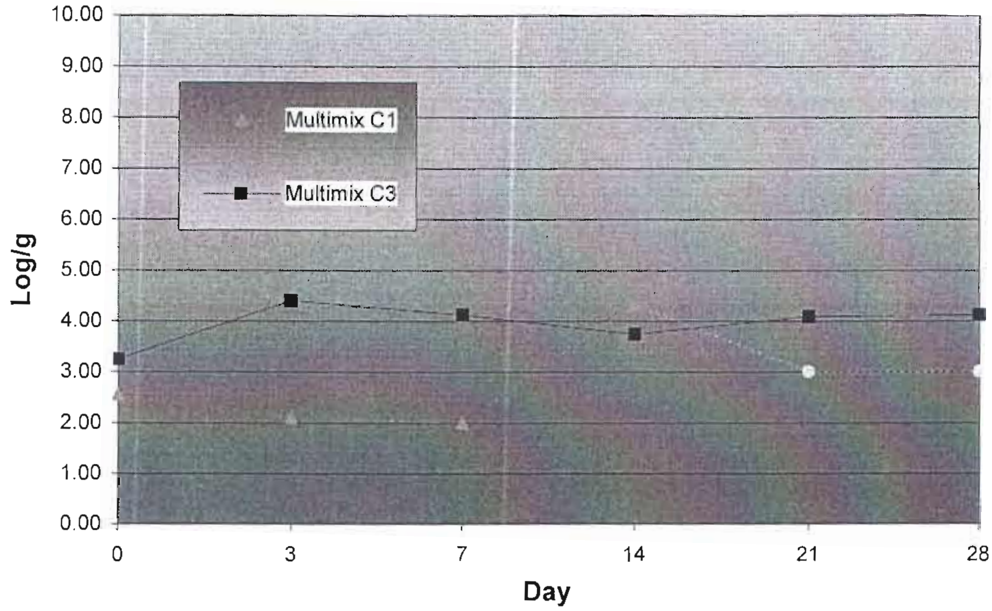

Figure 3: Total aerobic counts for multi-mix C1 and C3 stored at 25 °C for 28 days

The last 2 points for multi-mix C1 (day 21 and 28) are not a true reflection of the counts. The counts for these 2 days for the total aerobic plate count were smaller than 1000 cfu/g. Since the true value is not known the counts were given as though the counts were 999 cfu/g, to complete the graph.

5.3.7.2 Yeast and mould count

The yeast and mould count for multi-mix C1 started at a very low 40 cfu/g and increased by one log/g to 650 cfu/g as can be seen in Figure 4.. The counts for the multi-mix C3 started at

280 cfu/g and increased by one log to 1100 cfu/g on day 21, and then decreased by two log/g to 60 cfu/g on the last day of the trial. The fluctuation of the yeast and mould counts can be ascribed to the sample material that was not uniform. The sample consisted of powder particles of different textures and this may have caused uneven distribution of the microorganisms in the sample. It might be that a bigger load of organisms was concentrated on the portion that was sampled on day 21 than for instance on day 3. This reason can also be applied to the Total aerobic count for both the samples where there is also a fluctuation in the

counts.

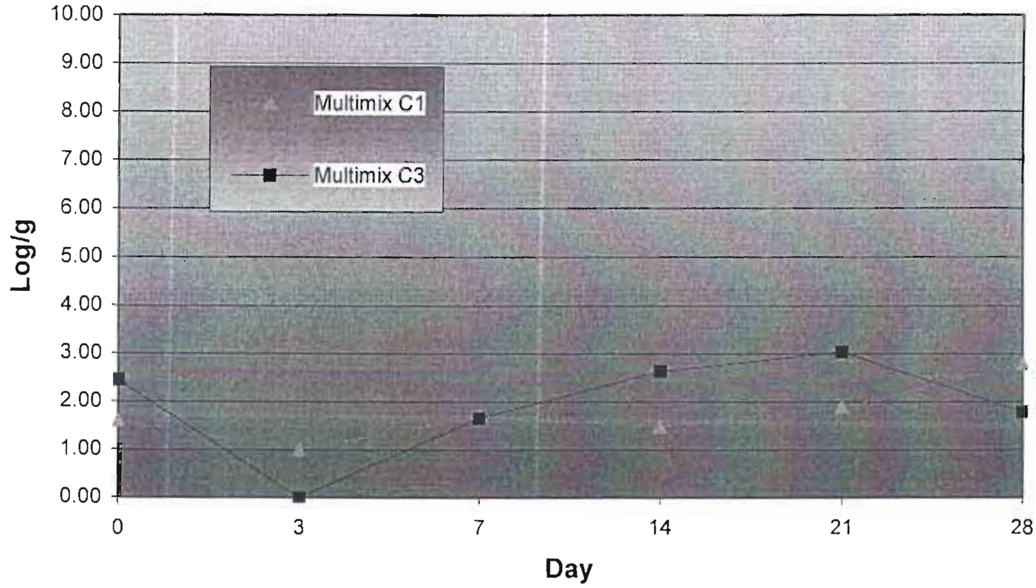

Figure 4: Yeast and mould counts for multi mix C1 and C3 stored at 25° for 28 days

The counts for the multi-mix C1 in general were lower than the overall counts for the multi-mix C3. The multi-mix C1 thus will probably have a longer shelf life than the multi-mix C3, if the shelf life will continue. Both the samples are still edible on day 28, and will have a longer shelf life than 28 days.

Step 9

5.3.8 Recipe development

Recipes developed for soups and gravy for FMM C1 and C3 are as shown in Tables 32-35.

Table 32: Recipe for multi-mix C1 soup

Ingredient	Quantity used
Multi-mix powder(C1)	100 grams
Onions	30 grams
Cooking oil	2 teaspoonful
Salt	½ teaspoonful
Water	450mls

The above recipe yielded 450mls of soup, thus 2 portions.

Onions were washed, peeled and finely grated. Multi-mix was formed into a paste with 100mls of water .Oil was heated, and the onions were added and fried till golden brown. Multi-mix paste was added and carefully stirred to avoid lumps. Water was added to correct the consistency, stirring continuously. The multi-mix soup was seasoned with salt and allowed to simmer for 20 minutes.

Table 33: Recipe for multi-mix C1 gravy

Ingredient	Quantity used
Multi-mix powder(C1)	100 grams
Fresh tomatoes	15grams
Onions	30 grams
Cooking oil	2 teaspoonful
Salt	½ teaspoonful
Water	250ml

The above recipe yielded 250 ml (gravy) thus two portions.

Onions were washed and grated. Tomatoes were also washed and finely chopped. A multi-mix paste was formed with 100mls of water. Grated onions were fried in heated oil till golden brown. Tomatoes were added and cooked for two minutes. The multi-mix paste was added and carefully stirred to avoid lumps. The consistency of the gravy was corrected. The multi-mix gravy was seasoned with salt, and allowed to simmer for 20minutes and served.

Table 34: Recipe for multi-mix C3 soup

Ingredient	Quantity used
Multi-mix powder(C3)	100 grams
Onions	30 grams
Cooking oil	2 teaspoonful
Salt	½ teaspoonful
Water	450mls

The above recipe yielded 450ml (soup), thus two portions.

Onions were washed, peeled and finely grated. Multi-mix was formed into a paste with 100mls of water .Oil was heated, and onions were added and fried till golden brown. Multi-mix paste was added and carefully stirred to avoid lumps. Water was added to correct consistency, stirring continuously. The multi-mix soup was seasoned with salt and allowed to simmer for 20 minutes.

Table 35: Recipe for multi-mix C3 gravy

Ingredient	Quantity used
Multi-mix powder(C3)	100 grams
Fresh tomatoes	15grams
Onions	30 grams
Cooking oil	2 teaspoonful
Salt	½ teaspoonful
Water	250grams

The above recipe yielded 250 mls (gravy) thus two portions.

Onions were washed peeled and finely grated. Tomatoes were also washed and finely chopped. A multi-mix paste was formed with 100mls of water. Grated onions were fried in heated oil till golden brown. Tomatoes were added and cooked for two minutes multi-mix paste was added and carefully stirred to avoid lumps. The consistency of the gravy was corrected. The multi mix gravy was seasoned with salt, and allowed to simmer for 20minutes and served.

Step 10

5.3.8.1 Recipe leaflet development

Simple illustrations in the form of ladles, spoons, water flowing through a tap etc were used to develop recipe leaflets to make reading and cooking easy for subjects (See Annexure A).

Step 11

5.3.9 Costing of Recipes

Table 36: Cost of FMM CI (soup)

Ingredient	Quantity used	Cost
Multi-mix	100g	R0.82
Onions	100g	R0.30
Cooking oil	2 teaspoon full	R0.25
Water	450 mls	R0.01
Salt TOTAL	½ teaspoon full	R0.01 R1.39

In Table 36 the individual costs of ingredients used and the total cost of soup made with food multi-mix CI are displayed. The total recipe yielded two portions of 250 ml at a cost of R 1.78 per portion, which is still meeting the "low-cost, affordable" criterion.

Table 37: Cost of FMM C3 (soup)

Ingredient	Quantity used	Cost
Multi-mix	100g	R0.65
Onions	30g	R0.50
Cooking oil	2 teaspoon fuls	R0.25
Water	450 mls	R0.01
Salt	½ teaspoon full	R0.01
TOTAL		R1.42

In Table 37 the individual costs of ingredients used and the total cost of soup made with food multi-mix C3 is displayed. The total recipe yielded two portions of 250 ml at a cost of R0.86 per portion, which is still meeting the "low-cost, affordable" criteria.

Table 38: Cost of FMM C1 (gravy)

Ingredient	Quantity Used	Cost
Multi-mix	100g	R0.82
Onions	30g	R0.50
Fresh tomatoes	15g	R0.60
Tomato puree	Two tea spoonfuls	R0.20
Cooking oil	2 teaspoonful	R0.25
Water Salt	250mls Half teaspoonful	R0.01 R0.01
TOTAL		**R2.39**

In Table 38, the individual costs of ingredients used and the total cost of gravy made with food multi-mix C1 are displayed. The total recipe yielded two portions of 250 ml at a cost of R1.75 per portion, which still meets the "low-cost, affordable" criterion. However, the nutrient content per portion is thus half of that of the 100g FMM as the FMM yields two portions of 250 ml each.

Table 39: Cost of FMM C3 (gravy)

Ingredient	Quantity Used	Cost
Multi-mix	100g	R0.65
Onions	30g	R0.50
Fresh tomatoes	15g	R0 60
Tomato puree	two teaspoonful	RO.20
Cooking oil	two teaspoonful	R0.25
Water	250mls	R0.01
Salt	½ teaspoonful	R0.01
Total		**R.2.22**

In Table 39 the individual costs of ingredients used and the total cost of soup made with food multi-mix C3 is displayed. The total recipe yielded two portions of 250 ml at a cost of R1.22 per portion, which is still meeting the "low-cost, affordable" criterion.

The theoretical nutrient composition was calculated by Dietary Manager and is summarized in Tables 40 and 41 for all the recipes per portion.

Table 40: Nutritional values of nutrients in FMM CI (soup and gravy) per 250ml portion (non optimised FMM)

Nutrient	Unit	C1 Soup	C1 Gravy	C3 Soup	C3 Gravy
Energy	kJ	1751.5	702	1615.5	1653
Protein	G	13.51	6.88	13.9	14.02
Carbohydr	G	38.85	19.99	41.57	42
Fat	G	23.73	6.9	18.81	18.83
Iron	Mg	2.19	1.18	2.39	2.5
Folate	µg	71.5	71.5	77	78.5
Calcium	Mg	166.5	167	174.5	174.5

Table 41: Nutritional values of FMM C3 (soup and gravy) per 250 ml portion

Nutrient	Unit	C1 soup	C1gravy	C3soup	C3 gravy
Energy	kJ	1668	16.7	153	1549
Protein	G	17.15	12.9	23.16	23.37
Carbohydrate	G	22.21	11.42	27.71	24.04
Fat	G	118.65	118.67	54.05	94.17
Iron	Mg	7.3	3.97	7.95	8.2
Folate	µg	17.5	9.25	19.25	19.25
Calcium	mg	13.8	6.95	14.54	14.54

Step 12

5.3.10 Sensory analysis results

In step 12 a sensory evaluation for the developed recipes (soup and gravy) was performed to test the acceptability of the products by the target group. Figures 5 to 9 depict results of the sensory evaluation.

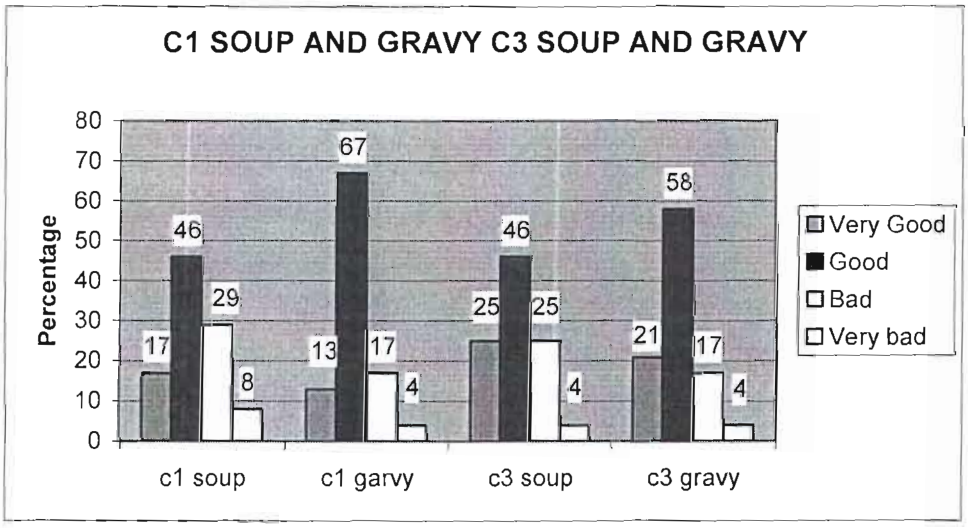

Figure 5: FMM C1 soup and gravy and FMM C3 soup and gravy compared

Most respondents indicated that they enjoyed both the C1 and C3 soup and gravy. According to the above graph, in general, most of the respondents indicated GOOD for the taste of the C1 (soup and gravy) and C3 (soup and gravy).

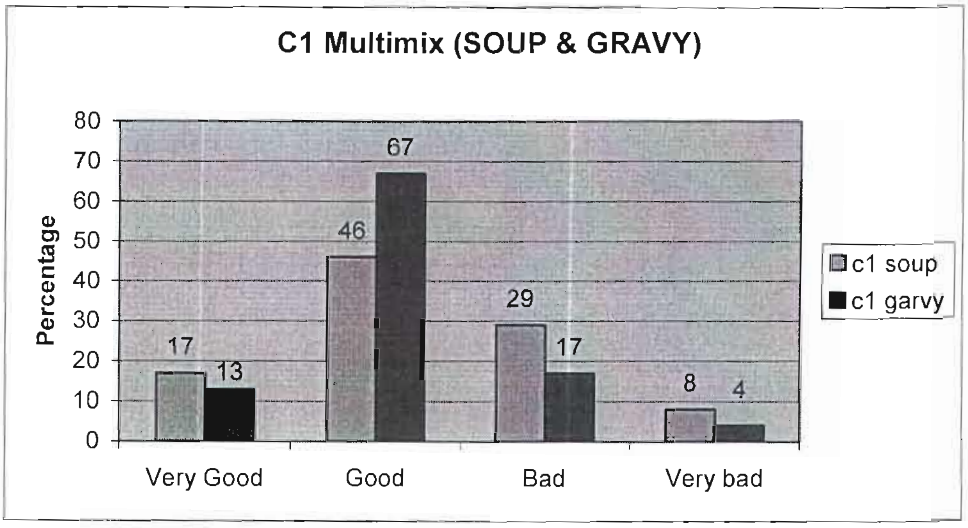

Figure 6: FMM C1 soup and gravy compared

The majority of respondents (80%) liked the taste of the gravy and 63% liked the soup.

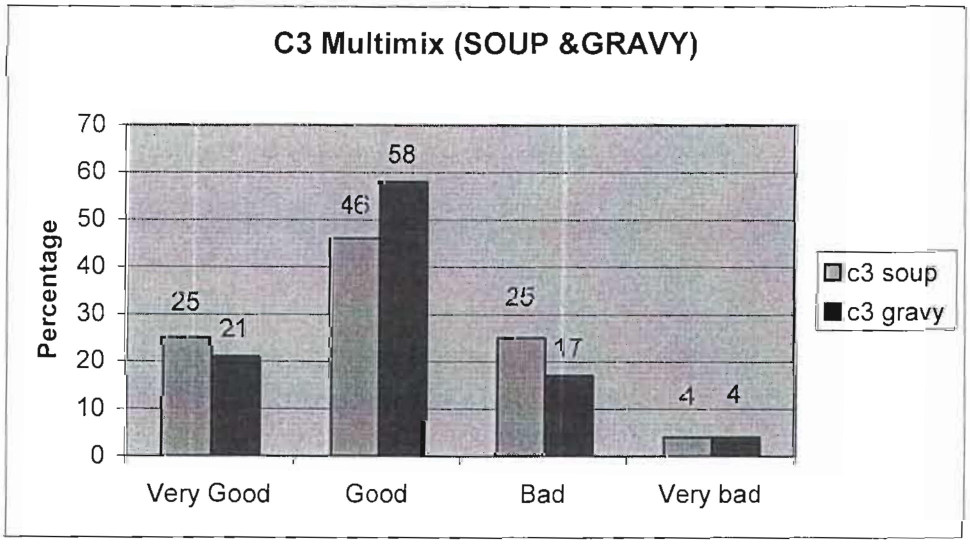

Figure 7: FMM C3 soup and gravy compared.

The majority of respondents (58%) liked the taste of the gravy and (46%) liked the soup.

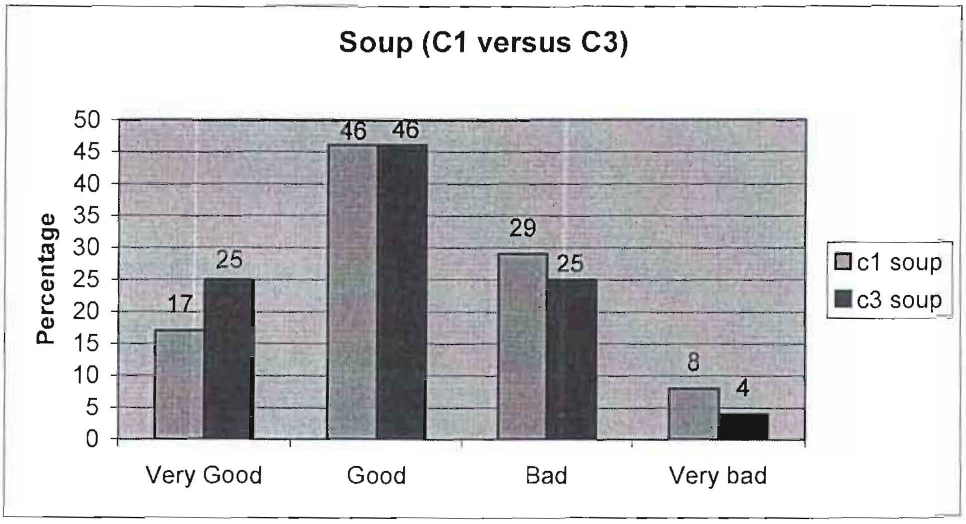

Figure 8: FMM C1 and C3 soup compared

When C1 multi-mix (soup) is compared with the C3 multi-mix Soup, an equal percentage of respondents (46%) indicated that they like the soup for C1 and C3.

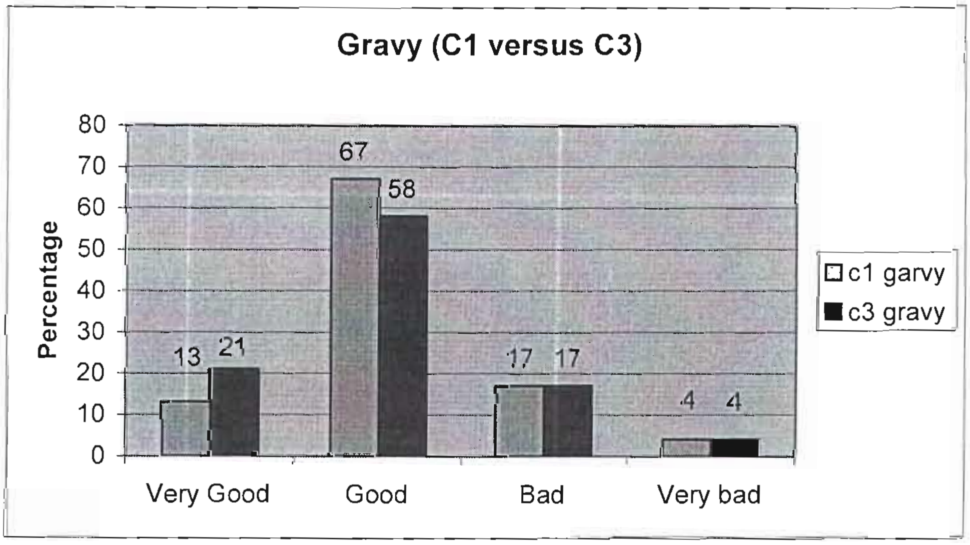

Figure 9: FMM C1 and C3 gravy compared

The majority of respondents (67%) liked the taste of the gravy and (58%) liked the soup

5.4 CONCLUSION

In summary the chapter started with a compilation of formulated 20 food multi-mix supplements according to the formulation criteria. Iron, folate, protein and carbohydrate were the nutrients considered since these are the nutrients that play protective roles against adverse outcomes during pregnancy (Gibley *et al* 2004:291). Food multi-mix supplement C1 was chosen for the study because FMM C1 was found to contain higher, folate and protein than multi-mix C3. Food multi-mix C3 was also found to contain the recommended 20% of RDA of iron and was added to FMM C1 for development of recipes and sensory evaluation.

The process proved that, it is possible to formulate a FMM or any other food product according to certain formulation criteria as FMMC1 and C3 met the criteria of at least 20% RDA of protein and energy. However, the micronutrients were difficult to meet as Folate, Iron and energy showed lower percentages of 10%, 14% and 18% respectively experimentally. Further more, it was possible to formulate and develop product that are culturally acceptable to the consumers (pregnant women)as sensory analysis indicated the majority (85%) of the respondents liked the gravy and 65% liked the soup. The shelf life testing, furthermore, proved safety for the time of consumption, as very little micro biological growth was found in 28 days.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

Pregnancy is a time when nutritional needs are higher, and meeting those needs has a positive effect on the health of both the mother and her unborn baby. The effects of nutrition during pregnancy on the developing foetus last for a lifetime and children should inherit a legacy of good health for the future. Pregnant women should enjoy a healthy pregnancy without negative effects of poor nutrition on their health, and remain in the best possible nutritional state to support breastfeeding. Good maternal nutrition is vital for the health and survival of both mother and foetus. Adequate intake of micro and macronutrients by this vulnerable group must be ensured to avoid maternal and infant morbidity and mortality (M.O.H 2006).

6.2 LIMITATIONS EXPERIENCED DURING THIS STUDY

- The VUT chemical analysis equipment (AAS machine) broke down during analysis. Food multi-mix supplement (FMM) had to be taken to the ARC laboratory for chemical analysis to be done.
- The chemical analysis results from the ARC, took a long time to arrive and cost as much as R6300 per sample
- Theoretical re-analysis was done, but the chemical analyses of the optimised FMM could not be done owing to the high costs of the ARC analysis.

6.3 MAIN FINDINGS OF THE STUDY

The main aim of this project was to develop a multi-mix dietary supplement that was cost effective, culturally acceptable and nutrient-dense for consumption in the household, most especially for pregnant mothers in the Vaal Region.

Malnutrition remains a persistent problem among pregnant women globally and the mortality rate of pregnant women in Africa is high and continues to rise due to poverty and lack of strategies in place to the correct the nutritional status of pregnant women. In Africa nearly 200 million pregnant women are severely undernourished. It is believed that children born to these malnourished pregnant women will grow up with impaired mental development (Iyenga 2002:2). Iron deficiency and anaemia affect 50% or more of pregnant women and the prevalence of folic acid deficiency is up to 30-50% and there is evidence to suggest that zinc deficiency is likely to be widespread. However, the contribution of micronutrient deficiencies to prenatal mortality and duration of gestation is limited, and the evidence base for individual micronutrient effects on neonatal mortality and morbidity is not substantial (Seshadri 2005: 92).

Evidence of poor nutrition practices also exists in the Vaal Region (the area of research). A study conducted by Kesa (2001) examined the iron status of pregnant women in Vaal region. There was clear evidence of poor dietary practices amongst women of the Vaal region. The study revealed that owing to malnutrition, 72.12% of pregnant women were overweight during and after pregnancy, and 50% showed clear signs of iron deficiency anaemia (Kesa 2001: 2). The diets of these women consisted primarily of plant food, and apart from milk, animal food was not easily affordable. Maize meal was the most commonly consumed food.

Research has proved that if pregnant women receive all their nutritional requirements, maternal and infant mortality and stillbirth are drastically reduced (Uddoh 2002:123). Adequate nutrition of women, particularly before and during pregnancy, should thus be secured and remain an important goal for developing countries.

Food diversification is a strategy designed to reduce exposure to risk by combining a variety of investments. The diversification of the diet to increase the consumption of iron, vitamin A and other micronutrients on a daily or continuing basis is a practical, long-term measure to eliminate and prevent micronutrient deficiencies. Activities that improve production, availability and access to micronutrient-rich and locally produced foods are a major focus of this type of intervention (Heleigh 2006:3). The inclusion of a FMM supplement is a theoretical strategy that can be implemented as part of food diversity.

It is possible to develop a novel food product, namely the FMM which meets 20% of RDA for the identified micronutrients, folate and iron, is prepared with low-cost ingredients and is available in the majority of households in the sample, and is acceptable to the majority. This was proved by the FMM developed in this study.

The criteria for the development of the FMM included:

* Affordability in that a daily portion should not cost more than R 1.75 because this was found to be the amount of money that pregnant women were prepared to spend daily on food, snacks and supplements per day (Kesa 2001). This criterion was met as the two FMMs developed in this study cost R 0.82 and R 0.65 per 100g respectively. Even the recipes developed with the FMM met the affordability criterion.

* Nutritive value, meeting 20% of the RDA for iron, folate, and protein. The chemical analyses showed that the FMM developed contained 21g and 14g of protein respectively. This was equal to 35% and 23% of RDA respectively, thus meeting the 20% RDA criterion. As far as the micronutrients were concerned, the iron content was 4.2 mg and 5.7 mg respectively, thus meeting 14% and 19% of RDA. The folate content was 600 µg and 400 µg, thus 6.5% and 43% of RDA respectively. This study proved that it is very difficult to meet the 20% criterion for both macro- and micronutrients. Although the RDA of iron content was almost reached in the FMM C3, it was not met in FMM C1 and the RDA of folate could not be met in either of these multi-mixes. Optimization was done to try and improve the folate content, but as stated in the limitations of this study this could not be re-analysed chemically as stated in the limitations for this study.

* Cultural acceptability using ingredients familiar to the pregnant women in the area Kesa, (2001). Most of the ingredients chosen for the formulation of the FMM were available in the households of pregnant women in the Vaal region. However, the onions had to be dried and the maize meal roasted in order to make the phytates less active, in other to assist iron absorption. The sensory analyses showed that the FMM and recipes were acceptable to the pregnant women for consumption as the majority rated the soup and gravy as good or very good. This criterion was thus met.

* Safety for human consumption. This criterion was met as proved by the microbiological testing of the FMM and recipes.

6.4 CONCLUSIONS

This research project provided the opportunity to develop a novel food product, namely FMM, for pregnant women. It was one of the first multi mixes developed in South Africa. The major objective of this study was to develop a food multi-mix supplement to meet 20% of RDA for pregnant women. The objective was achieved through analysis of data gathered from previous studies conducted amongst pregnant women in the Vaal region, development and chemical analysis of the FMM, optimizing of the product, shelf life testing and sensory analysis of the FMM. From the results of this study, it is concluded that an FMM can be developed and optimized to meet certain criteria for pregnant women. However, not all the criteria, specifically those related to the nutrient content, were met in this study. The nutrients should be prioritised and focused on for the development of the FMM.

6.5 RECOMMENDATIONS

The results of this project showed that FSM and nutritionists could work together in addressing malnutrition amongst pregnant women. Further research is needed to address the following:

1) Impact on nutritional status
2) Long-term compliance
3) Development of range of food multi mixes with various ingredients to determine the most nutritious, cost effective and acceptable product for pregnant women
4) Market research to determine the need for such a product in retail
5) Shelf life testing on various recipes
6) Chemical analysis of various recipes
7) Bio- availability of nutrients in the FMM.

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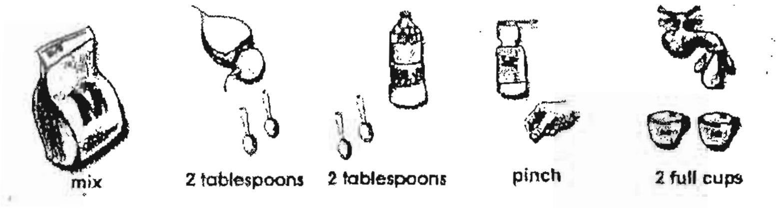
ANNEXURE A SOUP MIX

SOUP MIX



1. Add  mix +  1 cup water

+  pinch of salt and mix to form paste 

2. Chop onion 

3. Heat oil and fry onions 

4. Add multimix paste and stir 

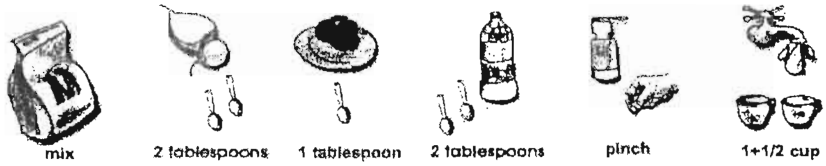
5. Add  water and keep stirring 

6. Allow to cook for 20 minutes. 

ANNEXURE B GRAVY MIX

RECIPE LEAFLET AND ILLUSTRATIONS

GRAVY MIX



1. Add mix + 1 cup water

+ pinch of salt and mix to form paste 

2. Chop tomatoes and onion 

3. Heat oil and fry onion then tomatoes 

4. Add multimix paste and stir 

5. Add water and keep stirring 

6. Allow to cook for 20 minutes. 

ANNEXURE C TOP 20 FOODS CONSUMED BY PREGNANT WOMEN (Kesa 2001:5)

NUMBER	FOODS ITEM	MEAN QUANTITY PER DAY
1.	Milk whole fresh	237 ml
2.	Tea, brewed instant	83 ml
3.	Coffee, Brewed instant	43 ml
4.	Maize meal	161g
5.	Cold drink, low calories	68 ml
6.	Cold drink Squash	55 ml
7.	Mahewu/ Mageu (non-alcoholic fermented maize drink)	48 ml
8.	Bread rolls, brown	80g
9	Bread rolls, white	103 g
10	Yogurt low fat fruit	55 g
11	Rice, white cooked	102 g
12	Sugar, white granulated	185 g
13	Chicken, roasted	111 g
14	Fruit juice baby	25 ml
15	Fruit juice dairy mix	33 ml
16	Apple, raw with skin	96 g
17	Custard, whole milk	89 ml
18	Maltabella, uncooked	60 g
19	Banana, raw	88 g
20	Beef, rump steak	79 g

ANNEXURE D SHELF LIFE ANALYSES

APPENDIX 8

Shelf life analysis of Nutritional Powders

Introduction

The Nutritional powders were delivered to the ARC-Microbiology section on Monday afternoon the 12th of September 2005. The powders were individually packed in plastic bags.

Shelf life study

The powders were 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 analysis were included in the rest of the trial. The Yeast and Moulds* were analysed on Rose Bengal agar with Chloramphenicol and incubated at 25°C for 5 days.

ANNEXURE E SENSORY EVALUATION FORM

NAME:……………………………………….

RATINGS:

…………………………………………………………………………………………

…

…………………………………………………………………………………………

…

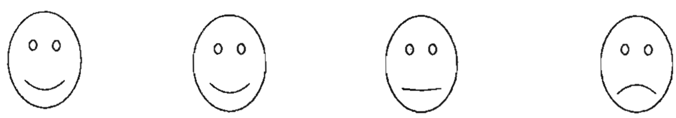
Very good (4/4) Good (3/4) Bad (2/4) Very bad (1/4)

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

<u>RECIPE:……………………………………..</u>

1. APPEARANCE

2. FLAVOUR



3. TASTE

4. FEEL

5. SMELL

COMMENTS:

....

....

....

ANNEXURE F LANGUAGE EDITING CERTIFICATE

Mary Hoffman
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1939

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2 June 2008

To Whom It May Concern

This certifies that the following dissertation has been edited for language accuracy.
I trust that the corrections made have been applied after due consideration by the author of the document:

DEVELOPMENT OF FOOD MULTI-MIX
FOR PREGNANT WOMEN IN THE VAAL REGION

submitted in fulfilment of the requirements for the award of MTech: Food and Beverage Management
in the department of Hospitality, and Tourism

Faculty of Human Sciences

at the
Vaal University of Technology.

By
CHARLOTTE TWENEFOR

Mary Hoffman
(SATI Registration: 1001632)