EFFICACY OF PLUMPY NUT IN IMPROVING NUTRITIONAL STATUS OF HIV POSITIVE PREGNANT WOMEN IN TEMEKE MUNICIPALITY

BY

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ABSTRACT

A six month study was done to investigate the efficacy of Plumpy nut in improving nutritional status of 108 HIV positive pregnant women aged between 15-49 years and who were attending Private and Government Reproductive and Child Health (RCH) clinics at Temeke Municipality. Seventy three (73) subjects received Plumpy nut made from Nutriset, France and thirty five (35) subjects received maize meal made from Azam, Tanzania. The subjects who received Plumpy nut, consumed a sachet of 92 g of Plumpy nut per day and those who received maize meal, receive a 250 g of maize meal per day. Physical measurements of weight, total body fat and MUAC, bio-chemical measurement (hemoglobin concentration) and morbidity information were taken monthly; height was taken at baseline only. Infant's weight was taken at birth. A 24-hr dietary recall technique was used to collect information on food consumption at baseline and at the end of the study. Significant differences were observed in birth weight and mean daily intakes for energy and fat between the subjects who received Plumpy nut and those who did not receive it. Subjects who received Plumpy nut give birth to heavy babies ($p=0.000$), higher intakes of energy ($p=0.028$) and fat ($p=0.000$). However, the differences in maternal weight, MUAC, Total body fat and Haemoglobin concentration between subjects during this study were not significant. This study concludes that, the plumpynut product is effective in improving nutritional status of HIV positive pregnant women and their infants. The Government and non-governmental organizations are called upon to improve the nutritional status of

pregnant women living with HIV/AIDS by supporting them through nutritional based initiatives if they are to produce healthy babies and breastfeed successfully.

DECLARATION

I, ELINA JOHN KWEKA, do hereby declare to the Senate of Sokoine University of Agriculture that the work presented here is my own original work and has not been submitted for a degree award in any other University.

_____ _____

ELINA J. KWEKA **Date**

MSc. Human Nutrition

The above declaration is confirmed

_____ _____

PROF. J. KINABO **Date**

Supervisor

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LIST OF ABBREVIATIONS

AIDS	-	Acquired Immuno Deficiency Syndrome
CSPD	-	Child Survival Protection and Development
GMO	-	Genetically Modified Organisms
Hb	-	Hemoglobin
HIV	-	Human Immuno Deficiency Virus
MoH	-	Ministry of Health
MTCT	-	Mother to Child Transmission
MUAC	-	Mid Upper Arm Circumference
NACP	-	National Aids Control Programme
NIMR	-	National Institute for Medical Research
PMTCT	-	Prevention of Mother to Child Transmission

PRB	-	Population Reference Bureau
RNA	-	Ribonucleic Acid
UNICEF	-	United Nations Children’s Fund
URT	-	United Republic of Tanzania
WHO	-	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

A healthy and varied diet is important at all times in life, but particularly so during pregnancy. The maternal diet must provide sufficient energy and nutrients to meet the mother's usual nutritonal requirements, as well as the needs of the growing fetus, and enable the mother to have a reserve of nutrients required for fetal development as well as for lactation (Williamson, 2006). Malnutrition and HIV/AIDS work in tandem. HIV compromises the immune system of infected persons, increasing their susceptibility to infections, which can negatively affect nutritional status of the victims. Conversely, malnutrition weakens the immune system, which decreases the body's ability to fight HIV and other infections. The effects of HIV infection on a person's nutritional status can occur early in the course of infection even when symptoms are not yet present (Mwadime *et al.*, 2003).

HIV and AIDS have more severe impacts on people in the Eastern and Southern Africa than the fragile health systems can handle, making more children hopeless than the educational systems can inspire, creating more orphans than communities canafford to care for, wasting families and threatening the food systems. Malnutrition is one of the earliest recognised complications of AIDS and has been used as a clinical diagnose of AIDS. However, in the management of HIV related diseases clinicians find it much easier to deal with such complications as diarrhoea or pneumonia than to manage malnutrition (WHO, 2003).

1.2 Problem Statement and Justification

About 13 million women of childbearing age in sub-Saharan Africa are HIV positive (WHO, 2005). In Tanzania, HIV affects 7.7% of the women of child bearing age (NACP, 2005). The issue of HIV infected women is a matter of serious concern in any nation on grounds that women's immune system is highly compromised. This make women become malnourished even when their normal intake of food is adequate. HIV creates extra demand for energy, iron, iodine, folic acid and other nutritents so as to meet the nutrient requirement for a successful pregnancy outcome. In developing countries, the staple foods include cereals (maize, rice, wheat, sorghum and millet), tubers and legumes, providing 70% of the total energy intake (Southgate *et al.*, 2000). In addition, small amounts of vegetables and fruits are part of the diet, while animal products are only rarely consumed because they not affordable. Therefore, the diet which is mainly consumed is bulky, has low energy and nutrient density, and high in poor bioavailable vitamins and minerals. This scenario has serious long term adverse effects on the mother and the child. These effects include preterm delivery, low birthweight, birth defects and other pregnancy complications. HIV infected asymptomatic pregnant women need to increase energy intake by 10 percent over the level recommended for a healthy non HIV infected pregnant women of same age and activity level (WHO, 2003).

In Tanzania, more than two million adults are living with HIV and AIDS (URT, 2007), which means that at least one out of nine adults is HIV positive. Among women attending different antenatal care clinics on the mainland, 9.6% tested

positive for HIV (PRB, 2003). Rates of HIV infection in towns and cities are often about three times higher than in rural areas. Smaller towns or trading centers and road side settlements may sometimes have HIV prevalence levels similar to the ones observed in larger towns and cities (PRB, 2003)

In Temeke 9.1% of pregnant women attending antenantal clinics are living with HIV (Temeke Municipal Council report, 2007). Because of lack of intervention 25 - 40% of HIV infected pregnant women transmit the virus to their newborn babies either during pregnancy, labour and delivery or through breast-feeding (URT, 2006). Temeke is one of the districts with Child Survival Protection and Development (CSPD) programme which is funded by UNICEF with well established Prevention of Mother to Child Transmission [PMTCT] services. PMTCT services increase awareness among community members about HIV and AIDS.

In this study, a food supplement called plumpy nut was provided to seventy three HIV positive pregnant women for six months so as to improve their nutritional status and that of their expected offsprings. The fact that a woman's nutritional status can support fertility does not necessarily mean that it can support pregnancy. It is uncommon for pregnant women to be given supplement food during pregnancy as this is not in the culture of many people in Tanzania. This study sought to generate information on the efficacy of plumpy nut which is a supplement concentrated in macro- and micro- nutrients in improving nutritional status of HIV

positive pregnant women, reducing the severity of the disease and reducing the rate of mother to child transmission.

1.3 Study Objectives

1.3.1 General objective

To improve the nutritional status of pregnant women living with HIV and AIDS by supplementing their diet with plumpy nut for a successful pregnancy outcome.

1.3.2 Specific objectives

i) To assess the nutritional status of HIV positive pregnant women participating in the study in Temeke Municipality.

ii) To assess food consumption pattern of HIV positive pregnant women in Temeke Municipality.

iii) To examine the effect of plumpy nut supplementation on haemoglobin concentration of pregnant women participating in the study in Temeke Municipality.

iv) To identify morbidity pattern among HIV positive pregnant women at Temeke Municipality.

v) To examine the effect of plumpy nut supplementation on nutritional status and total body fat of pregnant women participating in the study in Temeke Municipality.

vi) To assess the birth weight of the off-springs of study women in Temeke Municipality.

1.4 Study Hypothesis

Ho: There is no difference in nutritional status between subjects in the Plumpy nut group and those in the Non-Plumpy nut group.

H1: There is a difference in nutritional status between subjects in the Plumpy nut group and those in the Non-Plumpy nut group.

Ho: There is no difference in birth weight between babies born from subjects in the Plumpy nut group and those in the Non-Plumpy nut group .

H1: There is a difference in birth weight between babies born from subjects in the Plumpy nut group and those in the Non-Plumpy nut group.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Meaning of HIV/AIDS and Scope

HIV is an abbreviation of Human Immuno Deficiency Virus, that causes damage to the human immune system, resulting into opportunistic infections which cause virulent and fatal disease to an individual. There is enough evidence now which suggests that HIV causes AIDS (RCQHS, 2003).

Acquired Immuno Defficiency Syndrome (AIDS) is an acronym referring to a group of deadly diseases caused by HIV (Cox, 1997). HIV attack white blood cells, attaching itself to a cell with the help of a specific surface protein called CD4 (RCQHC, 2003). The protein is found in white blood cells which are known as T-helper lymphocytes and macrophages. These cells help to stimulate the production of antibodies and multiplication of other white blood cells. The macrophages help to destroy infected body cells. HIV binds itself to the CD4 cell surface, its particles enters cytoplasm of the attached cell. This impairs the functioning of the attached cell, inducing it to make more copies of RNA with the help of a virus-specific enzyme called reverse transcriptase. As more and more cells are attached, the body's immunity system is gradualy weakened. The person becomes vulnerable to a variety of life threatening illnesses and is said to have AIDS (RCQHC, 2003).

2.2 HIV/AIDS Situation

2.2.1 HIV/AIDS situation world wide

Since the reporting of the first case of AIDS in 1981 the HIV infection has grown to pandemic proportions, resulting into the infections of the estimated 65 million people and death of 25 million people (UNAIDS, 2006). Sub-Saharan Africa is the world's most severely affected region (NACP, 2005). Aproximatelly 10% of the worlds population lives in Sub Saharan Africa, but the region is home to aproximattely 64% of the world population living with HIV/AIDS (UNAIDS, 2006), with the number of women infected with HIV/AIDS exceeding that of men (Piwoz and Bentley, 2005).

In 2003 over 90% of newly infected children were babies born to HIV positive women, who acquired the virus at birth or through their mothers breast milk (AVERT, 2004c), of these, almost nine –tenths were in sub-saharan Africa. In 2004, an estimated 640000 children aged 14 years or younger become infected with HIV. Africa leads in mother to child transmission of HIV, this means that HIV infected women still get pregnant despite the evidence that HIV impaires women's fertility. Once infected, a woman can be expected to bear 20% fewer children than otherwise would have been the case if she was not infected (AVERT, 2004d).

2.2.2 HIV/AIDS in Tanzania

The first case of AIDS in Tanzania was reported in 1983 in Kagera region. Since that time HIV epidemic has spread rapidily to all regions and districts of Tanzania affecting all sectors of the society (NACP, 2005). The spread of the virus was

reported to be at a slower rate only in Zanzibar. HIV/AIDS is the most pressing social and health issue facing Tanzania today. More than 2 million adults are living with HIV/AIDS, this means that at least one out of nine adults is HIV positive. Among women attending antenatal clinic on the mainland, 9.6 percent tested positive for HIV. However higher levels of HIV infeections were reported among blood donors (11% tested positive in 2001). The rates of HIV infection is higherin towns and cities and are often be with about 3 times higher than in rural areas. Smaller towns or trading centers and road side settlements may sometimes have HIV prevalence levels similar to those found in larger towns and cities (PRB, 2003).

Mother-to-child transmission (MTCT) occurs when an HIV positive woman passes the virus to her baby either during pregnancy, labour and delivery, or breastfeeding. Without treatment, around 15-30% of babies born to HIV positive women would become infected with HIV during pregnancy and delivery (De Cock *et al*., 2000). In 2005, around 700,000 children under 15 years became infected with HIV, mainly through mother-to-child transmission (UNAIDS/WHO, 2005). According to UNAIDS (2004), approximately 17 million women worldwide between the ages of 15 and 49 years are HIV positive, and 77% of these live in sub-Saharan Africa.

2.3 Physiological Changes During Pregnancy

During pregnancy large amounts of nutrients are required for the growth and metabolism of maternal and fetal tissues and for the storage of nutrients in the fetus. Some of the additional needs of nutrients are met by increasing martenal food

intake, but regardless of dietary intake, enormous metabolic adjustment in nutrient utilization support the development of the fetus (Bowman and Russell, 2001). Adequate energy intake and a diversified diet that includes fruits, vegetables, and animal products throughout the life cycle of the mother helps to ensure it (FANTA, 2004). HIV infected asymptomatic pregnant women (WHO Stage 1) need to increase energy intake over the level recommended for healthy non HIV infected pregnant and by 10 percent of the intake level recommended for non-pregnant adolescents or women of the same age and activity level (WHO, 2003).

The weight of the fetus increases throughout pregnancy, approximately 90% of fetal growth occurs in the last 20 weeks (Table 1). Fetal growth is accompanied by the expansion of placenta, uterus, and mammary glands. The additional tissues raises the martenal metabolic rate up to 60% higher during the last half of pregnancy, thus creating a need for additional dietary energy. The protein, fat, minerals and vitamins deposited in the fetal tissues come from higher martenal food intake and more efficient intestinal absorption or renal reabsorption, depending on the specific nutrient.

Table 1: Recommended weight gain during pregnancy

Category	**BMI before pregnancy (kg/m^2)**	**Total weight gain (kg)**	**Weekly weight gain (kg) during 2nd and 3rd trimisters**
Low	<19.8	12.5-18.0	0.5+
Normal	19.8-25.9	11.5-16.0	0.5
High	≥26.0-29.0	7.0-11.5	0.3
Obese	≥29.0	<7.0	0.25

Source: FANTA, 2004.

2.4 HIV/AIDS and Nutrition

Good nutrition is important for all pregnant women and contributes to maternal health and optimal birth outcomes. Inadequate food intake, poor dietary quality, and untreated infections before and during pregnancy increase the risk of maternal mortality and morbidity and are the risk factors for negative birth outcomes such as low birth weights of the infants (LBW) or intrauterine growth restriction (IUGR) (FANTA, 2004). Women's nutrient needs increase during pregnancy and lactation. Some of the increased nutrient requirements protect maternal health while others affect birth outcome and infant health. Birth weight is one of the most important determinants of a child's survival and is highly influenced by the mother's nutritional status before and during pregnancy (FANTA, 2004).

2.4.1 Nutritional needs during pregnancy

Pregnancy is an anabolic condition that affects the metabolism of all nutrients in order to support maternal homeostasis, foetal growth and development and to prepare the mother for lactation. In response to these demands for nutrients, one or more of the following can occur: increased deposition of maternal stores and foetal tissue, redistribution of nutrients, and an increase or a decrease in nutrient absorption and rate of metabolism (King, 2000). Pregnant women require more protein, iron, iodine, folate (which are more difficult to achieve through normal diet), and other nutrients. Deficiencies of these nutrients lead to maternal complications and death, fetal and newborn death, birth defects, and decreased physical and mental abilities of the child (WHO, 2003). No single food is able to meet all the nutrients the body needs and in the right quantity and combinations.

Only breast milk contains the combination and quantity needed for a young baby. A nutritious diet is the one that provides a variety of food and of adequate quantities and combinations to supply essential nutrients on a daily basis.

Nutrients are important in maintaining a health immune system especially for PLWHA; prevent weight loss, muscle wasting, fight opportunistic infections and other diseases (URT, 2007). It is therefore necessary to eat a variety of foods to provide all the nutrients required by the body. The nutrients include carbohydrates, protein, fat and oils, vitamins, and minerals. The relationship between HIV and nutrition, however, may be more complicated than the relationship between nutrition and other infectious diseases. This is because in the former the virus directly attacks and destroys the immune system. Nutritional deficiencies affect immune function in ways that may influence viral expression and replication, further influencing HIV disease progression and mortality (Piwoz and Preble, 2000). HIV infection also affects the production of hormones such as glucagon, insulin, epinephrine, cortisol, all of which are involved in metabolism of carbohydrates, proteins, and fats.

2.4.1.1 Energy intake

The body needs energy to support metabolic process and to perform internal and external work. The extra energy neededby a pregnant woman vis ā vis that needed by a non pregnant women is 85 kcal/day in the fist trimester 285 kcal/day in the second trimester and 475 kcal/day in the third trimester (FAO, 2001). During pregnancy, the energy needs are greater because of an increase in all factors that

determine total energy expenditure. More energy is required to synthesize new cells and tissues in both the mother and the conceptus. The internal work is greater since respiratory movement become more frequent and both the rat e of heart beatand cardiac output increase. For PLWHA the amount of energy needed to meet the requirementof these processes is increased. In asymptomatic stage energy requirement should be increased by 10%, and by 20-30% in symptomatic stage, this means more energy than the recommended daily allowance for HIV negative individuals of the same sex, age and physical activity (URT, 2007). Dietary intake during pregnancy must provide the energy that will ensure a full term delivery of a healthy new born baby of adequate size and appropriate body composition by a woman whose weight, body composition and physical activity levels (PAL) are consistent with a long term good health and well being (FAO, 2001).

2.4.1.2 Vitamins and minerals

Many vitamins and minerals (also known as micronutrients) are important to the HIV and nutrition relationship due to their critical roles in cellular differentiation, enzymatic processes, immune system reactions and other body functions (Fawzi and Hunter, 1998) such as energy releasing metabolic reactions in carbohydrates, fats and proteins. Some vitamins are water soluble (B group and C) and should be consumed continuously as the body doesn’t store them but excrete any excess taken, on the other hand other vitamins such as A, C, E and minerals such as selenium, zinc and iron act as antioxidants (Latham, 2002). They are associated with the protection of body cells and damage from infections and some types of cancers. Some minerals such as iron, folic acid and B_{12} are involved in the synthesis

of hemoglobin which transports oxygen in the body (URT, 2007). A number of minerals (e.g. iron, zinc, selenium and cupper) are known to boost both the cell-mediated and humoral immune defences of the body (Huang *et al.*, 2003).

The role of micronutrient in dealing with other infectious diseases, such as measles, diarrhea, and respiratory infections has been intensively studied and it has been established that several vitamins and minerals are required by the immune system and major organs to fight infectious pathogens. Persons with inadequate food intake, low blood levels, or inadequate body stocks of these micronutrients have difficulties in resisting infections. As a result, the role of micronutrients in dealing with HIV/AIDS infections takes on special importance on individuals and populations with marginal or low micronutrient intake (Friis and Michaelson, 1998). Micronutrient deficiencies resulting from HIV vary across populations and according to the stage of the disease, results into accelerated progression of HIV infection to AIDS; and are predictive of AIDS related mortality (Semba and Tang, 1999).

In Tanzania randomized, placebo controlled trial conducted among pregnant HIV-infected women in Tanzania who were given multivitamins (20 mg B_1, 20 mg B_2, 25 mg B_6, 100 mg niacin, 50µ B_{12}, 500 mg C, 30 mg E and 0.8 mg folic acid). This procedure was found to be associated with significant increase in CD4, CD8 and CD3 cell counts, decreased the risk of fetal death and other adverse pregnancy outcomes (Garland and Fawzi, 2002).

2.5 Effect of Maternal Nutrition on Infant and Maternal Health

Poor nutritional status before and during pregnancy has been associated with intrauterine growth retardation, low birth weight and premature delivery conditions. Such events are also associated with maternal HIV infection (Papathakis and Rollins, 2005). Iron deficiency anaemia is associated with inadequate maternal weight gain, toxaemia, and labor and delivery complications with an increased risk of maternal mortality (Tomkins, 2001). Increased iron utilization by the developing fetus and placenta, as well as blood volume expansion significantly increase the iron requirement during pregnancy. Epidemiological studies provide strong evidence of an association between severe anemia in pregnant women and adverse pregnancy outcomes such as low birth weight, premature birth, and maternal mortality. Another study conducted in Tanzania, the incidence of low birth weight was 7.8% among the infants in the multivitamin group and 9.4% among those in the placebo. The rate of prematurity were 16.9% in the multivitamin group and 16.7% in the placebo group (relative risk 1.01; 95% CI, 0.91 to 1.11; P=0.87). Supplementation reduce both the risk of a birth size that was small for gestational age and the risk of martenal anaemia(hemoglobin level,<11g per deciliter; relative risk, 0.88; 95% CI, 0.80 to 0.97; P=0.01).

Fawzi *et al*. (1998), examined the effects of vitamin A and multivitamins on birth outcomes in HIV-positive women in Tanzania and the results showed that Multivitamin supplementation decreased the risk of low birth weight (<2,500 g) by 44 percent, severe preterm birth (<34 weeks' gestation) by 39 percent, and small size for gestational age at birth by 43 percent. Vitamin A supplementation had no

significant effect on these variables. Multivitamins, but not vitamin A, resulted in a significant increase in CD4, CD8 and CD3 counts. Multivitamin supplementation is a low-cost way of substantially decreasing adverse pregnancy outcomes and increasing T-cell counts in HIV-1-infected women. Micronutrient suppliment to pregnant women has proven to have a lot of benefits as shown in a study in Nepal a comparison was made on four combinations of micronutrients taken from early pregnancy through six weeks postpartum to a control supplement. The test supplements contained folic acid alone, folic acid and iron, folic acid and iron and zinc and eleven other micronutrients. All supplements contained the RDA of vitamin A the entire effect, however, was observed in preterm infants, among whom mortality was lowered by over 60 percent ($p<0.001$). Adding iron to folic acid improved martenal hemoglobin concentration, increased mean birth weights and reduced the prevalence of low birth weight.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

Temeke is one of the three districts in Dar es Salaam Region other districts are Kinondoni and Ilala. Temeke District is located in the South of Dar es Salaam Region. It is bordered by Kinondoni and Ilala Municipalities. The district also borders the Indian Ocean in the East and South while to the West it borders Mkuranga District of the Coast Region. Temeke Municipality has an area of 786.5 Square km and is the largest in terms of land size among the three Municipalities of the Dar es Salaam City.

Temeke Municipality lies in the tropical belt where it experiences high temperatures ranging between 25°C from May to August and 35°C from September to April. The district has two rainy seasons, the short rains September to mid-January and the long rains from mid-March to May. The high temperatures and rainy conditions make the area highly endemic for Malaria. The soil is largely sandy and clay in most parts. Loamy soil may be found in areas where the top layer is covered with natural vegetation. On the shores of the Indian Ocean and in open spaces further inland, coconut and cashew nut trees are grown. In general, most of the natural vegetation has been cleared to pave way for human settlements and farming. The District has both urban and rural settlings in juxtaposition making the area have a unique geographical outlook.

Temeke Municipality is administratively divided into 3 divisions (Chang'ombe, Mbagala and Kigamboni), 24 wards, 97 streets, 15 villages and 62 hamlets. Furthermore, the district has 4 hospitals, 6 health centers, 105 dispensaries and 2 maternity homes (Temeke Municipal Council (2007). The District has a population of 771 500 of which 389 245 and 382 255 are males and females respectively, and a total of 187 609 households with an average size of 4.6 persons per household. The original inhabitants of the district are the Zaramo and Ndengereko, but due to urbanization the district has become multi-ethnic (URT, 2004).

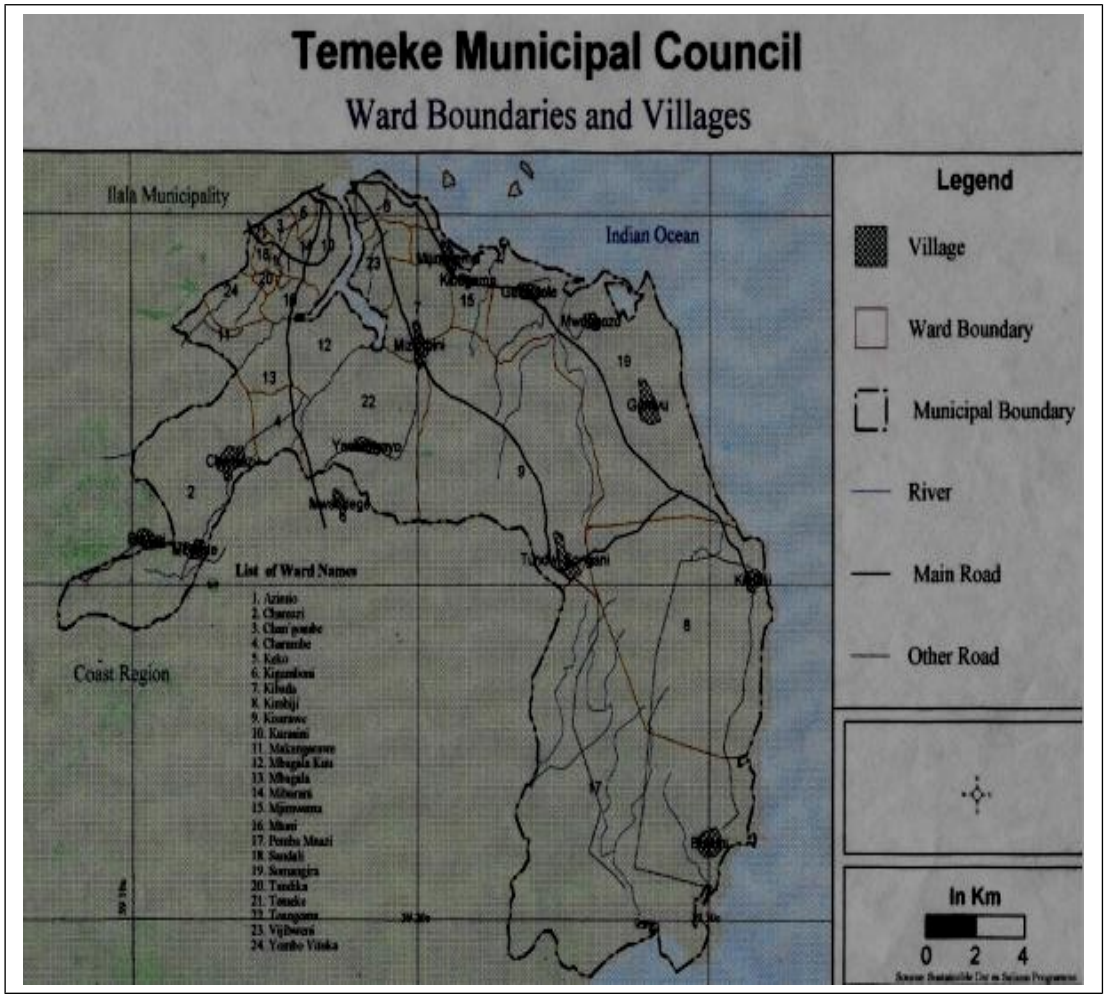

Figure 1: Temeke Municipality

3.2 Study Design

The study was a randomized clinical trial involving Government and Private health centers. A list of health centers was randomly allocated into two groups:

1 Treatment health centers: pregnant women attending to these centers were supplied with Plumpy nut supplement for six months and hereinafter referred to as the Plumpy nut group.

2 Control health center: supplied with maize meal for six months and hereinafter referred to as Non- Plumpy nut group.

The follow up of these groups was carried out monthly at their usual health centers.

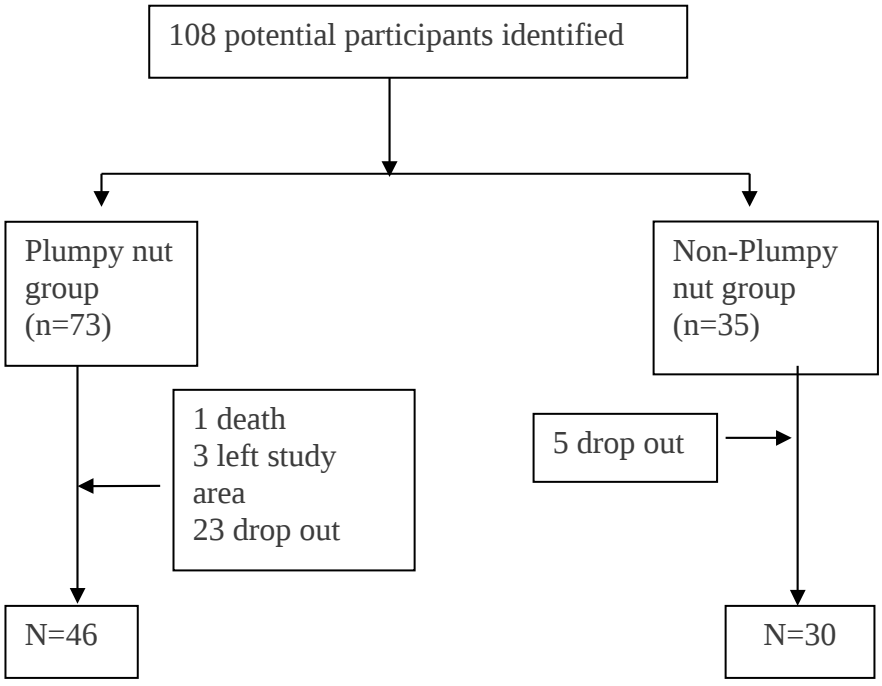

Figure 2: Study Trial Profile

3.3 Study Population

The study population involved women of child bearing age (15-49 years) with gestational age between 20-24 weeks and who were tested and proven to be infected with HIV. This gestational age was used because many pregnant women delay to start antenatal clinic; it was difficult to capture them below that gestational age.

3.3.1 Inclusion criteria

The following inclusion criteria were used to recruit the subjects into the study:

1. HIV positive pregnant women,
2. Gestation age between 20-24 weeks,
3. HIV stage I Persistent generalized swelling of the lymph nodes,
4. HIV stage II Weight loss < 10 percent of body weight,
5. On Antiretroviral treatment or not,
6. Attending one of the selected health centers and planning to deliver in the hospital or in the neighborhood and
7. Women living within Temeke Municipality.

3.3.2 Exclusion criteria

Any HIV positive pregnant woman with the following established medical risk factors for having reduced or excessive birth weight of the neonate was excluded: hypertension, tuberculosis, renal disease, heart disease, urinary tract infection, diabetes mellitus, smoking, women taking alcohol or taking other drugs, women already receiving iron and folic or other micronutrient tablets and aged below 15

years or above 49 years with gestation age less than 20 weeks or above 24 weeks, HIV stage III and IV.

3.4 Study Area Selection

A purposive sampling technique was employed to select the region and district. Temeke district is one of the CSPD catchment sites under UNICEF. Five government health centers namely; Buza, Yombo Vituka, Kigamboni, Tambuka reli and Maji matitu, and four private health centers namely; Consolata sisters, Arafa ugweno, Keko MSD and Chang'ome SDA were randomly selected from a total of 24 health centers.

3.5 Subject Selection

From the selected health centers any HIV positive pregnant woman who met the inclusion criteria was selected to participate in the study.

3.6 Sample Size

An appropriate sample size was calculated using the following formula provided by John, (2003) depending on the following parameters:- minimum expected difference, estimated measurement variability, statistical power, significance criterion and statistical analysis;

$$N = \frac{4\sigma^2 (Z_{crit} + Z_{pwr})^2}{D^2}$$

NB: See Appendix 4 for explanation of letters

One hundred and two HIV positive pregnant women were selected and participated in the study. An attrition rate of 10% was included and a total of 112 subjects were selected when the study started.

3.7 Data Collection Tools

The following were the data collection tools employed in the study; a structured questionnaire, Digital Tanita body composition analyzer (BF-350 Model Tanita Corporation of America. Inc) scale accurate to 0.1 kg, Shorr portable adult height measuring board (Shorr productions, Olney, Maryland, USA) accurate to 0.1cm. Talc insertion tape (Talc Ltd. and St. Albans UK), Hemocue photometer (HemoCue AB Box 1204 SE- 262 23 Ängelholm Sweden) accurate to 0.01 g/dl and Sohnle infant scale (Sohnle, Murrhardt, Germany) accurate to 0.01 kg.

3.8 Data Collection Methods

3.8.1 Interviews

A structured questionnaire was administered to subjects through a face to face interview to obtain information on socio demographic, socio economic, morbidity, and dietary intake data.

3.8.1.1 Food Intake

A 24-hr dietary recall technique was used to collect information on energy, iron and fat consumption at baseline and at the end of the study. Subjects were requested to recall all the dishes, snacks, or other foods eaten during the previous day including food consumed out of home. A detailed list of all the ingredients of the dishes,

snacks, or other foods mentioned, was collected directly from the subject being interviewed and recorded in the questionnaire.

3.8.1.2 Morbidity information

Morbidity information was obtained by requesting the subject to recall the number of times she had fallen sick for the past two weeks from the date of interview and the types of illness she had suffered from during the same period of time. The data obtained were recorded and used to calculate the percentage of diseases and infections, which are commonly affecting HIV positive pregnant women. The sick subjects were referred to the health centers for further medical attention.

3.8.2 Measurements

3.8.2.1 Anthropometric

Weight, height, mid upper arm circumference and total body fat measurements were measured to determine the nutritional status of the individuals.

3.8.2.1.1 Weight

A digital Tanita body composition analyzer (BF-350 Model Tanita Corporation of America. Inc) scale accurate to 0.1 kg was used to measure weight of the subjects. The subject was requested to stand unassisted on the weighing scale and look straight ahead, standing relaxed but still. The subject was requested to wear light clothes. Body weight was recorded to the nearest 0.1 kg.

3.8.2.1.2 Height

A shorr portable adult height measuring board (Shorr productions, Olney, Maryland, USA) was used to measure height. The subject was requested to stand straight with the head positioned such that the Frankfurt plane was horizontal, feet together, knees straight, and heels, buttocks, and shoulder blades in contact with the vertical surface of height board. Hands were hanged loosely at the sides and measurements were recorded to the nearest 0.1 cm.

3.8.2.1.3 MUAC

A TALC insertion tape (Talc Ltd. and St. Albans UK) flexible and non stretchable was used to take MUAC measurements. The subject was requested to stand upright and side way to measurer, with the head in Frankfurt plane, arms relaxed and legs apart. If the subject was wearing a sleeve garment then she would be requested either to remove or to roll up the sleeves. Measurement was taken at the mid point of the upper left arm between the acromium process and the tip of olecranon. After locating the midpoint, the left arm was extended so that it was hanging by the side, with the palm face inwards. The tape was wrapped gently but firmly around the arm at the midpoint, care was taken to ensure that the arm is not squeezed. Measurement was taken to the nearest 0.1cm. MUAC classification indicators are presented in Table 2.

Table 2: MUAC classification

Level of undernutrition	MUAC (cm)
Normal	>18.5
Moderate	16.0-18.5
Severe	< 16.0

Source: Vishwanath, 1998

3.8.2.1.4 Total body fat

The percentage of body fat was determined by bioelectrical impedance analysis technique method using body composition analyzer (BF-350 Model Tanita Corporation of America Inc.). The subject was requested to stand on the body fat scale, without shoes and any metal on the body. This method measures body composition by sending a low, safe electrical current through the body. The current passes freely through the fluids contained in the muscle tissue, but encounters difficulty/resistance when it passes through fat tissue. This resistance of the fat tissue to the current is termed 'bioelectrical impedance', and is accurately measured by the body fat scale.

3.8.3 Biochemical analysis

3.8.3.1 Hemoglobin (Hb) determination

Haemoglobin was determined using the HemoCue technique (HemoCue AB Box 1204 SE- 262 23 Ängelholm Sweden). The HemoCue system consists of disposable microcuvettes, which contain reagents (chemicals) in dried form (sodium deoxycholate) haemolyses the red blood cells, sodium nitrate converts Hb to methaemoglobin, sodium azide converts methaemoglobin to methaemoglobinazide. All standard procedures in blood sampling were followed to avoid contamination. The middle finger of the left hand was used to collect blood sample. Blood sample was drawn from a finger prick by an experienced laboratory technician for hemoglobin concentration determination. The site was punctured using disposable sterile lancets, after the finger had been cleaned with methylated spirit and allowed to dry. The drop of blood was drawn up into microcuvettes by capillary action and

inserted into the HemoCue photometer. The microcuvette with blood was then placed in the portable photometer (light measuring instrument) to determine the Hb concentration. Light was allowed to pass through the sample and absorbance of methaemoglobinazide was measured at 570 nm and 880 nm. The results were displayed after 45 to 60 seconds in g/dl on an LCD display. Subjects were categorized into different categories according to their hemoglobin concentration based on WHO/UNICEF/UNU (2001) classification for pregnant women (Table 3).

Table 3: Classification of Haemoglobin concentration for pregnant women

Class	Hemoglobin concentration (g/dl)
Normal	>11.0
Mild anaemia	10-10.9
Moderate anaemia	7.0-9.9
Severe anaemia	<7.0

Source: WHO/UNICEF/UNU, 2001.

3.9 Birth Weight

Birth weight of the baby was determined to the nearest 0.01 kg by using a Sohnle infant scale (Sohnle, Murrhardt, Germany) and the baby was weighed naked. Birth weight of the baby was recorded within 72 hrs after birth and was classified using the UNICEF and WHO, (2004) criterion (Table 4).

Table 4: Birth weight classification

Classification	Birth weight (g)
Low birth weight	Below 2500
Normal	2501 - 4500
Large birth weight	4501 and above

Source: UNICEF and WHO, 2004

3.10 Intervention

Daily dietary intake of the Plumpy nut group was supplemented with Plumpy nut while Non-Plumpy nut group was given maize meal as a gesture of appreciation for participating in the study.

3.10.1 Plumpy nut

Plumpy nut is a ready to use therapeutic food in the form of a spread. It is used to treat severe or moderate malnutrition. It has a low surface area to volume ratio. This means a reduced exposure to oxygen and longer shelf life compared to powdered products. It can be eaten without water. It is not a water-soluble and its water-soluble ingredients are released from the stomach more slowly. This minimizes problems associated with high osmolarity.

Composition of Plumpy nut

Plumpy nut is composed of vegetable fat, peanut paste, skimmed milk powder, malto-dextrin, sugar, and mineral and vitamin complex as shown in Table 5. Plumpy nut does not contain any genetically modified organisms (GMO) or ingredients of animal origin, apart from milk products.

Table 5: Nutrient content of plumpy nut

Nutrient	Unit	Sachet of 92 g	Nutrient	Unit	Sachet of 92 g
Energy	kcal	500	Vitamin A	mcg	840
Proteins	g	12.5	Vitamin D	mcg	15
Lipids	g	32.86	Vitamin E	mg	18.4
Calcium	mg	276	Vitamin C	mg	49
Phosphorus	mg	276	Vitamin B1	mg	0.55
Potassium	mg	1022	Vitamin B2	mg	1.66
Magnesium	mg	84.6	Vitamin B6	mg	0.55
Zinc	mg	12.9	Vitamin B12	mcg	1.7
Copper	mg	1.6	Vitamin K	mcg	19.3
Iron	mg	10.6	Biotin	mcg	60
Iodine	mcg	92	Folic acid	mcg	193
Selenium	mcg	27.6	Pantothenic acid	mg	2.85
Sodium	mg	<267	Niacin	mg	4.88

Source: Nutriset, 2006

Dosage and administration

Each subject was provided with 92 g of Plumpy nut per day. Subjects were given verbal instructions on the consumption of the product. The instructions insisted that the product is to be taken with food so as to ensure maximum absorption of nutrients and not to substitute the product with normal meals.

3.10.2. Maize meal

The maize meal was provided to the Non-Plumpy nut group on a weekly basis. The storage of the product was at room temperature. Nutrient content of 100 g edible portions of maize meal are presented in Table 6.

Table 6: Nutrient content of maize meal

Nutrient	Unit	Amount per 100 g
Energy	Kcal	345
Protein	g	9.4
Fat	g	4.2
Carbohydrates	g	72
Calcium	mg	16
Iron	mg	36
Phosphorous	mg	220
Potassium	mg	250
Sodium	mg	5
Vitamin B1	mg	0.33
Vitamin B2	mg	0.10
Vitamin B6	mg	0.20
Niacin	mg	2.2

Source: Burlingame, 2010

Dosage and administration

Each subject was provided with a packet of 2 kg maize meal per week. They were given verbal instructions on the product consumption, in that it can be consumed in the form of stiff porridge or thin porridge and as part of the household meal.

3.11 Data Analysis

Data were collected and edited (to detect errors, omissions and to correct where applicable) after a follow up of that particular day's work. Birth weight and nutritional status of the mother were the primary outcome variables. Baseline variables and outcome measures were compared by unpaired student *t* test for continuous variables and the χ^2 test or fisher exact test for categorical variables. To determine the differences among group of subjects, multiple regression analysis was performed for continuous dependent variables (i.e. birth weight), Statistical

significance was defined as a 2-tailed $p<0.05$. The data analysis was performed using Statistical Package for Social Sciences (SPSS) version 11.5.

3.12 Ethical Consideration

Permission to conduct this research was obtained from the National Institute for Medical Research (NIMR), Ethics Committee in Tanzania. The consent forms explaining the purpose of the study, potential risks or discomfort, the rights of the subjects and the benefits to them were available both in English and in the Kiswahili languages (Appendix 1) and participant signed the agreement form before being enrolled into the study. At the end of the study, the subjects in the group that did not receive plumpy nut were given Plumpy nut for one month so as to improve their nutritional status but no data was collected on this group.

CHAPTER FOUR

4.0 RESULTS

4.1 Demographic and Socio Economic Characteristics of Subjects

The demographic and socio economic characteristics of the subjects included age, education and occupation, marital status and gestational age. Symbols used in this section are P which stands for all HIV+ pregnant women who were receiving Plumpy nut and NP which stands for all HIV+ pregnant women who were not receiving Plumpy nut. SD stands for standard deviation, which shows how the group deviates from the mean. The word subject as used in this chapter stands for all HIV+ pregnant women who participated in the study. Some of the graphs show gestation age of 43 weeks and 44 weeks which is abnormal for pregnant women this is because some of the women were not sure of the date of when they conceive.

4.1.1 Age

The mean age for all subjects was 27.7 ± 6.0 years. The mean age of those receiving Plumpy nut was 28.2 ± 5.9 years and 26.7 ± 6.1 years for the group of subjects which did not receive Plumpy nut. The age range of about 59% of the subjects who participated in the study was between 25-35 years (63% for subjects who received Plumpy nut and 52% for subjects who did not receive Plumpy nut) (Table 7).

Table 7: Age of subjects

Age (year)	P		NP		TOTAL	
	n	%	n	%	n	%
≤24	19	26	13	37.1	32	29.6
25-35	46	63	18	51.4	64	59.3
≥ 36	8	11	4	11.4	12	11.1
Total	**73**	**100**	**35**	**100**	**108**	**100**

P=Plumpy nut group, NP= Non Plumpy nut group

4.1.2 Gestational age, marital status, education level and occupation

The mean gestational age of the subjects was 22.7±1.3 weeks at the beginning of the study and they were followed up until delivery. The mean gestational age of the subjects who received Plumpy nut was 23.1 ± 1.2 weeks (22-24 weeks) and it was 22.6±1.3 weeks (22-24 weeks) for those who did not receive Plumpy nut. About 65% of the subjects were married (66% of those received Plumpy nut and 63% did not receive Plumpy nut). Only 1% of the subjects who received Plumpy nut were divorced and none in subjects who did not receive Plumpy nut. The highest level (62%) of education attained by subjects was primary education. Of the participants who had primary education, 75% received Plumpy nut where as 34.3% of the subjects in this category did not receive Plumpy nut. However 40% of subjects in Non Plumpy nut group had no formal education. About 57% of subjects were unemployed and 0.9% were peasants (Table 8).

4.1.3 Source of food

About 95% of the subjects do not grow their own food for consumption rather they do depend on purchasing it at the local markets (Table 8).

Table 8: Marital status, Education, Occupation and Source of food of subjects

Variable		P		NP		Total	
		n	**%**	**n**	**%**	**n**	**%**
Marital status	Married	48	65.8	22	62.9	70	64.8
	Unmarried	24	32.9	13	37.1	37	34.2
	Divorced	1	1.4	-	-	1	0.9
	Total	**73**	**100**	**35**	**100**	**108**	**100**
Education	No formal education	7	9.6	14	40	21	19.4
	Adult education	2	2.7	2	5.7	4	3.7
	Primary education	55	75.3	12	34.3	67	62.0
	Secondary education	9	12.3	7	20	16	14.8
	Total	**73**	**100**	**35**	**100**	**108**	**100**
Occupation	Unemployed	40	54.8	22	62.9	62	57.4
	Formal employment	15	20.5	10	28.6	25	23.1
	Small business	17	23.2	3	8.6	20	18.5
	Peasant/farmer	1	1.4	0	0	1	0.9
	Total	**73**	**100**	**35**	**100**	**108**	**100**
Source of food.	Remittances	1	1.4	-	-	1	0.9
	Own Production	4	4	-	-	4	3.7
	Market	68	93.2	35	100	103	95.4
	Total	**73**	**100**	**35**	**100**	**108**	**100**

P=Plumpy nut group, NP= Non Plumpy nut group

4.2 Characteristics of the Subjects

The characteristics of the subjects reported here include both physical and biochemical ones. Physical characteristics included weight, height, MUAC, and total body fat; and biochemical characteristics included Haemoglobin concentration only. In this section the characteristics are presented in two parts. Part one presents the characteristics of the subjects at baseline. Part two presents characteristics of the subjects after being supplemented according to the gestation age at the point of recruitment. The measurements were taken after every four weeks.

4.2.1 Physical characteristics at baseline

4.2.1.1 Weight

The mean weight of the subjects was 61.7 ± 10.6 kg (44.0 - 93.4 kg). The mean weight of the subjects who were to receive Plumpy nut was 60.95 ± 11.03 kg (45-93.4 kg) and 62.97 ± 12.32 kg (44.0 – 90.0 kg) for the subjects who were not to receive Plumpy nut.

4.2.1.2 Height

The subjects mean height was 158.4 ± 5.9 cm (140.3 - 185.0 cm). The mean height of the subjects who were to receive Plumpy nut was 158.35 ± 5.80 cm (140.3 - 173.4 cm) and 158.6 ± 6.11 cm (148.0 -185.0 cm) for the subjects who were not to receive Plumpy nut.

4.2.1.3 Mid upper arm circumference

The mean MUAC was 27±3.7 cm (16.8 - 37.8 cm). The mean MUAC were 27.38±3.59 cm (16.8 -37.8 cm) and 27.47±3.89 cm (19.2-35.8 cm) for the subjects who were to receive Plumpy nut and for those who were not to receive Plumpy nut repectively.

4.2.1.4 Total body fat

The mean total body fat was 25.5±7.2% (10.4 - 42.7%). The mean total body fat was 25.09±7.67% (10.4-42.7%) and 26.33±6.23% (18.7-41.7%) for subjects who were to receive Plumpy nut and who were not to receive Plumpy nut respectively.

4.2.2 Biochemical characteristics at baseline

4.2.2.1 Haemoglobin concentration

The mean Hemoglobin concentration at baseline was 8.8±1.8 g/dl (4.8 - 14.8g /dl). The mean hemoglobin concentration of the subjects who were to receive Plumpy nut was 8.37±1.82 g/dl (4.8-14.8 g/dl) and for those who were not to receive Plumpy nut was 9.68±1.51 g/dl (6.6-14.2 g/dl).

4.2.3 Effect of supplementation on nutritional status of subjects

4.2.3.1 Weight

4.2.3.1.1 Weight of subjects recruited at 20 weeks

Throughout the study the subjects in the Non-Plumpy nut group had more weight than those in the Plumpy nut group except at 20 (60.8 kg for P and 60.7 kg for NP) weeks. The subjects in the Plumpy nut group gained mean weight until they were 24 weeks (61.4 kg) and lost mean weight at 28 weeks (55.2 kg). They then started to gain mean weight at 36 weeks (58.3 kg) until the end of study. The weight difference between subjects in the Plumpy nut group and subjects in the Non-Plumpy nut group was not statistically significant throughout the study (Fig. 3).

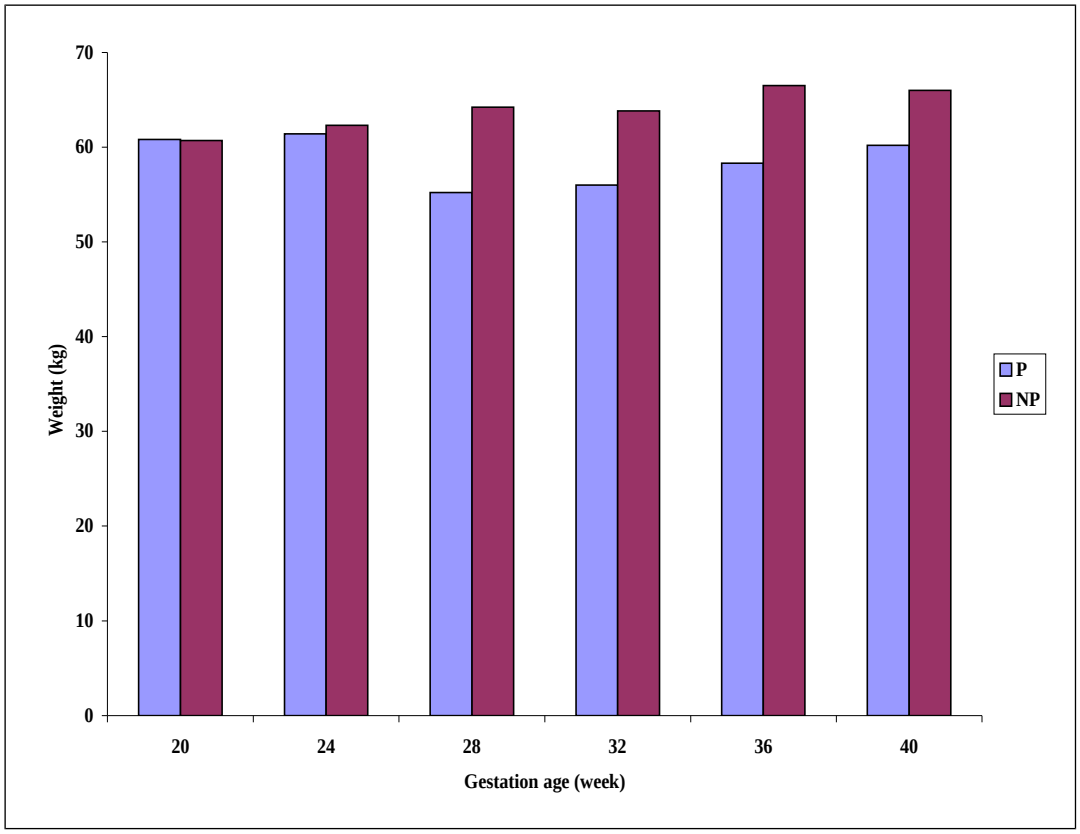

Figure 3: Mean gestational weight of subjects recruited at 20 weeks

4.2.3.1.2 Weight of subjects recruited at 21 weeks

The mean weight of subjects in the Plumpy nut group was consistently higher than that of subjects in the Non plumpynut group throughout the study except at 25 weeks (65.2 kg for P subjects and 65.3 kg for NP subjects). The subjects in the Plumpy nut group gained weight throughout the study and the subjects in the Non-Plumpy nut group had their weight under fluctuations throughout the study. There was no subject in the Plumpy nut group at 41 weeks because all of them had delivered. Throughout the entire period of study the mean weight of the subjects recruited at 21 weeks, the differences found were not statistically significant (Fig. 4).

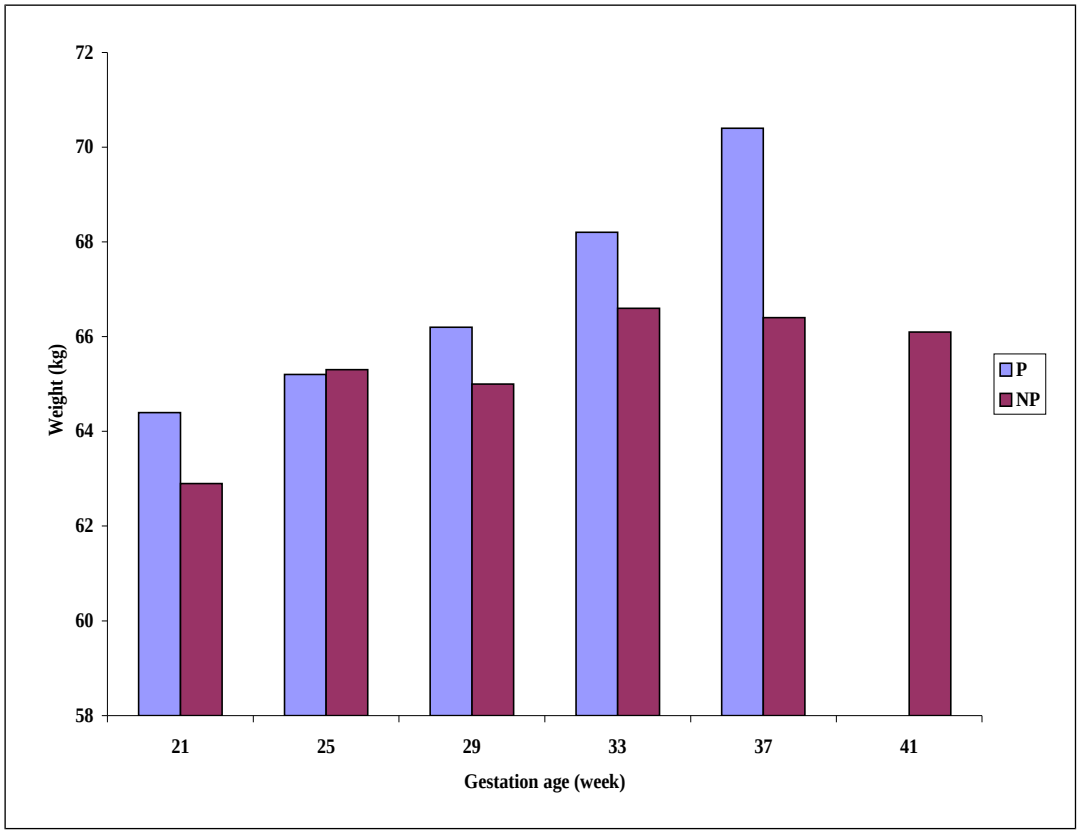

Figure 4: Mean gestational weight of subjects recruited at 21 weeks

4.2.3.1.3 Weight of subjects recruited at 22 weeks

Subjects in the Plumpy nut group had more weight than those in the Non-Plumpy nut group throughout the study except at 22 weeks (64.9 kg for subjects in Plumpy nut group and 65.4 kg for subjects in Non Plumpy nut group). At the gestational age of 42 weeks subjects in the Plumpy nut group had their weight at the peak (83.7 kg) and at 38 week was Non-Plumpy nut group (69.1 kg). At gestational age of 42 weeks there were no subjects in the Non-Plumpy nut group as all of them had delivered. Though Plumpy nut group was having a higher mean weight throughout the study, the differences in weight observed between them and the other group were not statistically significant (Fig. 5).

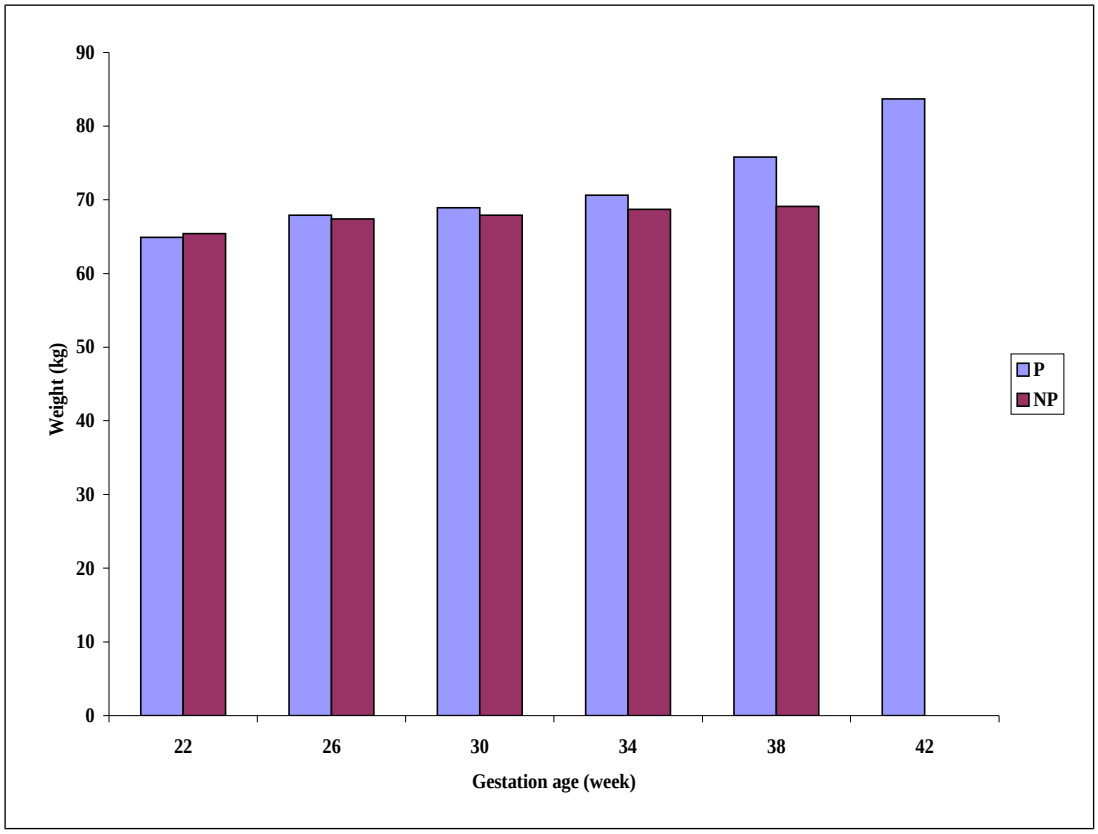

Figure 5: Mean gestational weight of subjects recruited at 22 weeks

4.2.3.1.4 Weight of subjects recruited at 23 weeks

Mean gestational weight for both groups was at peak at 43 weeks with 67.8 kg and 60.8 kg for subjects in the Plumpy nut and Non-Plumpy nut groups respectively. Subjects in the Plumpy nut group consistently maintained a higher mean weight throughout the study. Observed mean weight differences between Plumpy nut and Non Plumpy nut groups were not statistically significant (Fig. 6).

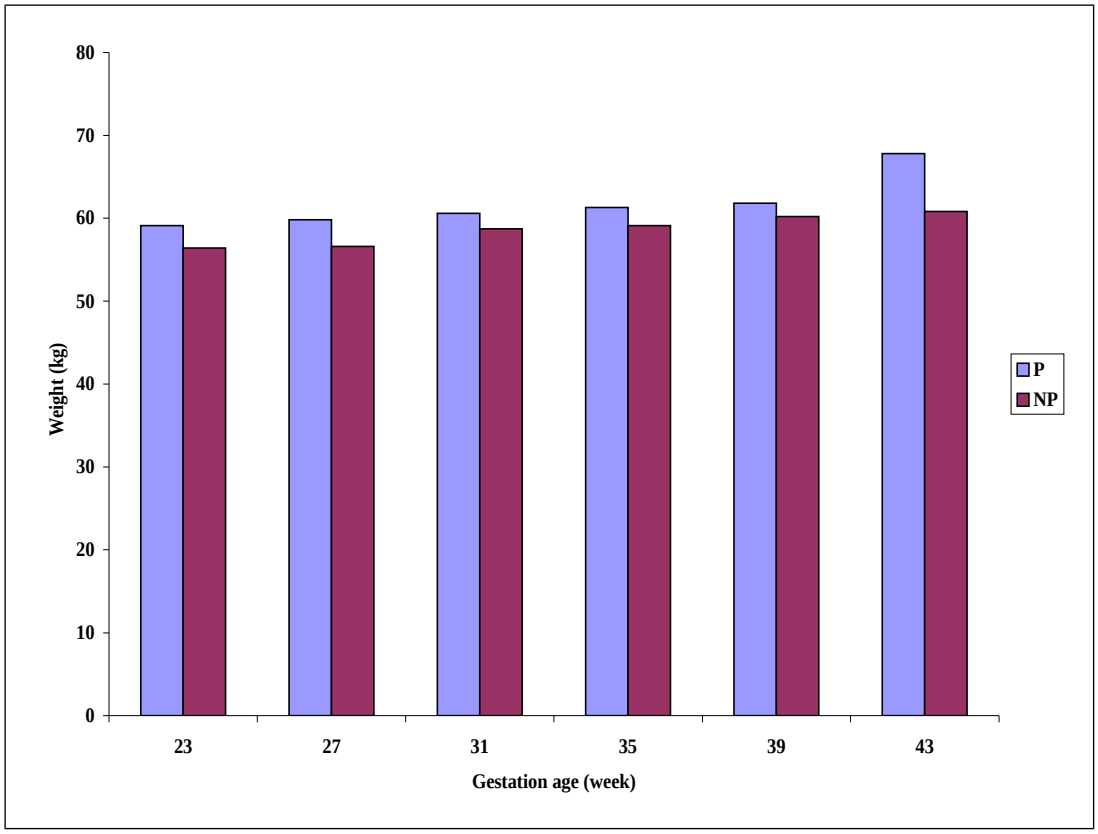

Figure 6: Mean gestational weight of subjects recruited at 23 week

4.2.3.1.5 Weight of subjects recruited at 24 weeks

Throughout the study subjects in the Plumpy nut group were found to have higher mean weight than was the case with subjects in the Non-Plumpy nut group. Subjects in the Non-Plumpy nut group lost mean weight at 28 weeks (59.4 kg) and started to gain at 32 weeks (60.4 kg) up to 36 weeks (61.6 kg). At 36 weeks both groups had a peak mean weight of 64.2 kg and 61.6 kg for subjects in the Plumpy nut group and those in the Non-Plumpy nut group respectively, thereafter at 40 weeks they started to loose the mean to 60.6 kg and 60.1 kg for subjects in the Plumpy nut and those in the Non Plumpy nut groups, respectively, towards the end of study. The observed differences in weight of the subjects between groups were not found to be statistically significant (Fig. 7).

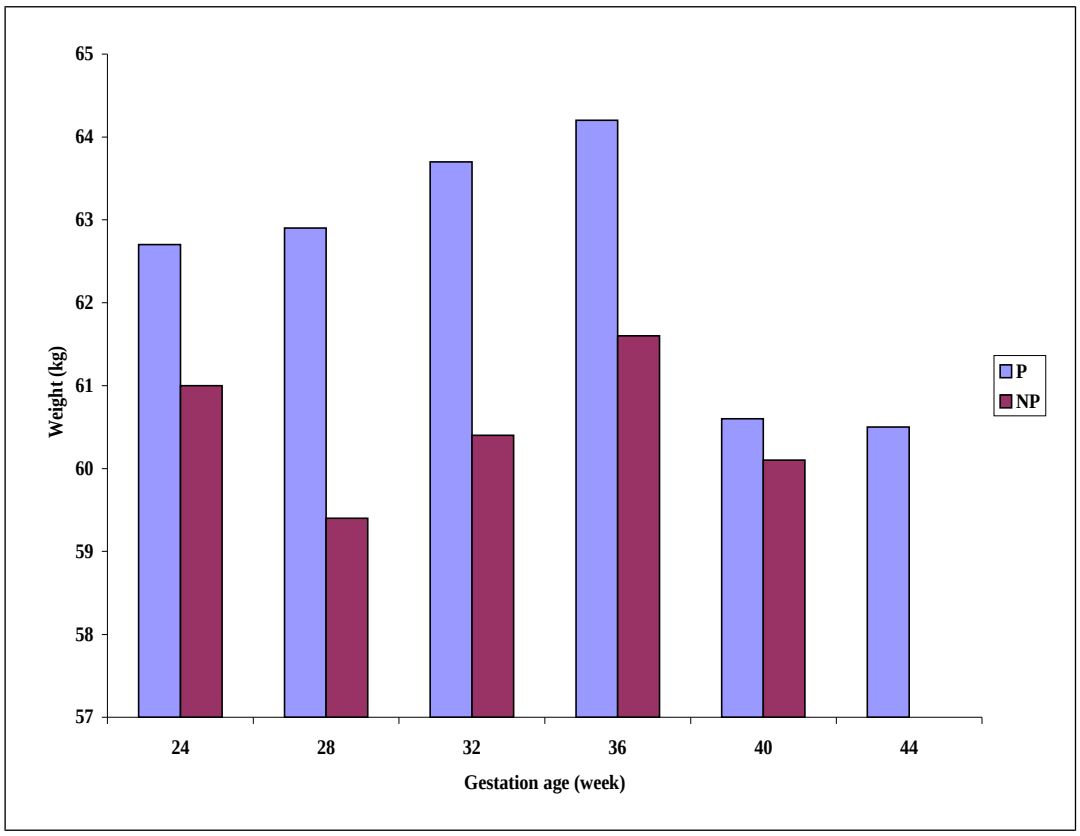

Figure 7: Mean gestational weight of subjects recruited at 24 weeks

4.2.3.2 Mid upper arm circumference (MUAC)

4.2.3.2.1 MUAC for subjects recruited at 20 weeks

The mean MUAC for subjects in the Non-Plumpy nut group was higher throughout the study except at 40 weeks where the subjects in the Plumpy nut group had higher mean MUAC (26.2 cm) than those in the Non-Plumpy nut group (25.8 cm). The subjects in the Plumpy nut group increased mean MUAC until in the 28 week (24.1 cm) when had remained constant for 8 weeks until in the 36 week (24.2 cm) and started to pick up again and reached its peak at 40 weeks (26.2 cm). There was no statistically significant differences observed between Plumpy nut and Non Plumpy

nut groups in MUAC throughout the study for subjects who joined with 20 weeks gestation age (Fig. 8).

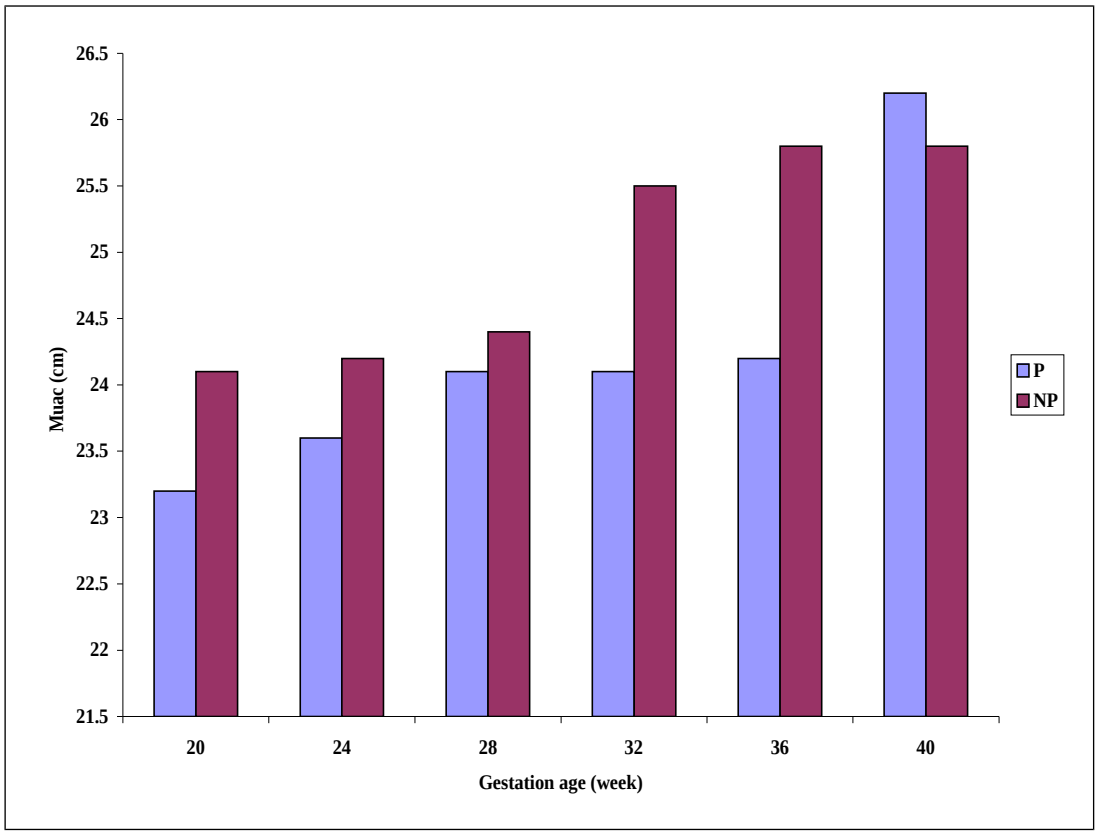

Figure 8: Mean MUAC of subjects recruited at 20 weeks

4.2.3.2.2 MUAC for subjects recruited at 21 weeks

Throughout the study subjects in the Plumpy nut group were found to have higher mean MUAC than the subjects in the Non-Plumpy nut group. Both groups were increasing their mean MUAC throughout the study with a mean difference of 1.6 cm for subjects in the Plumpy nut group and 0.6 cm for subjects in the Non-Plumpy nut group. There was no subject in the Plumpy nut group at 41 weeks as all of them had delivered. The observed differences in MUAC between Plumpy nut and Non Plumpy nut groups were not statistically significant (Fig. 9).

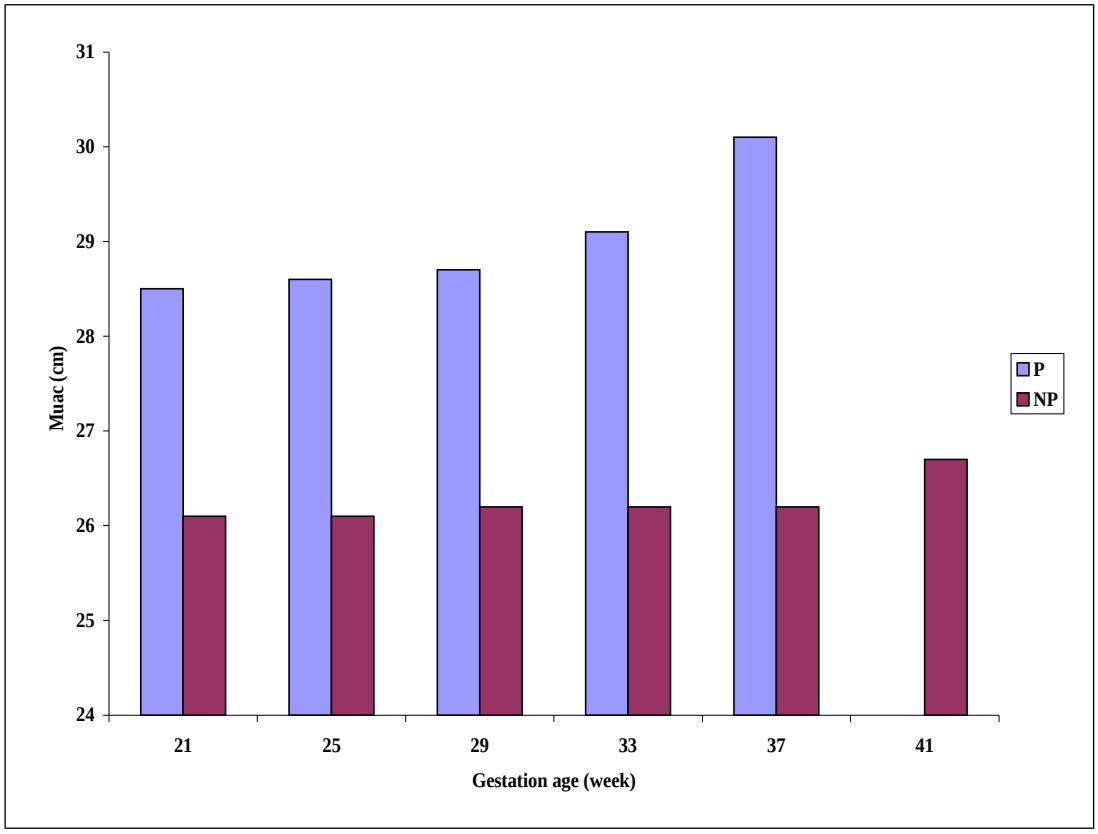

Figure 9: Mean MUAC of subjects recruited at 21 weeks

4.2.3.2.3 MUAC for subjects recruited at 22 weeks

Subjects in the Plumpy nut group were having a higher mean MUAC than those in the Non-Plumpy nut group throughout the study except at 22 weeks where the subjects in the Non Plumpy nut group had a mean MUAC of 28.2 cm and those in the Plumpy nut group had a mean MUAC of 27.3 cm. At 30 weeks subjects in the Plumpy nut group (28.4 cm) lost its MUAC and regained it at 34 weeks (28.8 cm). At 42 week there were no subjects in Non-Plumpy nut group as they had already given birth. There was no statistically significant difference observed between the groups throughout the study (Fig. 10).

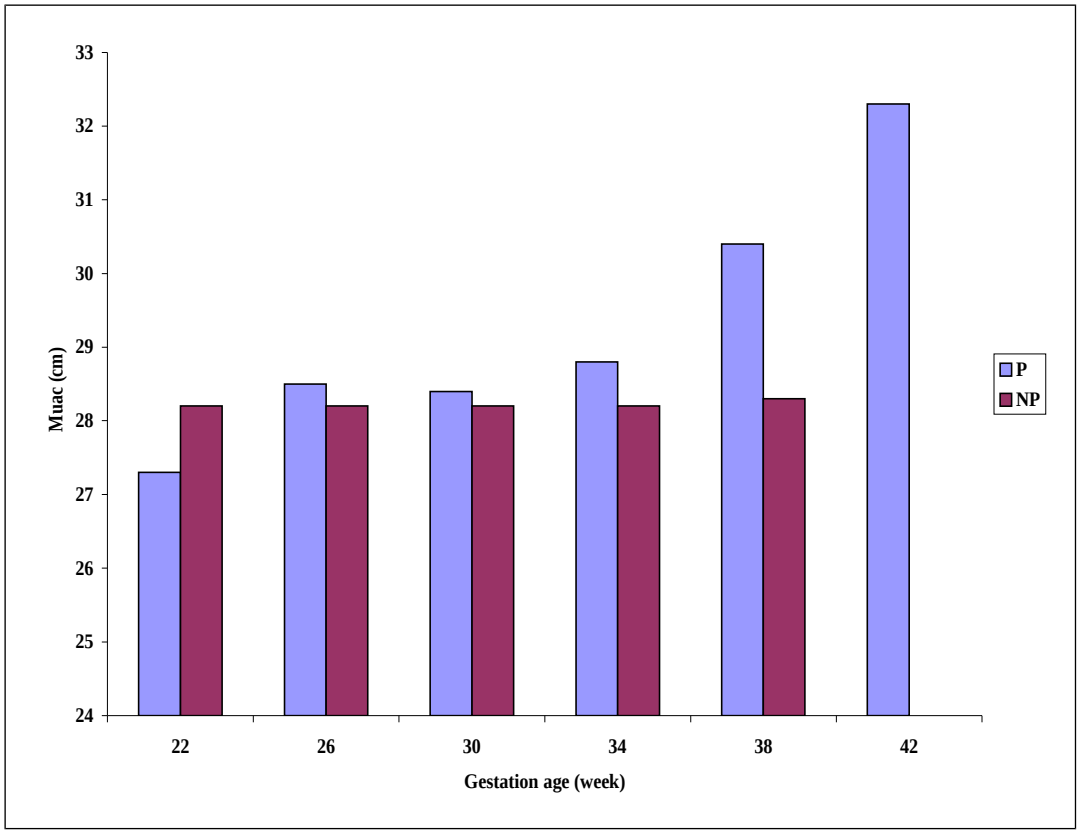

Figure 10: Mean MUAC of subjects recruited at 22 weeks

4.2.3.2.4 MUAC for subjects recruited at 23 weeks

The subjects in the Plumpy nut group started with a wide (27.6 cm) MUAC than those in the Non-Plumpy nut group (26.0 cm) and remained so throughout the study. Subjects in both groups had been increasing their mean MUAC up to the end of the study. Though mean MUAC for subjects in the Plumpy nut group was higher than the mean MUAC of those in the Non-Plumpy nut group, the difference was not statistically significant (Fig. 11).

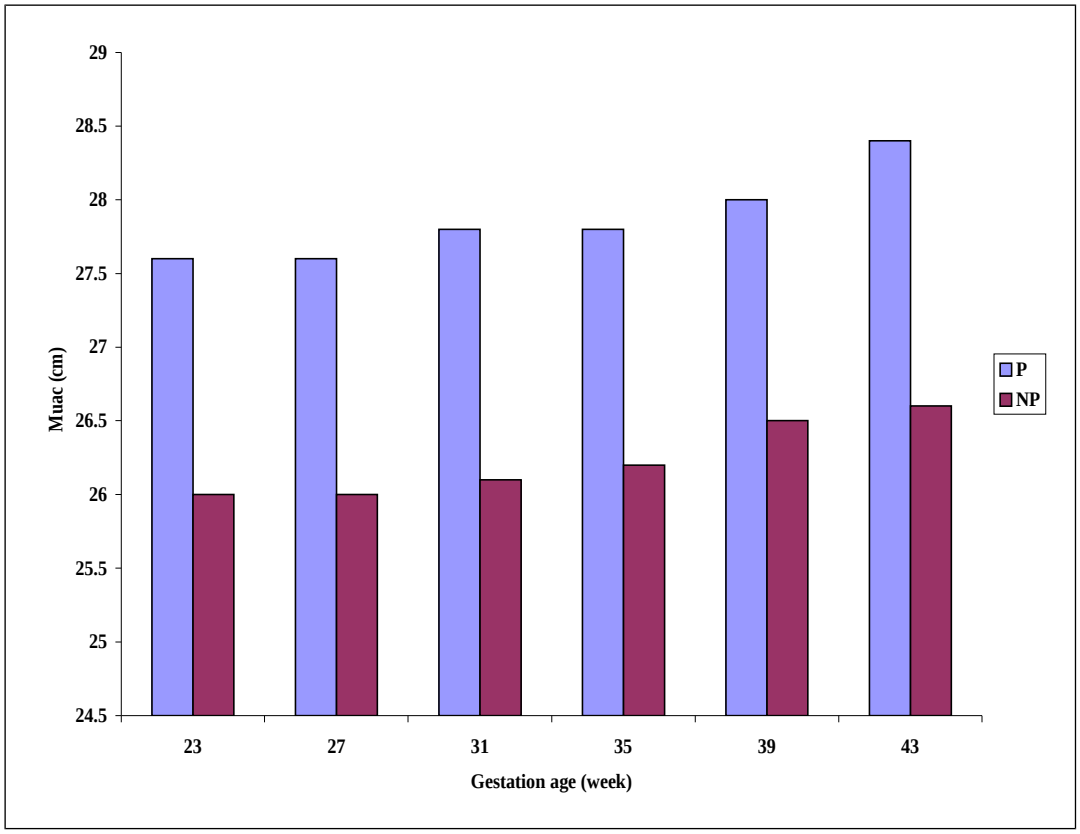

Figure 11: Mean MUAC of subjects recruited at 23 weeks

4.2.3.2.5 MUAC for subjects recruited at 24 weeks

Throughout the study, the subjects in the Plumpy nut group were having higher mean MUAC than those in the Non-Plumpy nut group. At 32 weeks (27.8 cm) towards 40 weeks (26.6 cm) those in the Plumpy nut group lost their mean MUAC but regained it at 44 weeks (27.2 cm). The subjects in the Non-Plumpy nut group reached their peak mean MUAC at 28 weeks (26.4 cm) and lost some of it at 32 weeks (26.1 cm); they started to regain the mean MUAC at 36 weeks (26.2 cm) towards the end of study. Though the mean MUAC for subjects in the Plumpy nut group was higher than mean MUAC for subjects in the Non-Plumpy nut group, there was no statistically difference found between the groups (Fig. 12).

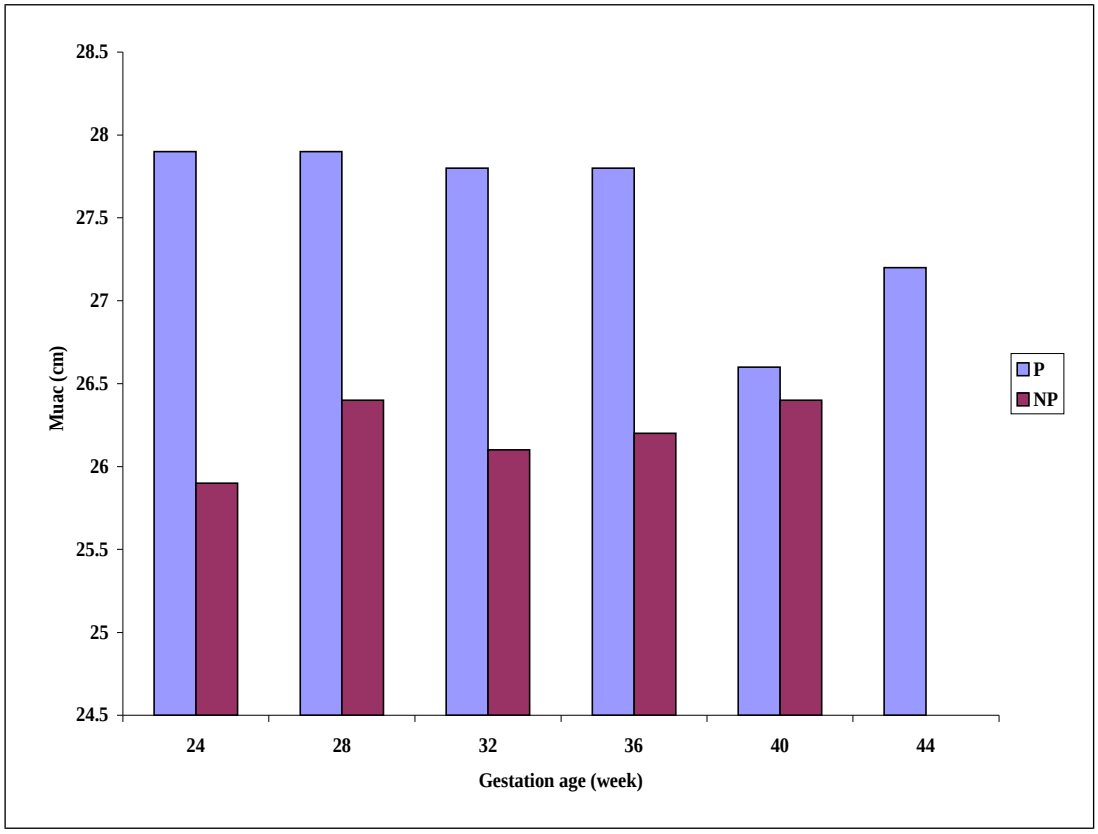

Figure 12: Mean MUAC of subjects recruited at 24 weeks

4.2.3.3 Total body fat

4.2.3.3.1 Total body fat of subjects recruited at 20 weeks

The subjects in the Non-Plumpy nut group who recruited at 20 weeks gestation age were having high amount of total body fat (31.5%) compared to subjects in the Plumpy nut group (19.3%) of the same gestational age throughout the study. Subjects in the Plumpy nut group gained total body fat throughout the study (19.3% at 20 weeks, 22.8% at 24 weeks, 24.3% at 28 weeks, 25.3% at 32 through 36 weeks and 25.9% at 40 weeks) while subjects in the Non-Plumpy nut group reached their peak at 28 weeks (34.8%) and thereafter started to decline towards the end of the

intervention (34.4% at 32 weeks, 33.0% at 36 weeks and 33.0% at 40 weeks). There was no statistically significant difference among the subjects in the two groups throughout the study (Fig. 13).

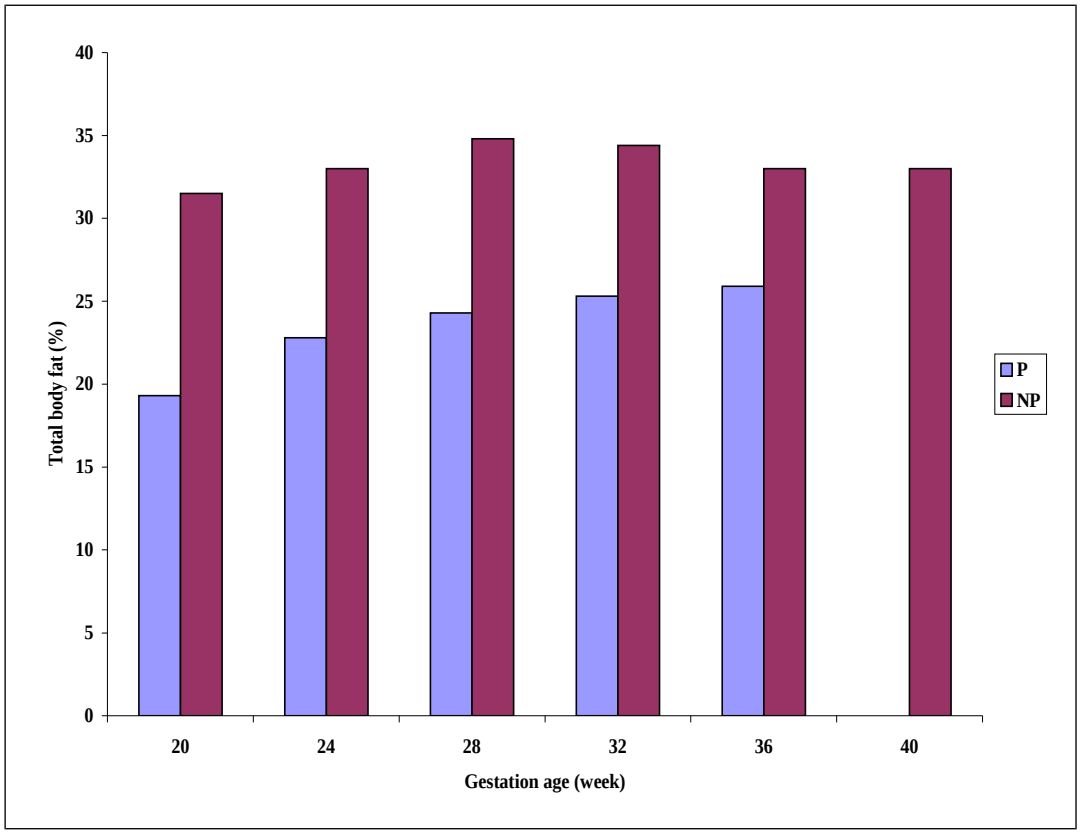

Figure 13: Mean gestational total body fat of subjects recruited at 20 weeks

4.2.3.3.2 Total body fat of subjects recruited at 21 weeks

Throughout the study, the subjects in the Plumpy nut group were having higher mean total body fat than those in the Non-Plumpy nut group. The mean total body fat of subjects in the Plumpy nut group increased from 26.6% at 21 weeks to 34.9% at 37 weeks. Mean body fat for subjects who did not receive plumpynut increased

from 24% at 21 weeks to 29% at 29 weeks. However, body fat declined to 27% at 33 weeks. The differences in mean total body fat for subjects recruited at 21 weeks were not found statistically significant between the two groups (Fig. 14).

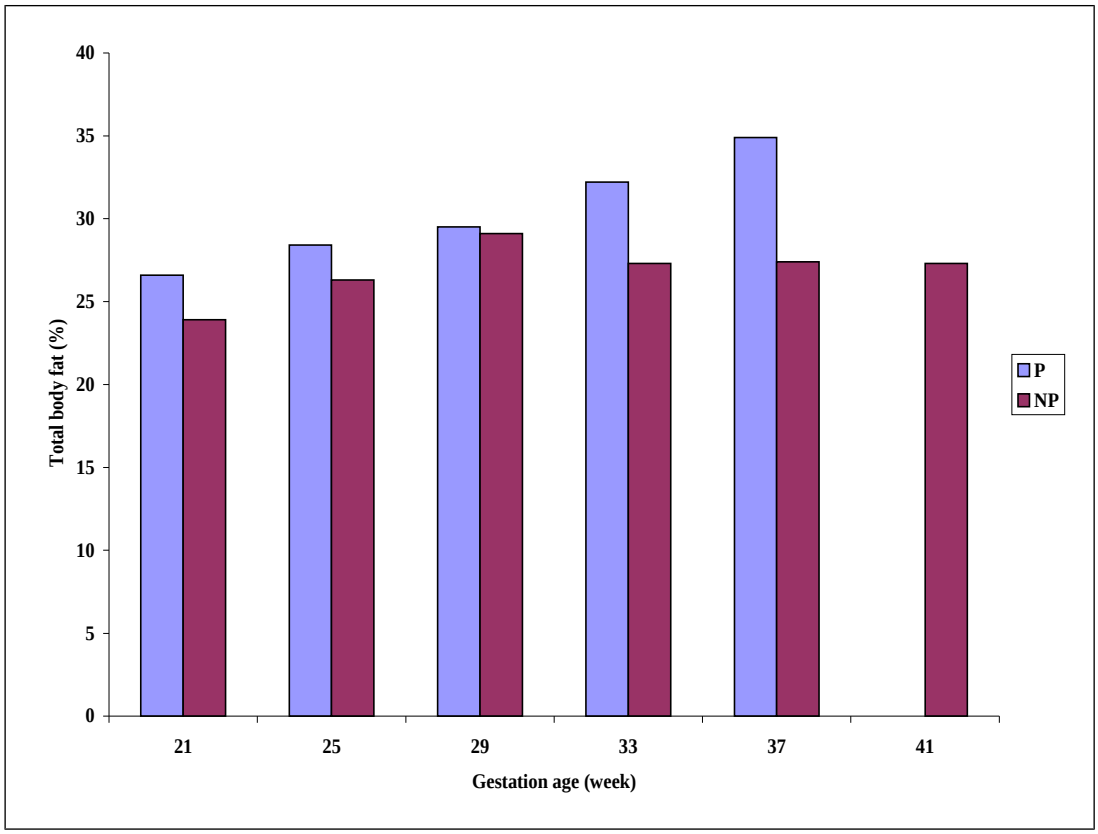

Figure 14: Mean gestational total body fat of subjects recruited at 21 weeks

4.2.3.3.3 Total body fat of subjects recruited at 22 weeks

The subjects in the Non-Plumpy nut group were having higher mean total body fat than those in the Plumpy nut group only from 22 weeks (27.8%) to 26 weeks (28.9%), however, thereafter subjects in the Plumpy nut group outweighed those in the Non-Plumpy nut group. The mean total body fat for subjects in the Plumpy nut

group was increasing throughout the study period. The mean total body fat for subjects in the Non-Plumpy nut group was increasing but at a slower rate. At 42 week there were no subjects in the Non-Plumpy nut group as they had already given birth. Statistical significance between subjects recruited at 22 weeks in Plumpy nut and Non Plumpy nut groups was not found throughout the study (Fig. 15).

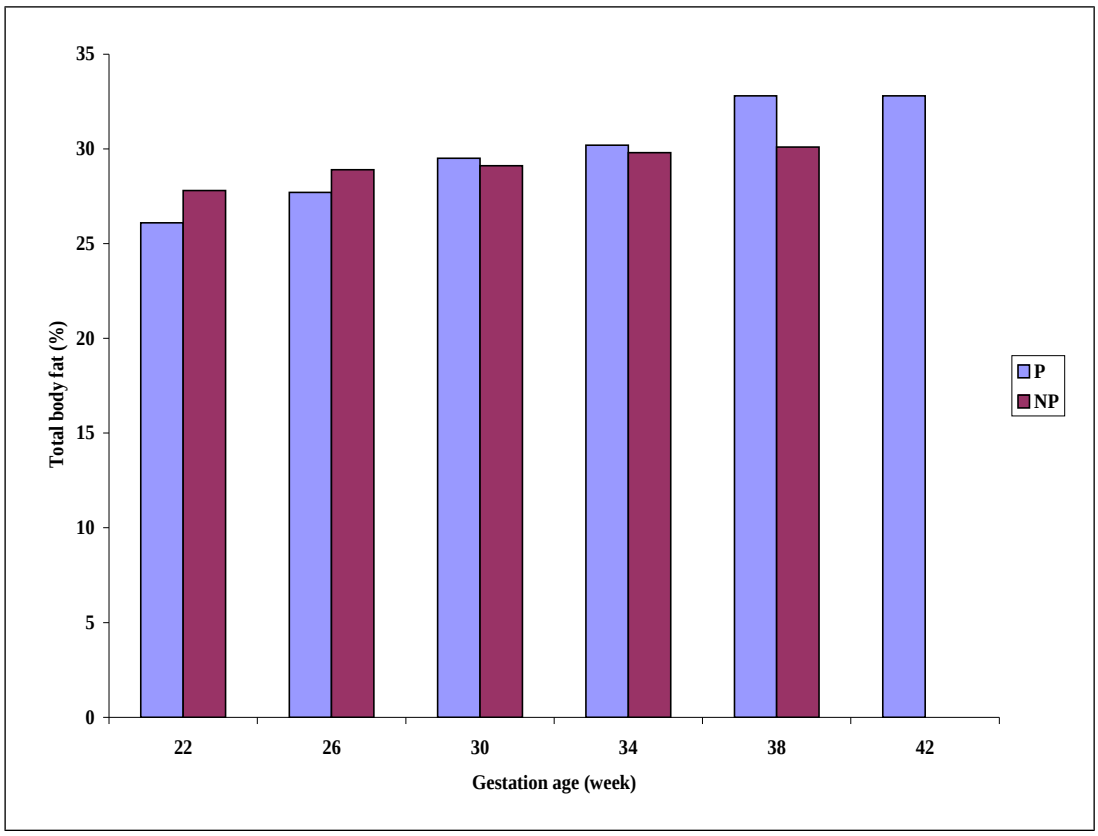

Figure 15: Mean gestational total body fat of subjects recruited at 22 weeks

4.2.3.3.4 Total body fat of subjects recruited at 23 weeks

Subjects in the Non-Plumpy nut group gained their mean total body fat from 23 (23.7%) to 35 (26.7%) weeks. but started to loose it at 39 (26.6%) weeks towards the end of the study as some started giving birth and breastfeeding. For subjects in the Plumpy nut group were gaining mean total body fat throughout the study period.

The observed differences between groups were however not found statistically significant ($p<0.05$) (Fig. 16).

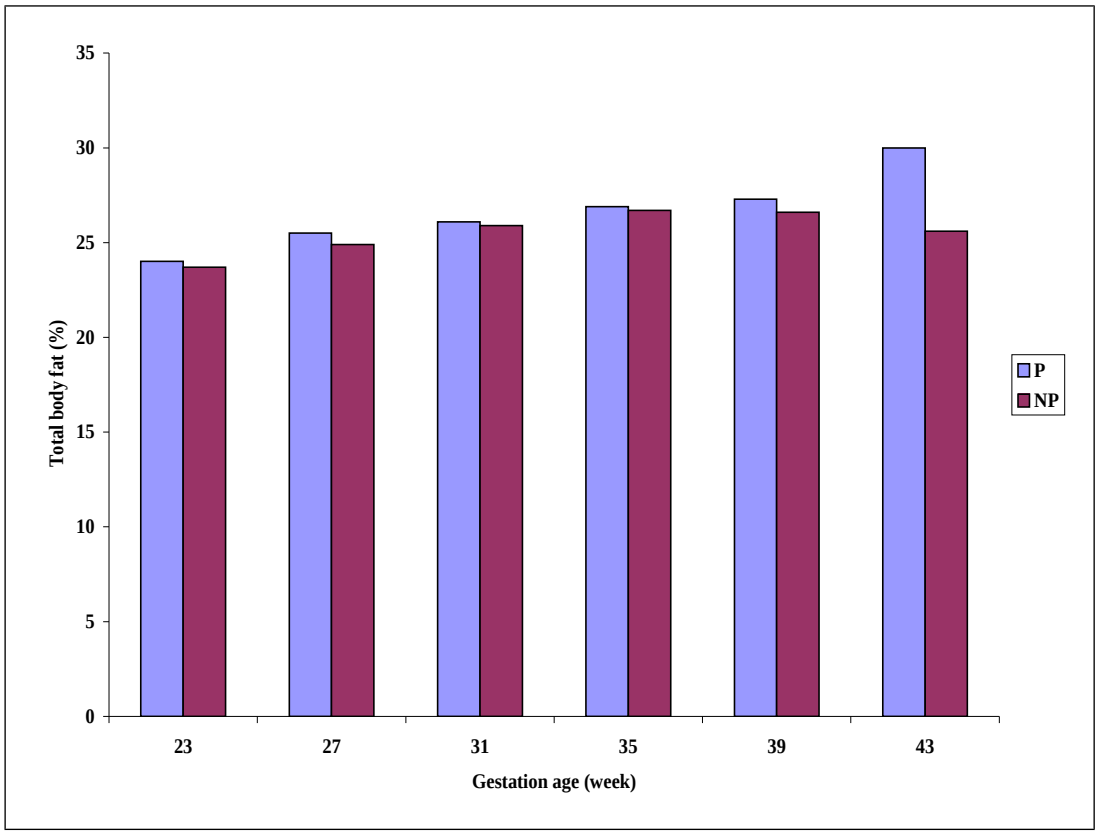

Figure 16: Mean gestational total body fat of subjects recruited at 23 weeks

4.2.3.3.5 Total body fat of subject recruited at 24 weeks

The subjects in the Non-Plumpy nut group were found to have higher mean total body fat compared to those in the Plumpy nut group throughout the study period except at 32 weeks where subjects in both groups droped their fat by 27.7% and 27.1% for subjects in the Plumpy nut and Non Plumpy nut groups respectively. There was a mean increase in total body fat for subjects in the Plumpy nut group from 25.6% at 24 weeks to 27.9% at 32 weeks and decreased thereafter from 27.3% at 40 weeks towards the end of study. The subjects in the Non-Plumpy nut group

had their mean total body fat increased from 26.4% at 24 weeks to 27.2% at 28 weeks and decreased to 27.1% at 32 weeks but increased again towards the end of the study. The observed difference between groups was not found statistically significant (Fig. 17).

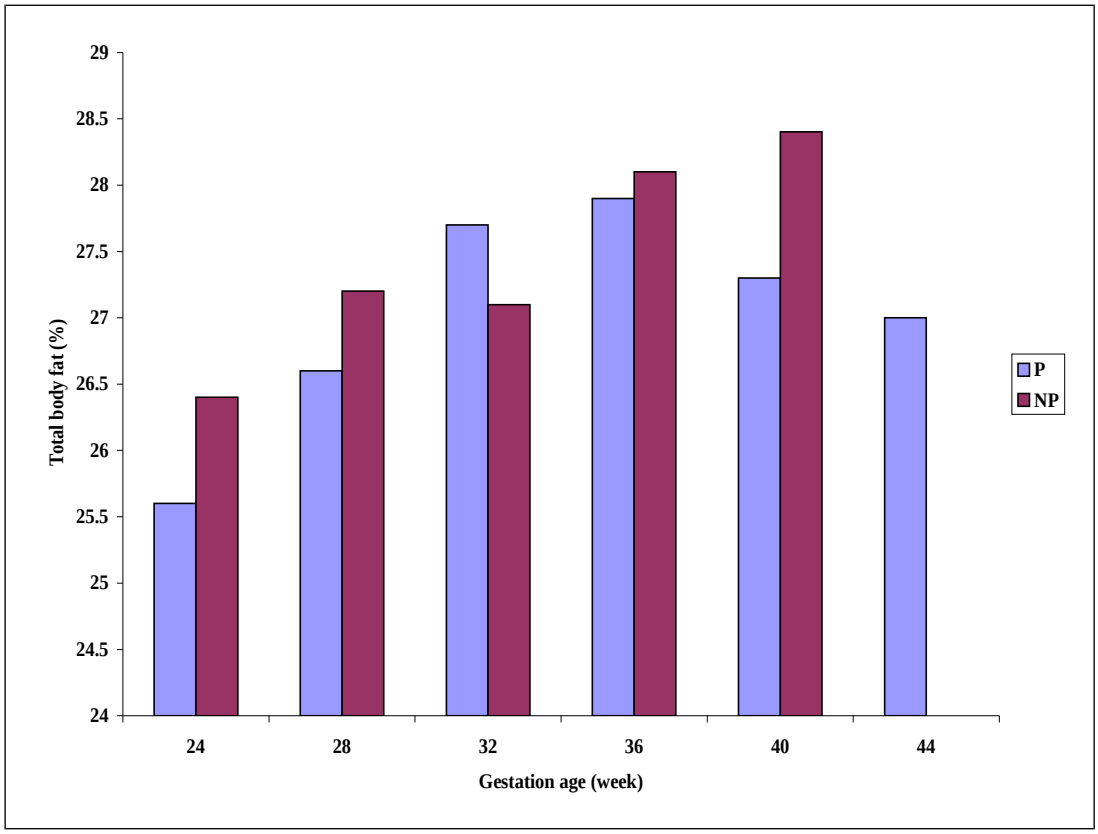

Figure 17: Mean gestational total body fat of subjects recruited at 24 weeks

4.2.3.4 Haemoglobin concentration

4.2.3.4.1 Haemoglobin concentration for subjects recruited at 20 weeks

The subjects in the Non-Plumpy nut group started with higher mean Hb concentration (8.1 g/dl) and increased it up to 9.9 g/dl at 36 weeks after which they were outweighed by the subjects in the Plumpy nut group who had 10.6 g/dl at 40

weeks. The peak mean Hb concentration was 10.6 g/dl at 40 weeks for subjects in the Plumpy nut group and 9.9 g/dl at 36 weeks for the subjects in the Non-Plumpy nut group. The difference observed was not statistically significant between the subjects in the Plumpy nut group and those in the Non-Plumpy nut group throughout the study period (Fig. 18).

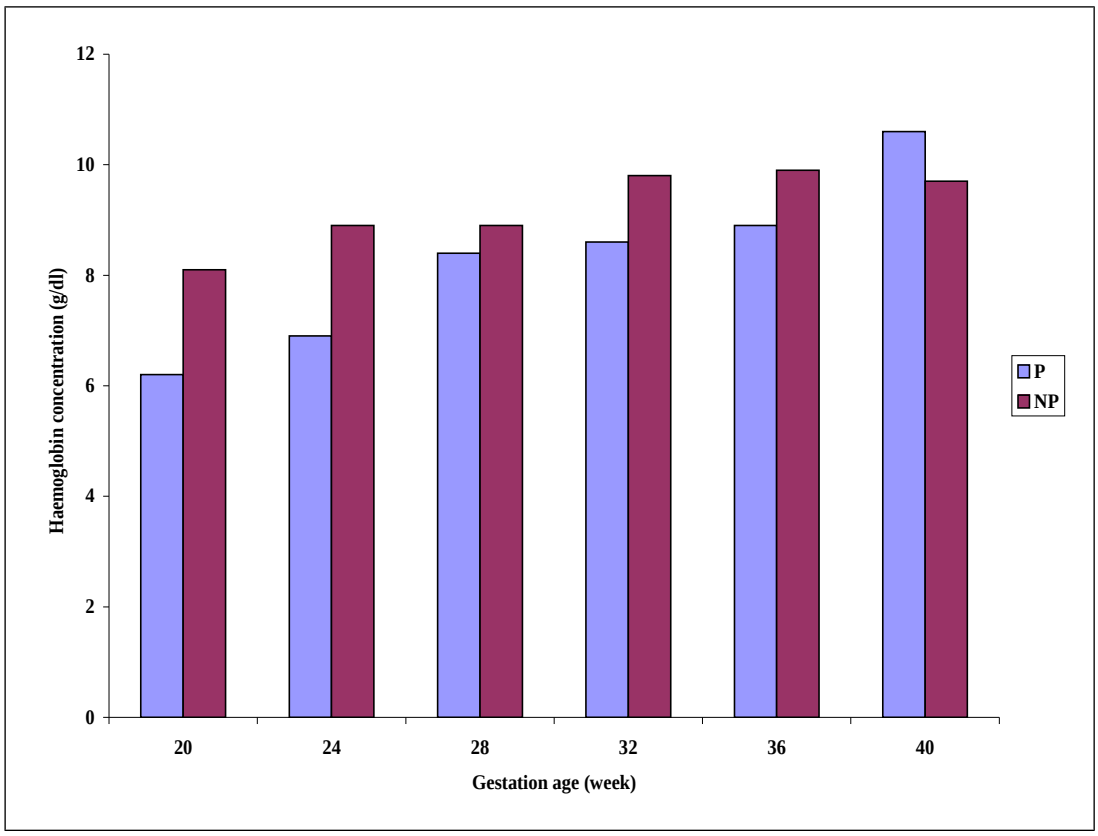

Figure 18: Mean Haemoglobin concentration of subjects recruited at 20 weeks

4.2.3.4.2 Haemoglobin concentration for subjects recruited at 21 weeks

Subjects in the Non-Plumpy nut group recruited at 21 weeks were having higher mean Hb concentration only at 21 weeks (9.9 g/dl) and the mean decreased up to 8.8 g/dl at 29 weeks and thereafter there was a regain of the mean Hb concentration from the age of 33 weeks (9.0 g/dl). A faster rate of increase in the mean Hb

concentration was observed in subjects in the Plumpy nut group as opposed to what was observed in the subjects in the Non-Plumpy nut group, the mean difference between 21 and 37 week was 0.9 g/dl for those in the Plumpy nut group and -0.9 g/dl for subjects in the Non-Plumpy nut group. The differences observed between groups were not statistically significant (Fig. 19).

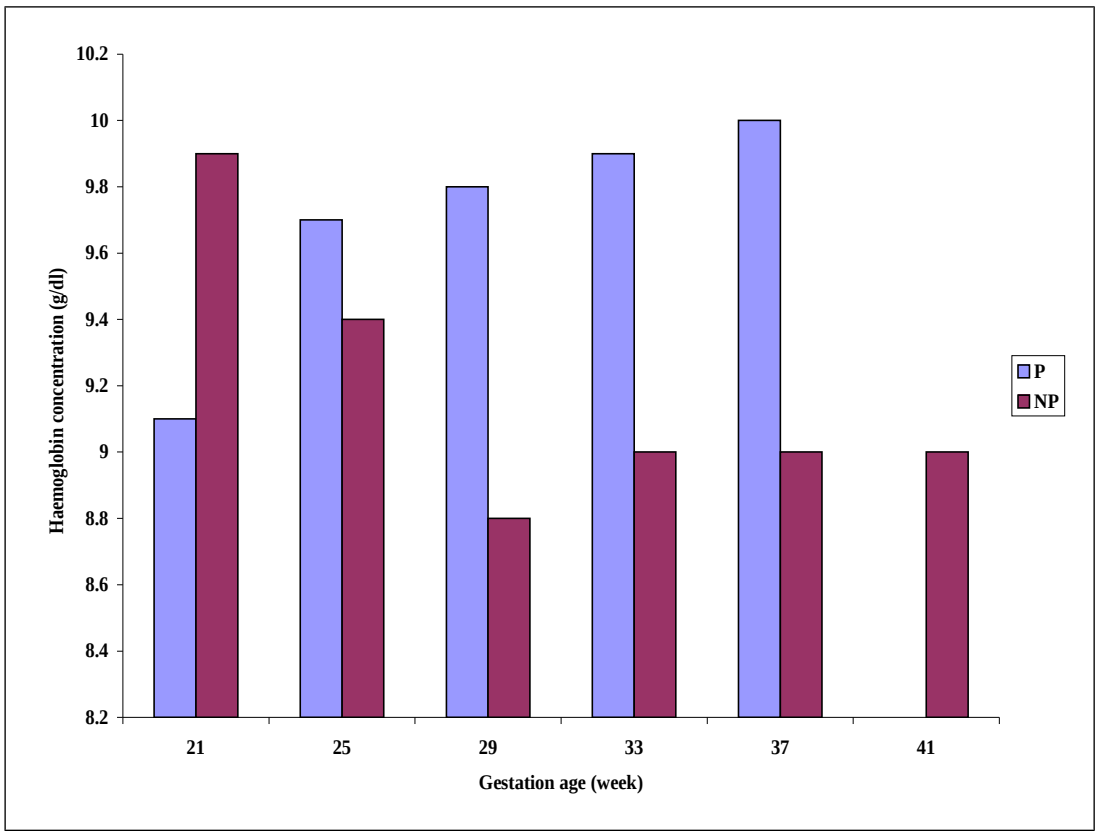

Figure 19: Mean Haemoglobin concentration of subjects recruited at 21 weeks

4.2.3.4.3 Haemoglobin concentration for subjects recruited at 22 weeks

At 22 (9.6 g/dl), 26 (9.7 g/dl) and 30 (9.8 g/dl) weeks subjects in the Non-Plumpy nut group were having slightly higher Hb concentration than those in the Plumpy nut group, but from 34 (10.2 g/dl), 38 (11.4 g/dl) and 42 (11.5 g/dl) weeks subjects in the Plumpy nut group mean Hb concentrations were higher than those of Non-

Plumpy nut group. Both groups were increasing their mean Hb concentrations at each visit until it reached the 38 week when the mean increase was 3.2 g/dl for subjects in the Plumpy nut group and 0.6 g/dl for subjects in the Non-Plumpy nut group. At week 42 there were no subjects in the Non-Plumpy nut group as they had already given birth. Though there were differences between groups observed, but those differences were not found to be statistically significant ie $p>0.05$ (Fig. 20).

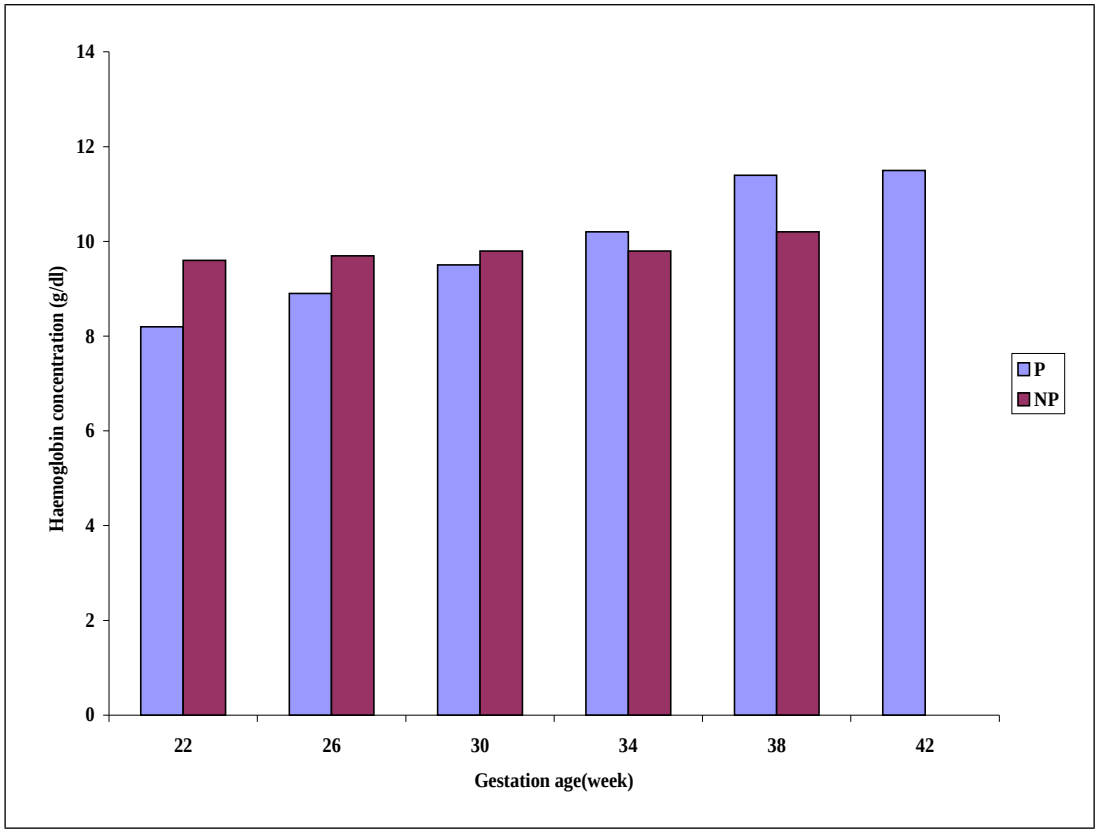

Figure 20: Mean Haemoglobin concentration of subjects recruited at 22 weeks

4.2.3.4.4 Haemoglobin concentration for subjects recruited at 23 weeks

The mean Hb concentration difference for subjects in the Plumpy nut group between 23 weeks and 43 weeks was found to be higher by 1.2 g/dl as opposed to the Hb concentration difference for subjects in the Non-Plumpy nut group which was 0.9 g/dl. Though subjects in the Plumpy nut group were having higher Hb

concentration as opposed to those in the Non-Plumpy nut group throughout the study, the differences were not statistically significant (Fig. 21).

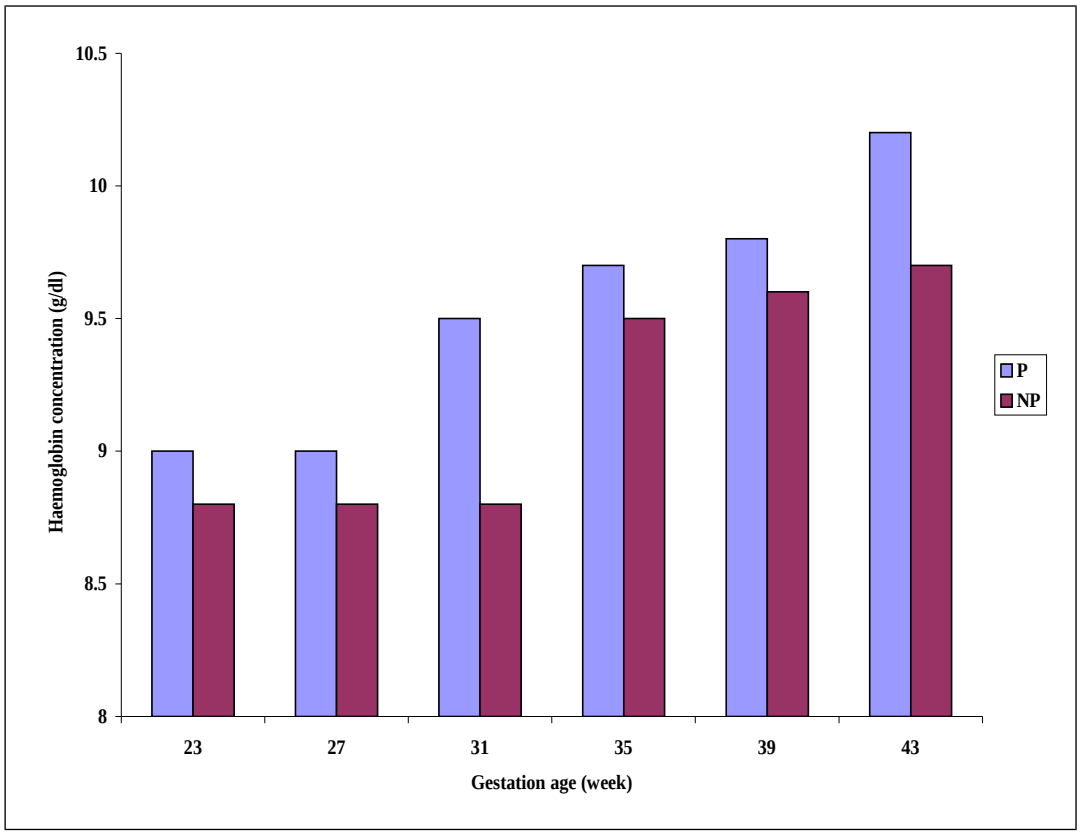

Figure 21: Mean Haemoglobin concentration of subjects recruited at 23 weeks

4.2.3.4.5 Haemoglobin concentration for subjects recruited at 24 weeks

There was no increase in mean Hb concentration for subjects in the Non-Plumpy nut group between 24 and 44 weeks but there was a decrease at week 28 and week 32 however, the mean Hb rose at week 36. At week 24 subjects in the Plumpy nut group started with low (8.8 g/dl) Hb concentration but ended up with a high (10.9

g/dl) Hb concentration compared to subjects in the Non-Plumpy nut group who started with a Hb concentration of 9.9 g/dl and ended up with a Hb concentration of 10.7 g/dl. The differences in Hb concentration between the groups were not statistically significant throughout the study (Fig. 22).

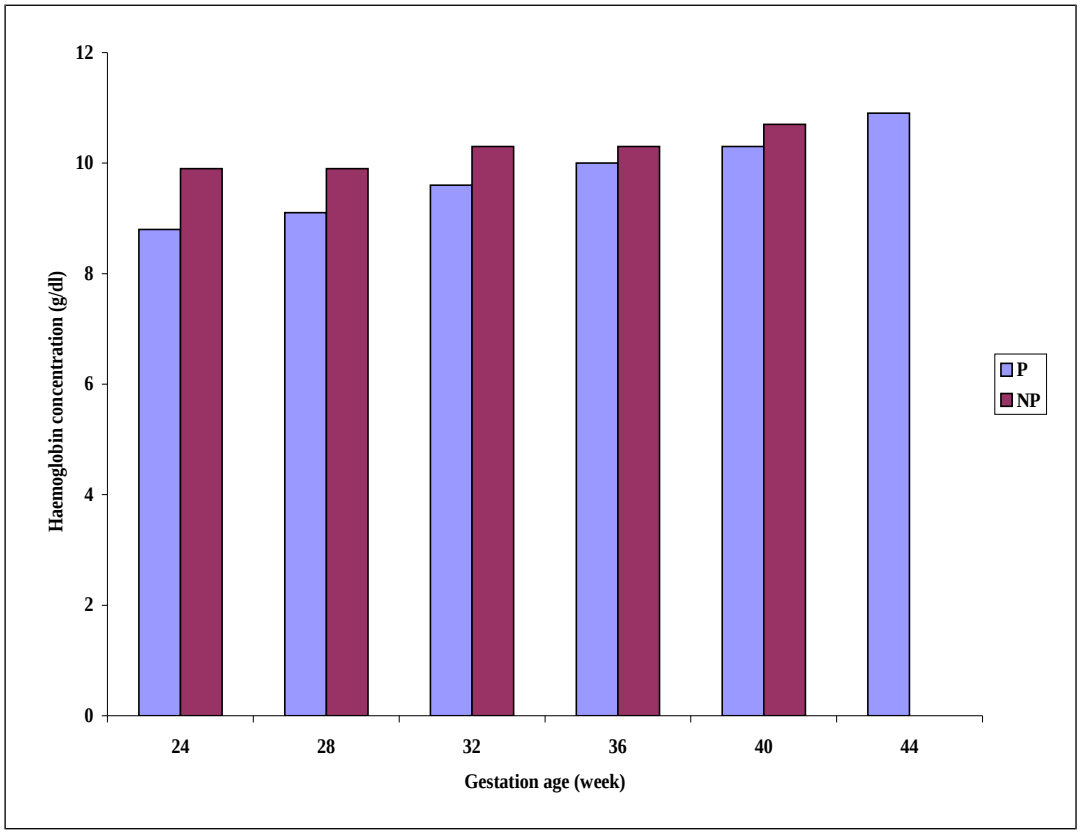

Figure 22: Mean Haemoglobin concentration of subjects recruited at 24 weeks

4.3 Dietary Intake

Common types of food consumed by subjects who participated in the study were stiff porridge, beans, fish, rice, sardine, and green vegetables. Fruits were eaten seasonally depending on availability.

4.3.1 Energy intake

The mean energy intake of all study subjects was 1735.0±454.4 kcal/day at baseline where that of subjects in the Plumpy nut group was 1786.3±436.6 kcal/day (1212.9-2847.0 kcal/day) and that of subjects in the Non-Plumpy nut group was 2265.1±477.7 kcal/day (1314.0-3347.0 kcal/day). After intervention (end of study), the mean energy intake increased to 2139.9±504.3 kcal/day. This was 2265.1±477.7 kcal/day (1314.0-3347.0 kcal/day) and 1866.7±469.12 kcal/day (1189.0-2515.1 kcal/day) for the subjects in the Plumpy nut and for those in the Non-Plumpy nut groups respectively. The energy intakes show significant statistical difference at p=0.028 between the groups at the end of the study (Fig. 23).

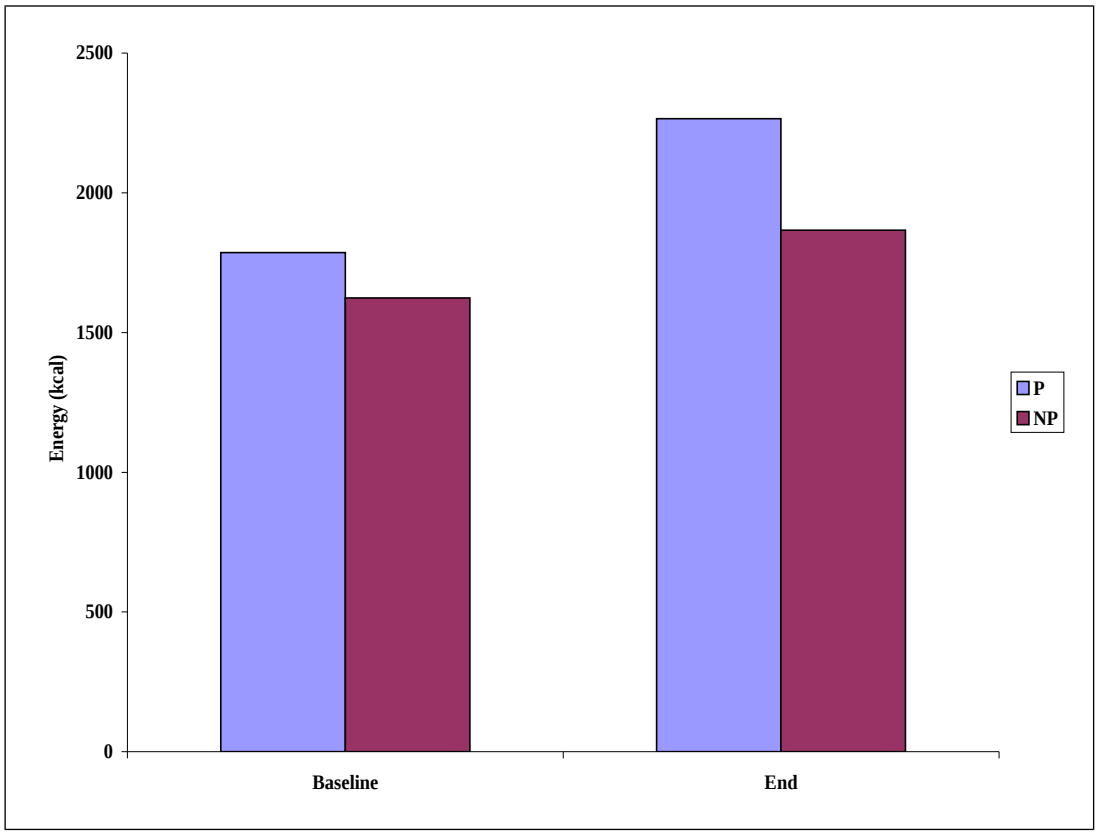

Figure 23: Mean Energy intake at baseline and at end of study

4.3.2 Fat intake

At baseline the mean fat intake of all subjects was 20.9±8.7 g/day. The mean fat intake was 21.2±7.3 g/day (7.7-32.3 g/day) for subjects in the Plumpy nut group and 20.3±11.8 g/day (2.4- 38.1 g/day) for those in the Non-Plumpy nut group. After intervention, the mean fat intake change, for all subjects was 32.7±9.4 g/day. When segregated, the subjects in the Plumpy nut group had a mean intake of 36.3±4.7 g/day (30.0-49.1 g/day) and the subjects in the Non-Plumpy nut group had a mean intake of 24.9±12.4 g/day (8.9- 49.2 g/day). There was a statistically significant difference at p=0.000 in terms of mean fat intake between the groups at the end of the study (Fig. 24).

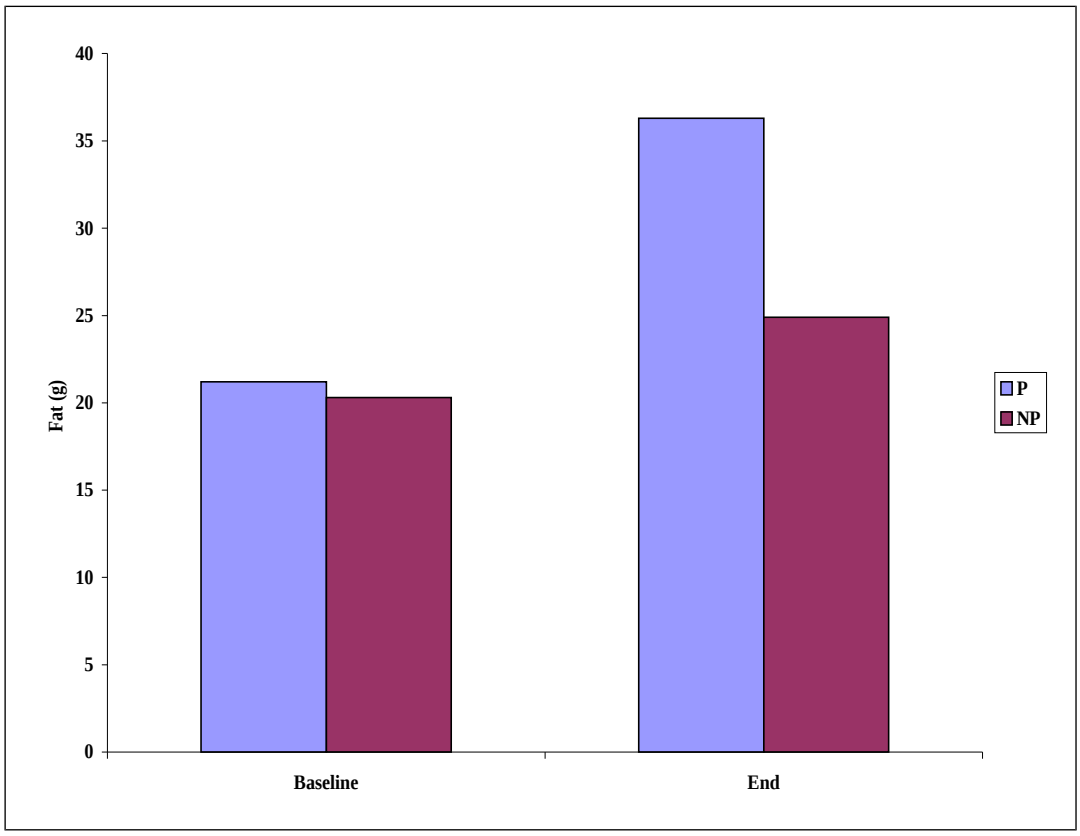

Figure 24: Mean fat intake at baseline and at the end of study

4.3.3 Iron intake

The mean iron intake was 21.3±8.4 mg/day for all subjects. The subjects in the Plumpy nut group had a mean iron intake of 21.7±8.1 mg/day (12.4-40.5 mg/day) and those in the Non-Plumpy nut group had a mean iron intake of 20.6±9.3 mg/day (11.7-38.3 mg/day) at baseline. At end of the study, for all subjects the mean iron intake changed, and increased to 29.6±9.3 mg/day. When segregated for individual groups, the mean iron intake was 30.4±9.1 mg/day (16.2-51.5 mg/day) and 27.6±9.8 mg/day (13.0-41.0 mg/day) for subjects in the Plumpy nut group and for those in the Non-Plumpy nut groups respectively. Though there were differences, the differences observed in mean iron intakes were not statistically significant (Fig. 25).

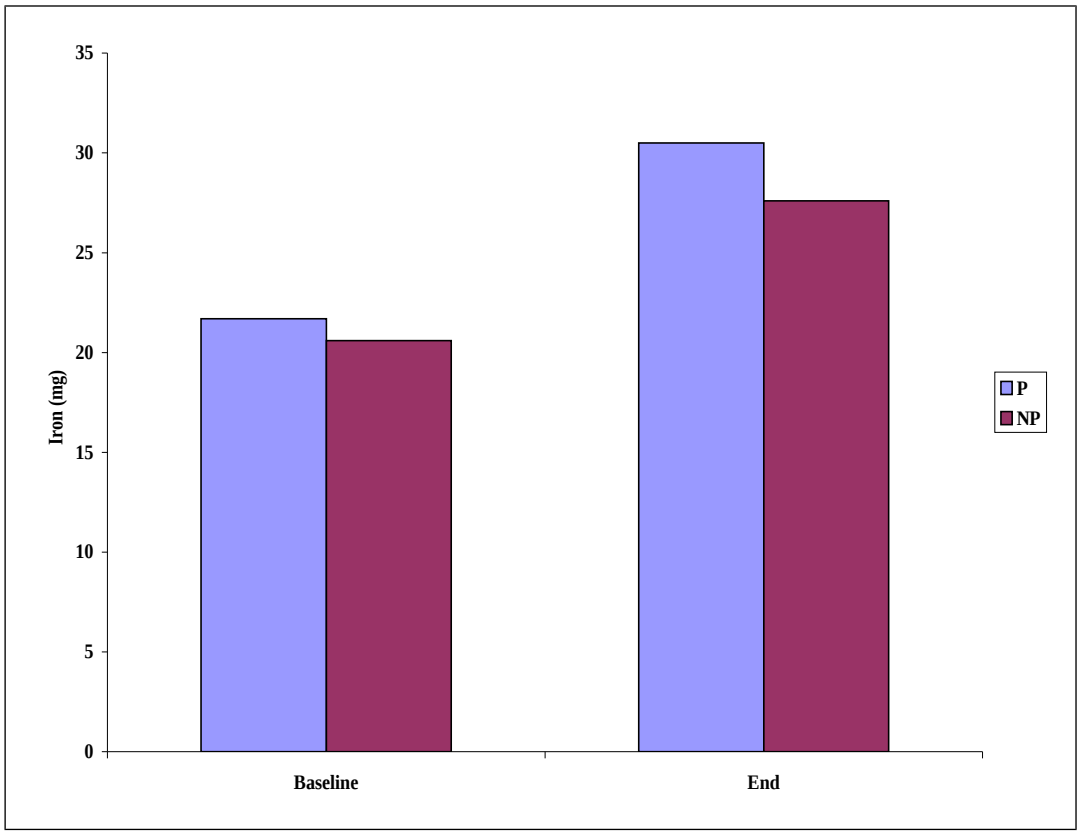

Figure 25: Mean Iron intake at baseline and at the end of study

4.4 Morbidity Pattern

Malaria was the major disease affecting both groups throughout the study. At baseline malaria was affecting about 21% of subjects in the Plumpy nut group and 17% in the Non-Plumpy nut group. At the end of the study malaria was still the leading cause of morbidity among individuals participating in the study though at a low rate as opposed to when the study started, at the end of the study Malaria affected about 2% and 3% of subjects in the Plumpy nut and those in the Non-Plumpy nut groups respectively (Table 9).

Table 9: Morbidity pattern of the subjects

Disease		**P**		**NP**	
		n	**%**	**n**	**%**
Baseline	Malaria	15	20.5	6	17.1
	Diarrhea	2	2.7	-	-
	Anemia	2	2.7	-	-
	Typhoid	-	-	2	5.7
	Vomiting	-	-	1	2.9
	Other illnesses	11	15.1	1	2.9
	Total	**30**	**41.1**	**10**	**28.6**
1st visit	Malaria	3	4.4	2	5.7
	Others	-	-	1	2.9
	Total	**3**	**4.4**	**3**	**8.6**
2nd visit	Malaria	4	6.0	4	13.3
	Others	2	3.0	-	
	Total	**6**	**9.0**	**4**	**13.3**
3rd visit	Malaria	3	4.8	2	6.8
	Total	**3**	**4.8**	**2**	**6.8**
4th visit	Malaria	3	6.5	2	6.7
	Total	**3**	**6.5**	**2**	**6.7**
5th visit	Malaria	1	2.2	1	3.3
	Diarrhea	1	2.2	-	-

typhoid	1	2.2	-	-
Total	**3**	**6.6**	**1**	**3.3**

4.5 Birth Weight

The mean birth weight for babies of subjects in the Plumpy nut group was 3610±380 g (2800-4500 g) and that of babies of subjects in the Non-Plumpy nut group was 2890±510 g (2000-4100 g). The observed difference in birth weight between two groups was statistically significant at p=0.00 (Table 10).

Table 10: Mean birth weight

	P			**NP**			**Mean difference**	**P value**
	mean	SD	n	mean	SD	n		
Birth weight (g)	3610	380	35	2890	510	17	720	0.00

4.6 Prevalence of Low Birth Weight

The results in Table 11 indicate that, about 6% (4% males and 2% females)of infants born during the study period were under weight and 94% (56% males and 39% females) were normal. Underweight infants were found with the subjects in the Non-Plumpy nut group only, and no underweight infant was found with the participant in the Plumpy nut group. Neither in Plumpy nut group nor Non-Plumpy nut group there were large babies.

Table 11: Prevalence of low birth weight

Birth	**P**	**NP**	**Total**

weight (g)	Male		Female		Male		Female			
	n	%	n	%	n	%	n	%	n	%
≤2500	-	-	-	-	2	3.8	1	1.9	3	5.7
2501 – 4500	22	42.3	13	25	7	13.5	7	13.5	49	94.3
≥4501	-	-	-	-	-	-	-	-	-	-
Total	22	42.3	13	25	9	17.3	8	15.4	52	100

4.7 Relationship between Gestational Age, Age of the Mother and Birth Weight

Table 12 shows that about 56% of infants born were from subjects aged 25-35 years, 30% were from subjects with 15-24 years and only 13% were born from subjects aged 36-49 years. Also the table reveals that about 23% of infant were born from subjects recruited at week 23 in Plumpy nut group and 21% of the infants were born from subjects recruited at week 24 in subjects of the Non-Plumpy nut group. For both groups subjects with 25-35 years (Plumpy nut group 36% and Non-Plumpy nut group 19%) were the ones with many infants than other age groups. Low birth weight was observed only with subjects in the Non-Plumpy nut group with gestation of 24 weeks and aged between 15 and 24 years (6%) and those aged between 25 and 35 years (2%).

Table 12: Relationship between gestational age, age of the mother and birth weight

		P					NP					Total
AM	GA	20	21	22	23	24	20	21	22	23	24	
	BWT	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	
15-24	LBWT										5.8	**5.8**
	NBWT			3.8	3.8	1.9					5.8	**15.4**
	OBWT			1.9	5.8	1.9					-	**9.6**
25-35	LBWT										1.9	**1.9**
	NBWT	1.9	1.9	3.8	1.9	5.8			1.9	7.7	5.8	**30.7**
	OBWT	1.9	1.9	7.7	5.8	3.8					1.9	**23**
36-49	LBWT											

NBWT				1.9			1.9				**3.8**
OBWT			1.9	3.8	3.8						**9.5**
Total	**3.8**	**3.8**	**19.1**	**23**	**17.2**		**1.9**	**1.9**	**7.7**	**21.2**	**100**

KEY: AM- Age of the Mother, GA-Gestation Age, BWT- Birth Weight, LBWT- Low Birth Weight, NBWT- Normal Birth Weight, OBWT- Slightly Over Normal Birth Weight.

4.8 Relationship between Parity, Gestational Age and Birth Weight.

About 67% of the infants were born from subjects in the Plumpy nut group of which majority (23%) were from subjects recruited at week 23 followed by 19% for subjects recruited at week 22. About 21% of infants in Plumpy nut group were from subjects with third parity followed by 15% for subjects with second and more than three parities while 15% were from subjects with first parity. Thirty two point six percent (32.6%) of infants were born in the Non-Plumpy nut group of which majority (21%) were from subjects recruited at week 24 followed by 8% from subjects recruited at week 23. Fifteen percent (15%) of infants in Non-Plumpy nut group were born from subjects with first parity, 10% were from those in the third parity and 6% were from those in the second parity. Low birth weight was only observed in infants born from Non-Plumpy nut group subjects of gestation age of 21 weeks in the third parity (2%) and those of gestation age of 24 weeks in the first parity (8%) (Table 13).

Table 13: Relationship between parity, gestational age and birth weight

	GA	Parity	Low birth weight (%)	Normal birth weight (%)	Slightly over birth weight (%)	**Total (%)**
		First	-	-	-	-
		Second	-	1.9	-	**1.9**
	20	Third	-	-	-	-
		More than three	-	-	1.9	**1.9**
		First	-	-	-	-
		Second	-	-	1.9	**1.9**
	21	Third	-	1.9	-	**1.9**
		More than three	-	-	-	-
		First	-	1.9	3.9	**5.8**
		Second	-	3.9	-	**3.9**
P	22	Third	-	1.9	5.8	**7.7**
		More than three	-	-	1.9	**1.9**
		First	-	1.9	3.9	**5.8**
		Second	-	1.9	1.9	**3.8**
	23	Third	-	1.9	3.9	**5.8**
		More than three	-	1.9	5.8	**7.7**
		First	-	1.9	1.9	**3.8**
		Second	-	3.9	-	**3.9**
	24	Third	-	1.9	3.9	**5.8**
		More than three	-	-	3.9	**3.9**
		First	-	-	-	-
		Second	-	-	-	-
		Third	-	-	-	-
	20	More than three	-	-	-	-
		First	-	-	-	-
		Second	-	-	-	-
	21	Third	1.9	-	-	**1.9**
		More than three	-	-	-	-

		First	-	-	-	-
		Second	-	1.9	-	**1.9**
	22	Third	-	-	-	-
NP		More than three	-	-	-	-
		First	-	1.9	-	**1.9**
		Second	-	1.9	-	**1.9**
	23	Third	-	3.9	-	**3.9**
		More than three	-	-	-	-
		First	7.7	5.8	-	**13.5**
		Second	-	-	1.9	**1.9**
	24	Third	-	5.8	-	**5.8**
		More than three	-		-	-
		Total	**9.6**	**48.3**	**42**	**100**

Key: GA -Gestational Age

4.9 Relationship between Gestational Age, Haemoglobin Concentration and Birth Weight

Table 14 below shows that, there was no low birth weight for infants born in the Plumpy nut group though there were subjects recruited with severe anemia (13.6%), while in the Non-Plumpy nut group a total of 9.6% infants were born with low birth weight. These subjects were recruited for the study while having severe anemia (1.9%) and moderate anemia (7.7%).

Table 14: Relationship between gestational age, Haemoglobin concentration and birth weight

	GA	Hb	Low birth weight	Normal birth weight	Slightly over birth weight	Total (%)
		Severe anemia	-	-	-	-
	20	Moderate anemia	-	1.9	-	1.9
		Mild anemia	-	-	1.9	1.9
		Normal Hb	-	-	-	-
		Total	**-**	**1.9**	**1.9**	**3.8**
		Severe anemia	-	-	-	-
		Moderate anemia	-	1.9	-	1.9
	21	Mild anemia	-	-	1.9	1.9
		Normal Hb	-	-	-	-
		Total	**-**	**1.9**	**1.9**	**3.8**
		Severe anemia	-	3.9	-	3.9
		Moderate anemia	-	3.9	7.7	6
	22	Mild anemia	-	-	1.9	1.9
		Normal Hb	-	-	1.9	1.9
P		**Total**	**-**	**7.8**	**11.5**	**19.3**
		Severe anemia	-	3.9	-	3.9
		Moderate anemia	-	3.9	7.7	11.6
	23	Mild anemia	-	-	5.8	5.8
		Normal Hb	-	-	1.9	1.9
		Total	**-**	**7.8**	**15.4**	**23.2**
		Severe anemia	-	3.9	1.9	5.8
		Moderate anemia	-	3.9	3.9	7.8
	24	Mild anemia	-	-	-	-
		Normal Hb	-	-	3.9	3.9
		Total	**-**	**7.8**	**9.7**	**17.5**
		Severe anemia	-	-	-	-
		Moderate anemia	-	-	-	-
	20	Mild anemia	-	-	-	-
		Normal Hb	-	-	-	-
		Total	-	-	-	-
		Severe anemia	1.9	-	-	1.9
		Moderate anemia	-	-	-	-
	21	Mild anemia	-	-	-	-
		Normal Hb	-	-	-	-
		Total	**1.9**	-	-	**1.9**

		Severe anemia	-	-	-	-
		Moderate anemia	-	1.9	-	1.9
	22	Mild anemia	-	-	-	-
		Normal Hb	-	-	-	-
		Total	-	**1.9**	-	**1.9**
NP		Severe anemia	-	1.9	-	1.9
		Moderate anemia	-	5.8	-	5.8
	23	Mild anemia	-	-	-	-
		Normal Hb	-	-	-	-
		Total	-	**7.7**	-	**7.7**
		Severe anemia	-	3.9	-	3.9
		Moderate anemia	7.7	5.8	1.9	15.4
	24	Mild anemia	-	-	-	-
		Normal Hb	-	1.9	-	1.9
		Total	**7.7**	**11.6**	**1.9**	**21.2**

Key: GA-Gestational Age, Hb- Haemoglobin concentration

CHAPTER FIVE

5.0 DISCUSSION

5.1 Overview

This chapter presents discussion of the findings of the study conducted at Temeke Municipality. The discussion is organized according to the research objectives and the main areas for discussion are efficacy of plumpynut on nutritional status of HIV+ pregnant women, hemoglobin concentration, total body fat, birth weight, morbidity pattern, and dietary intake.

In the setting of many developing countries, women seek antenatal care when pregnant and are rarely aware of their HIV status. In Tanzania, according to the Ministry of Health (URT 2003) it is compulsory for all pregnant woman to test for HIV status, STIs, haemoglobin concentration and have the privilage of receiving treatment of other infectious diseases and anything else she might be complaining about, she is also guaranteed with a low price mosquito net (*hati punguzo*) during her first antenantal clinic. During the second trimester, a single dose of antimalaria and antihelminth is administered and is to be taken at the clinic infront of a nurse.

The nutritional status of HIV infected woman prior to and during pregnancy influences their own health and survival, as well as the health and the survival of the newborns. The physiological changes that occur during pregnancy require extra nutrients for adequate gestational weight gain to support the growth and the development of the fetus. For women who are malnourished, daily energy-protein supplementation during pregnancy may improve maternal weight gain, increase infant birth weight, and reduces the risks of stillbirth and perinatal mortality. HIV infection increases energy requirements for pregnant mothers. These additional needs, coupled with the nutritional consequences of common HIV-related illnesses and infections e.g., diarrhea, tuberculosis, and appetite loss, place HIV-infected pregnant and lactating women at a greater nutritional risk than uninfected pregnant and lactating women of the same age and physical activity level.

5.2. Effect of Plumpynut on Nutritional Status of HIV Positive Pregnant Women

Anthropometric variables: maternal gestation weight, total body fat gain and Mid Upper Arm Circumferences were collected to determine nutritional status of individuals.

5.2.1 Maternal gestation weight gain

Gestational weight gain reflects the growth of the conceptus and maternal physiological adjustments such as blood volume expansion, fluid retention, fat accumulation and, to a lesser extent, an increase in lean tissue (uterus, mammary

gland) throughout pregnancy (Mardones and Rosso, 2005). All subjects were gaining weight regardless of their gestational age at which they joined the study; but the mean weight gain was well noticed to Plumpy nut group subjects; this might be due to daily 500 kcal supplementation.

Throughout the study there was no significant difference ($p>0.05$) on the mean gestational weight gain between the Plumpy nut group and the Non-Plumpy nut group subjects regardless of their gestational age at which they joined the study. However, the mean gestational weight of Plumpy nut group subjects was increasing from the time they joined the study until the end of the study except for the subjects who joined the study with the gestation age of week 20 and week 24. The non increase of the mean gestational weight to the participants in Plumpy nut group recruited with week 20 and week 24 could be due to diseases, lack of food, increased energy expenditure as many subjects remained active throughout their pregnancy. The increase in mean gestational weight in Plumpy nut group subjects could be attributed to supplementation with plumpy nut which was supplying a total of 500 kcal/day in addition of what they were obtaining from their daily meals, nutritional counseling and education, and prompt treatment of diseases that subjects were suffering from. The gain could have resulted from counseling that women received and which made them to reduce some of the activities.

Adequate weight gain during pregnancy is an important determinant of maternal health and reproductive success as energy requirements are increased to cover energy deposited in the mother and fetus as protein and fat (Papathakis and Rollins,

2005). Also, good body weight helps the mother to maintain her activity levels and ensure productivity and at the same time reducing chances of infections. The study showed advantages for subjects recruited at week 21, 22, and 23 as they gained mean weight between baseline and at the end of study by 6.0 kg, 8.8 kg and 8.7 kg respectively as opposed to other subjects recruited at week 20 and 24. Maternal pregnancy weight is a good indicator of well being of the mother as well as of the infant.

5.2.2 Total body fat

Fat synthesis is increased and lipolysis is inhibited in response to metabolic changes in early pregnancy and later in pregnancy there seems to be a shift towards a metabolic profile favoring lipolysis in response to the increased demands of the growing fetus for nutrient. The differences in total body fat between groups were probably due to nutritional education and counseling and the positive effect of supplementation as Plumpy nut was supplying a total of 32.86 g of fat per day on top of subjects' daily meals intake. A study by Villar *et al*, (1992) on the effect of fat and fat-free mass deposition during pregnancy on birth weight revealed that the largest maternal fat deposition was between the twentieth and thirtieth weeks. Fat deposition is important to pregnat women for successful breastfeeding. The mean increase in total body fat between baseline and at the of study was well marked for subjects who joined the study at week 20 (6.6%), week 21 (8.3%), week 22 (6.7%), and week 23 (6.0%) as opposed to those joined the study at week 24, and this shows that the ones who stayed in the study for a long time has benefited by gaining adequate body fat for successfully lactation.

5.2.3 Mid Upper Arm Circumference

MUAC represents past and current nutritional status but it is not sensitive to short term changes in nutritional status during pregnancy. Studies of changes in body composition and metabolism during normal pregnancy have shown that subcutaneous body fat as measured by skinfold thickness tends to accumulate through the second trimester of pregnancy. Through the third trimester and into the immediate postpartum period, skinfold thickness at all sites tends to decrease, indicating a mobilization of subcutaneous fat stocks.

The findings of the current study show that there was no statistical difference ($P<0.05$) between subjetcs in the Plumpy nut and those in the Non-Plumpy nut groups although subjects who were recruited with gestational age of week 20, week 21, week 22, and week 23 in Plumpy nut group had an increase in their mean MUAC 3 cm , 1.6 cm, 5 cm,and 0.8 cm respectively between baseline and end of study as opposed to subjects in the Non-Plumpy nut group. The mean MUAC increase among Plumpy nut subjects might be the results of a direct positive effect of supplementation that made them to increase their deposition of fat for the preparation of breastfeeding. The other reason could be attributed to proper medication when there was a health problem and good nutritional education and counseling.The same results were observed in a cross sectional study done by Villamor *et al*, (2003) in Tanzania who examined anthropometry and HIV status for women before week 23 of gestation; there was no statistical difference ($P<0.05$) on the mean MUAC found in this study.

5.3 Effect of Supplementation on Hemoglobin Concentration

An integrated approach to anaemia prevention and control services for pregnant women were met during each visit. The women received nutritional education and counseling, malaria prevention services including mosquito nets for malaria prevention (during their first antenatal clinic) and antimalaria dosage for malaria treatment and prevention (during second trimester). Also, there was a provision of helminthes control (one dose in second trimester) and all other infectious diseases were treated once reported. An increased iron utilization by the developing fetus and placenta, as well as blood volume expansion increase significantly the iron requirement during pregnancy.

The results show that regardles of gestational age at which subjects joined the study, there were maen differences observed between baseline and at the end of study for subjects in the Plumpy nut group for subjetcs recruited with 20, 21, 22, 23, and 24 weeks the mean differences were 4.4 g/dl, 0.9 g/dl, 3.3 g/dl, 1.2 g/dl and 2.1 g/dl respectively. However, the overall mean in hemoglobin concentration had been increasing in the Plumpy nut group subjects throughout the study as opposed to subjects in the Non-Plumpy nut group as the amount of iron required during the last half of pregnancy could not be met easily by diet, especially towards the end of pregnancy. The mean Hb concentration increase among subjects in the Plumpy nut group might be attributed to supplementation with plumpy nut which contained 10.6 g of iron and it was consumed in addition to the normal daily diet. In randomized trials of high dose vitamin supplementation by Fawzi *et al*, (1998) and West *et al*, (1999), it was found that women taking the multivitamins contained iron improved

their iron status compared to those who had not taken supplements. Hence, this shows that multivitamin supplementation which contains iron to HIV+ pregnant women improves their iron status and reduces the chances of opportunistic infections.

5.4 Morbidity Information

Since Malaria is highly endemic in the study area, pregnant women are highly susceptible to malaria, and both the frequency and the severity of disease are higher among pregnant women than in any other population group (Temeke Municipal Council, 2007). Malaria like any other infections such as fungal, bacterial,viral or parasitic can lead to a faster progression of HIV to AIDS disease as it may lead to reduced dietary intake and absorption, increased utilization and loss of micronutrients. At recruitment, there were more cases of malaria than were any other infections, and at the end only malaria remained the major cause of morbidity. Different studies have shown a positive effect on daily multivitamin supplementation in determining virulence of bacterial, fungal, parasites and possibly viral infections (Weinberg *et al*, 2002) and delay HIV disease progression (Tang and Smit, 2002, Fawzi *et al*, 2004) during pregnancy. A daily dose of multimicronutrients supplementation might strengthen the immune system and increased body defense against the viral, fungal, bacterial and parasitic infections and could keep pregnant women and their infants healthier.

5.5 Birth Weight

Birth weight is mainly determined by the nutritional status of the mother prior to and during pregnancy. Statistically, the results show a significant difference at p=0.00 in infants' birth weight between Plumpy nut and Non-Plumpy nut groups. The difference might be attributed to the supplementation with plumpy nut which contained multimicronutrients and which are basically needed during pregnancy for better weight gain of the fetus and the well being of the mother. Low birth weight observed among the Non-Plumpy nut group infants was linked to higher risks of negative health outcomes like neonatal and infant mortality, poor growth and cognitive development, and higher risks of chronic diseases like diabetes and heart disease later in life, (UNICEF and WHO, 2004).

Birth weight, parity and haemoglobin concentration was correlated with gestational age at which the subject joined the study; subjects in the Plumpy nut group recruited at week 20, 21, 22, 23 and 24 gave birth to healthy infants 3400 g, 3700 g, 3610 g, 3725 g and 3489 g respectively as opposed to subjects in the Non-Plumpy nut group with the same gestation age. WHO, 2004 and West, 1999 revealed that micronutrient supplementation was associated with mean increases in birth weight and reduced the prevalence of low birth weight of infants born to HIV- positive mothers.

Studies in Tanzania revealed that daily multivitamin (with vitamins B, C, and E) supplementation during pregnancy and breast-feeding reduced the incidence of fetal death, severe premature delivery (before week 34), small size for gestational age,

and low birth weight (Fawzi *et al*, 1998). Moreover, supplementation improved the immune status of infants (Fawzi *et al*, 2003), prevented HIV transmission among nutritionally and immunologically vulnerable women, i.e., those at the greatest risk of passing HIV to their children (Fawzi *et al*, 2002). Therefore, it is important for any HIV+ pregnant women to be supplemented with both macro and micronutrients because most of the time dietary intake does not meet daily nutritional requirements especially in societies with poor economic and social settings.

5.6 Dietary Intake

All the subjects were receiving nutritional counseling and education in each visit. The results show that there was a statistically significant difference in energy and fat intake but not in iron consumption between Plumpy nut and Non-Plumpy nut groups. The difference might be attributed to the amount of energy (500 kcal) and fat (32.86 g) that the plumpy nut was supplying. The iron intake between subjects in the Plumpy nut and those in the Non Plumpy nut group was not statistically significant though the subjects in the Plumpy nut group was suppllied with an extra amount (10.6 mg) of iron; thus nutritional education and counseling might have played a big role in improving the nutrient intake especially that of iron among the Non-Plumpy nut group. A study done by Buys *et al*, 2004 reveal that nutritional counseling had benefited malnourished HIV infected individuals by improving their energy intake.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The general objective of this study was to improve the nutritional status of pregnant women living with HIV/AIDS and that of their expected offsprings by supplementing them with the ready- to-eat therapeutic food known as Plumpy nut. The work involved examination of the effect of supplementation on martenal gestational weight, MUAC, total body fat and Haemoglobin concentration. Other objectives included the assessment of food consumption, and identification of morbidity pattern which mostly affect pregant women living with HIV/AIDS. Also, in the study was the birth weight of the off-spring assessed. The major reason for conducting this study was to generate information on the efficacy of Plumpy nut which is concentrated in macro- and micro- nutrients in improving the nutritional status of HIV+ pregnant women and of their off-springs and reducing severity of the opportunistic diseases. The data were collected through a structured questionaire from a randomized sample of 86 subjects from 9 health centres which provide RCH services in Temeke Municipality.

The following are the major conclusions drawn from the findings of this study:

The study concludes that with the intervention of Plumpy nut to HIV positive pregnant women, it was possible to improve infants' birth weight which was well noticed to subjects recruited with 21, 22, and 23 weeks, increase maternal dietary intake especially for energy and fat nutrients and also reduce morbidity pattern due to infectious diseases. A significant association between maternal age and gestational age and birth weight, parity and gestational age and birth weight, gestational age and Haemoglobin concentration and birth weight was also observed among the infants. Maternal gestational weight, MUAC, total body fat and haemoglobin concentration were not significantly improved by supplementation with the Plumpy nut. A longer time of intervention probably before conception was needed to observe improvement in maternal gestational weight, MUAC, total body fat and hemoglobin concentration. However Plumpynut was well accepted.

6.2 Recommendations for Future Research Opportunities

It is important to acknowledge that women in poor rural settings in many areas of the developing world are not passive recipients of the nutritional insults they experience. It may therefore be interesting to better understand the range of strategies employed by women in Temeke municipality to minimize nutritional deficits; this will assist in improving locally available foods to improve the overall nutritional status, especially of the women of child bearing age. A call for further research is made as Williamson, (2006) found that an adequate micronutrient intake is best achieved through an adequate diet. It is important for maternal micronutrient

status in the preconception period, and throughout pregnancy and lactation, to be viewed as a continuum (Allen, 2005). Since an HIV-infected woman's nutritional status prior to and during pregnancy and lactation influences her own health and survival, as well as the health and the survival of her newborn children (WHO, 2003). However, too often these 3 stages are treated and discussed separately from both scientific and public health perspective, so proper research should be planned to cover all 3 stages whenever resources are available.

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APPENDICES

Appendix 1 : Baseline Questionnaire

Sokoine University of Agriculture

Faculty of Agriculture

Department of Food science and Technology

TITLE: Efficacy of Plumpy Nut in Improving Nutritional Status of HIV Positive Pregnant Women and their Infants.

BASELINE QUESTIONNAIRE

Region ---------- District----------

Name of Health facility---------- Date----------

ID ----------

No.	SECTION A: Demographic Information of the woman and spouse **A1: Woman**	CODE
1	Age of the Mother ……..	
2	Gestational age ……. Weeks	
3	Parity 1.first, 2.second, 3 third, 4. More than three	
4	What was the birth weight of your last born …….kg	
5	How many children do you have……	
6	What is your family size ……	
7	Marital Status 1. Unmarried, 2.Married, 3.Divorced, 4.Widowed, 5.Cohabit	
8	What is the highest level of education that you attained? 1. No formal school, 2. Adult education, 3. Primary education, 4.Secondary education, 5. College education, 6. Others (specify) …….	
9	Occupation ……..	
	A2: Spouse	
10	Age of your spouse ……..	
11	What is the highest level of education that He attained? 1. No formal school, 2. Adult education, 3. Primary education, 4.Secondary education, 5. College education, 6. Others (specify) …….	
12	Occupation ……..	
	B: FAMILY INCOME	
13	What is the major source of income for your family? 1. Salary/wages, 2. Sales of crop produce, 3. Sales of livestock, 4.	

<table>
<tr><td></td><td>Petty business, 5. Casual labour, 6. Remittances, 7. Others (specify) ……..</td><td></td></tr>
<tr><td></td><td>C: FOOD SOURCE</td><td></td></tr>
<tr><td>14</td><td>Do you grow your own food? 1. Yes, 2. No</td><td></td></tr>
<tr><td>15</td><td>If no where do you obtain your food? 1. Bought, 2. Remittances from children and relatives, 3. Begging from friends and relatives, 4. Others (specify)……..</td><td></td></tr>
<tr><td></td><td>D: MORBIDITY INFORMATION</td><td></td></tr>
<tr><td>16</td><td>Is this your first RCH visit? 1. Yes, 2. no</td><td></td></tr>
<tr><td>17</td><td>If no do you go to the clinic (RCH) every month? 1. Yes (request the clinic card), 2. No</td><td></td></tr>
<tr><td>18</td><td>If no, why? 1. Staying far away from MCH clinic, 2. No time, 3. There is no need, 4. Others (specify)……</td><td></td></tr>
<tr><td>19</td><td>If Staying far away from MCH clinic; how far 1.1 km, 2. 2 km, 3. 3 km, 4. more than 3 km</td><td></td></tr>
<tr><td>20</td><td>How many times did you fall sick in the last two weeks? 1. None, 2. Once, 3. Twice, 4. Three times, 5. More than 3 times</td><td></td></tr>
<tr><td>21</td><td>Which illness did you suffer from the last two weeks? (If more than one disease, check all the diseases the mother has suffered) 1. Fever, 2. Vomiting, 3. Diarrhea, 4. Anemia, 5. Pneumonia, 6. Tuberculosis, 7. Typhoid, 8. Others (specify)……..</td><td></td></tr>
<tr><td>22</td><td>Do you take vitamin or mineral supplement? 1. Yes, 2. No</td><td></td></tr>
<tr><td>23</td><td>If yes how many tablets?
<table>
<tr><td>Supplement</td><td>Per day</td><td>Per week</td></tr>
<tr><td>Vitamins</td><td></td><td></td></tr>
<tr><td>Minerals</td><td></td><td></td></tr>
<tr><td>Multi-micronutrients</td><td></td><td></td></tr>
</table></td><td></td></tr>
<tr><td>24</td><td>What kind of services did you receive in the clinic
1……
2……..……
3.……..…….</td><td></td></tr>
<tr><td>25</td><td>Have you received adequate counseling about your HIV status? 1. Yes 2. No</td><td></td></tr>
<tr><td></td><td>E: ANTHROPOMETRICAL MEASUREMENT</td><td></td></tr>
<tr><td>26</td><td>Weight ----------.------kg</td><td></td></tr>
<tr><td>27</td><td>Height ----------.-----cm</td><td></td></tr>
<tr><td>28</td><td>MUAC----------.-----mm</td><td></td></tr>
<tr><td>29</td><td>Hb ----------g/dl</td><td></td></tr>
<tr><td>30</td><td>Total body fat ----------%</td><td></td></tr>
</table>

<table>
<tr><td></td><td>F: SENSORY EVALUATION OF THE PLUMPY NUT</td><td></td></tr>
<tr><td>31</td><td>
<table>
<tr><td></td><td>Like Strongly</td><td>Like Moderately</td><td>Like</td><td>Dislike Moderately</td><td>Dislike Strongly</td></tr>
<tr><td>Smell</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Taste</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Color</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>32</td><td>General acceptability 1. I like strongly, 2.I like moderately, 3.I like 4.I dislike moderately, 5.I dislike strongly</td><td></td></tr>
<tr><td>33</td><td>Would you like to take the Plumpy nut every day during your gestation? 1. Yes, 2. No</td><td></td></tr>
<tr><td></td><td>G: HIV STATUS</td><td></td></tr>
<tr><td>34</td><td>When did you know about your HIV status? 1. after being pregnant, 2.before being pregnant</td><td></td></tr>
<tr><td>35</td><td>Does your spouse know about your HIV status? 1.Yes, 2.No</td><td></td></tr>
<tr><td>36</td><td>If no when will you tell him about your status?</td><td></td></tr>
<tr><td>37</td><td>Have you been counseled about breast feeding options? 1. Yes 2. No</td><td></td></tr>
<tr><td>38</td><td>Which one have you opted.....</td><td></td></tr>
</table>

H: DIETARY INFORMATION

39. What have you consumed within the past 24 hrs?

Time	Description of food or drink. Give brand name if applicable	Household measure	Amount consumed
Morning			
Mid morning			
Lunch			

Mid afternoon			
Evening			

Appendix 2: Follow up Questionnaire

Sokoine University of Agriculture

Faculty of Agriculture

Department of Food science and Technology

TITLE: Efficacy of Plumpy Nut in Improving Nutritional Status of HIV Positive Pregnant Women and their Infants.

FOLLOW UP QUESTIONNAIRE

Region ---------- District----------

Name of Health facility---------- Date----------

ID ----------

No.	ITEMS	Base line	Follow up visits				
			1st	2nd	3rd	4th	5th
1	Weight(kg)						
2	MUAC(cm)						
3	Hb (g/dl)						
4	Body fat (%)						
5	Plumpy nut sachets remained						

6	Morbidity information Have you fallen sick from the last visit? 1. Yes (If yes specify) ----------2. No						
7.	Supplement acceptability 1. I like strongly, 2.I like moderately, 3.I like 4.I dislike moderately, 5.I dislike strongly						

8. What have you consumed within the past 24 hrs?

Time	Description of food or drink. Give brand name if applicable	Household measure	Amount consumed
Morning			
Mid morning			
Lunch			
Mid afternoon			
Evening			

Appendix 3: Research Participant Consent Form

RESEARCH PARTICIPANT CONSENT FORM

I. **Title of the study:** Efficacy of Plumpy nut in improving nutritional status of HIV positive pregnant women and their offspring in Temeke district**.**

II. **Purpose of the study:** This is the research that is going to compare the effectiveness of Plumpy nut to nutritional status of HIV positive pregnant women. The main objective of the study is to improve the nutritional status of pregnant women living with HIV/AIDS and their expected offsprings. The specific objectives of the study are; To assess the nutritional status of HIV positive pregnant women, To assess food consumption pattern, To examine the effect of supplementation on blood paramenter by measuring the hemoglobin concentration level, To identify morbidity pattern, To assess the nutrtional status of the off spring. This study is done in collaboration with Sokoine University of Agriculture, Department of Food Science and Technology, Temeke Municipality in particular health facilities of Consolata Sisters, Majimatitu, Keko, Arafa ugweno, SDA, Buza, Yombo Vituka, Tambukareli and Kigamboni, and UNICEF.

III. **Study procedure**: If you agree to participate in this study, please respond to my questionnaire and provide the required information. I will ask your permission to take your body measurements including weight, length, mid upper arm circumference and the blood will be drawn to measure the hemoglobin level when you visit the clinic. After the initial measurements the supplement will be provided for four weeks, this will be followed by monthly follow up for six months

IV. **Risk and discomfort:** No any risk is expected but you will fill some pain during finger pricking to take blood sample. If happen to be allergic to pea nut you may withdraw from the study.

V. **Benefits:** It is expected that there will be direct benefit to you where by the nutritional status will be improved, reduced morbidity, reduce chances of transmitting infections to fetus and nutritional counseling.

VI. **Compensation:** You will not be given any allowances for your participating in this study.

VII. **Confidentiality:** confidentiality will be maintained. However the study result will be shared with the members of research committee and will be a matter of public report.

VIII. **Participation:** To be part of this study is voluntary. You can choose not to take part in this study or stop taking part in the study at any time you wish, for any reason. Withdraw from the study will have no consequences to you as a participant.

IX. **Whom to contact:**

Elina Kweka,

Sokoine University of Agriculture,

Food Science Department,

Box 3006,

Morogoro- Tanzania.

+255 714 238 843

X. **Statement of consent** I have read the above information or it has been read to me. I have had the opportunity to discuss this research study with researcher, and I have had my questions answered by her in a language I understand.

Appendix 4: Sample Size Calculation

An appropriate sample size was determined depending on the following parameters:- minimum expected difference, estimated measurement variability, statistical power, significance criterion and statistical analysis (John, 2003).

Minimum expected difference: - was the smallest measured difference between comparison groups that the investigator detected. As the minimum expected difference was made smaller, the sample size needed to detect statistical significance increased. The minimal expected difference of hemoglobin concentration was 0.59 g/dl (Fawzi et al, 2007).

Estimated measurement variability: - parameter was represented by the standard deviation in the measurements made within each comparison group. As statistical variability increased, the sample size needed to detect the minimum difference increased. The estimated measurement variability was determined on the basis of preliminary data collected from a similar study population or reviews of a literature also provide estimates of this parameter. The estimated variability was 0.9g/dl.

Statistical power: - As power is increased, sample size increase. Statistical power is customarily set to a number greater than or equal to 0.80. In this study the statistical power was set at 0.80.

Significance criterion: - parameter was the maximum *P* value for which the difference was considered statistically significant. As the significance criterion was decreased (made more strict), the sample size needed to detect the minimum difference increased. The significance criterion for this study was set at 0.05.

Statistical analysis: - the study was a two tailed statistical analysis

$$N = \frac{4\sigma^2 (Z_{crit} + Z_{pwr})^2}{D^2}$$

N=total sample size (size of both comparison groups)

σ =assumed standard deviation of each group

Z_{crit} = desired significant criterion (set at 0.05)

Z_{pwr} = desired statistical power (set at 0.80)

D= minimum expected difference between the two means

Then,

$$N = \frac{4 \times 0.9^2 (1.96 + 0.842)^2}{0.5^2} = 101.7 \approx 102$$

Therefore:-

A total of 102 HIV positive pregnant women were selected to participate the study. Including 10% attrition it makes a total of 112 subjects selected when the study started.