NUTRIENT COMPOSITION OF *HYPOCHONDRIACUS AMARANTHUS* GRAIN AND CONTRIBUTION TO NUTRITIONAL STATUS OF HIVAND AIDS INFECTED CHILDREN ATTENDING THIKA DISTRICT HOSPITAL

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university or any other award.

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SUPERVIORS AUTHORIZATION

We confirm that the work reported in this thesis was carried out by the candidate under our supervision.

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To my daughters, Deborah and Mary-Delight and my husband Tito; persons who have continually inspired my life.

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ABBREVIATIONS AND ACRONYMS

AAC	African Agricultural Capital
ADA	American Dietetic Association
AIDS	Acquired Immuno Deficiency Syndrome
ANSA	Association of Nutrition Services Agencies
ANOVA	Analysis of Variance
AOAC	Association of Analytical Chemists
ART	Anti-Retroviral Therapy
ARVs	Anti-Retroviral Drugs
CCC	Comprehensive Care Clinic
FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agricultural Organisation
HIV	Human Immuno Deficiency Virus
KAIS	Kenya AIDS Indicator Survey
KEBS	Kenya Bureau of Standards
KDHS	Kenya Demographic Health Survey
NACC	National Aids Control Council
NASCOP	National AIDS and STI Control Programme
OVC	Orphans and vulnerable children
RDA	Recommended Dietary Allowances
SPSS	Statistical Package for Social Sciences
UNAIDS	United Nations Programme on HIV/AIDS
UNICEF	United Nations Children's Education Fund
USAID	United States Agency International Development

WFP	World Food Programme
WHO	World Health Organization

ABSTRACT

Food and nutrition interventions are critical components of comprehensive responses to the HIV and AIDS pandemic. High nutrition quality of amaranth grain has been established but it remains an underutilized crop in Kenya despite the potential to broaden the food base which is critical in the context of HIV and AIDS. Information on the utilization of amaranth grain and its contribution to the nutrition status of vulnerable groups has not been sufficiently documented. The purpose of this study was to determine the nutrient composition of *hypochondriacus amaranthus* grain and assess the contribution of amaranth-based porridge consumption to nutrition status of HIV and AIDS infected children attending Thika District Hospital Comprehensive Care Clinic. The study was a longitudinal (6 months), experimental pre and post single group design, with a comprehensive sample of 52 children. The study was conducted in two phases. In phase one, data on nutrient composition and sensory evaluation of researcher-developed amaranth-based porridges were collected (6 months). Phase two included baseline assessment and the intervention. Intervention included monthly provision of adequate amaranth flour to be consumed by the children on a daily basis, nutrition education and counselling. Phase two data comprised demography, dietary intake, anthropometric, morbidity, and CD4 counts) and during and after intervention data on, anthropometry (monthly), morbidity prevalence (monthly) dietary intake (at month six) and CD4counts (at month six). Quantitative data were analysed using SPSS 16.0 and anthropometry data were analyzed using EPI INFO anthro pack then transformed into Z-Score. Dietary intakes were analyzed using Nutrisurvey (2007). Descriptive statistics were used to describe the results on nutrient composition, sensory evaluation, demographic data, and children's dietary, anthropometric and morbidity characteristics. Inferential statistics such as ANOVA, paired t-test, independent t-test were used to determine statistically significant differences at 95% CI, Pearson's product moment correlation for significant relationships 95% CI and linear regression for significant associations between selected variables. The findings indicated that amaranth grain has higher content of proteins (15.29±0.80g), total lipids (8.50±0.90g) dietary fibre (5.50±0.20g), iron (20±0.8mg), zinc (4.00±0.6mg) and potassium 428.80±1.2mg) compared to the local cereals. The most preferred porridge was the amaranth maize blend followed by fermented amaranth porridge which was used for intervention. Baseline findings indicated inadequate mean intake of kilocalories (1281.10±379.69 kcal), vitamin A (268.35±216.65µg), calcium (412.41±253.79 mg) and selenium (26±12.93µg) by the study children. There was significant difference ($p< 0.001$) between pre- and post-intervention mean intake of all nutrients except for selenium. Pre-intervention stunting was 36.5%, wasting 34% and underweight 30.8%. Post-intervention stunting was 32.7%, wasting was 21.2% and underweight 17.3%.Wasting and underweight reduced significantly ($p=0.001$) after intervention. There was reduced prevalence of illness and significant improvement ($p<0.001$) between pre and post-intervention CD4 counts. The findings indicated that amaranth grain is higher in nutrients and that consumption of fermented amaranth grain porridge had a positive significant contribution to the nutrition status, CD4 counts and reduced morbidity incidences of HIV infected children. It is recommended that public awareness, education on the nutritive value and sensitization on consumption of amaranth grain by persons infected with HIV and AIDS be promoted and scaled up by nutritionists.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

The science of nutrition is complex and dynamic and it includes all aspects of ingestion, digestion, absorption, transportation and assimilation of chemical compounds (nutrients) present in foods (American Dietetic Association, 2004). The chemical compounds in foods have specific essential functions in the human body along the continuum of wellness and illness (WHO, 2008). Adequate nutrition is vital for growth, maintenance, health and survival for all individuals (WHO, 2008). The demand for food is increasing not only to meet the food security for growing populations but also provide more nutritious foods rich in nutrients and neutraceutical compounds (Barba *et al.,* 2009). A nutritious diet containing adequate nutrients (macronutrients and micronutrients) is vital for all people (WHO, 2008). It is even more critical for people living with HIV/AIDS in order to maintain and strengthen the immune capacity and keep opportunistic infections at bay (UNAIDS, 2004; NASCOP, 2006; Paton *et al.,* 2006; WHO, 2008).

Public nutrition is a multifaceted and broad-based problem solving approach addressing malnutrition in vulnerable groups (Young *et al.,* 2005). Globally, good nutrition has been recognized as essential for promoting health and quality of life of the people living with HIV and AIDS (NASCOP, 2006; WHO, 2008). The HIV and AIDS epidemic poses an inescapable challenge worldwide. HIV and AIDS has become the leading cause of ill health among people globally (UNAIDS, 2009). Towards the end of the twentieth century, HIV and AIDS joined a series of public health challenges so profound and far-reaching that major shifts in public health thinking and action were provoked (UNAIDS, UNHCR,WFP, 2007).

HIV and AIDS is a public health and socio-economic problem in many countries in the Sub-Saharan Africa where it is a major cause for morbidity and mortality (UNAIDS 2009). Morbidity and mortality related to human immunodeficiency virus (HIV) infection in the developing world remain unacceptably high, despite major advances in HIV therapy and increased funding internationally for care (Louise *et al.,* 2009). A major contributing factor is the fact that over 800 million people remain chronically undernourished globally (Louise *et al.,* 2009; Sci Dev Net, 2009). The HIV epidemic largely overlaps with populations' already experiencing malnutrition (Louise *et al.,* 2009). In Sub-Saharan Africa, where more than 22 million people are living with HIV and AIDS, malnutrition and food insecurity are endemic (UNAIDS, 2007).

Kenya like other countries in the Sub-Saharan region is severely affected by HIV and AIDS. According to the Kenya 2007 HIV and AIDS Estimates Report, the number of adults and children living with HIV and AIDS was estimated at 1,643, 065 by the end of 2009 (NACC and NASCOP, 2009). The report indicates a national adult (15+) rate of 6.5%. Kenya has an estimated burden of close to 1.2 million orphans and vulnerable children (OVC) directly related to HIV and AIDS mortality (World Bank, 2007). According to the Kenya National HIV and AIDS estimates (2010), the HIV prevalence is 6.2% (UNGASS, 2010). Most of the reports show that the prevalence has stabilized.

HIV and AIDS is both a cause and a consequence of wide spread hunger and malnutrition in Sub-Saharan Africa (UNAIDS, 2004). This is why the World Health Organisation (2008) urges a renewed focus on nutrition as fundamental part of

comprehensive package of care for people with HIV/AIDS at country level (WHO, 2008; UNAIDS, 2004). Combating under nutrition and HIV and AIDS are two of the eight United Nations Millennium Development Goals to be achieved by 2015 (UN, 2006; WHO, WFP and UNAIDS, 2008).

Food and nutrition interventions are critical components of comprehensive responses to the HIV pandemic (FANTA, 2006; Panagides *et al.,* 2007; FANTA, 2008). Provision of high quality and adequate food is a significant challenge to the caregivers due to financial constraints, inability to access adequate amounts of food and low diversibility of the diets (FANTA, 2006). A diverse and adequate diet is fundamental for better health for people living with HIV and AIDS (NASCOP, 2006). To diversify the food base, there is need to emphasize on utilization of underutilized nutritious food crops like the amaranth grain.

The benefits of food assistance programmes, which remain the most widespread form of nutrition support to HIV- infected individuals in Sub-Saharan Africa, are mostly speculative and have not been rigorously evaluated. A challenge to generating rigorous evidence of the impact of food assistance programmes on PLHIVs in countries where there is widespread co-existence of malnutrition, food insecurity, and HIV is the important ethical challenge in conducting experimental studies with randomized control groups that receive no intervention (Victora *et al.,* 2004).

While food assistance programmes to HIV affected households are widespread, studies evaluating the impact of these programmes are just emerging. This study focused on the contribution of amaranth grain consumption to the nutrition status of

HIV-infected children attending the Comprehensive Care Clinic at Thika District Hospital.

The amaranth grain has a unique composition of protein, carbohydrates and lipids. Along with the protein, amaranth provides a good source of dietary fiber and minerals including iron, zinc, magnesium, phosphorous, copper and manganese (Tacio, 2009). The food value of grain amaranth was recognized by people from Mexico, Peru, and Nepal long before any nutritional analyses were conducted (Bressanni, 1989). Grain amaranth was very popular for its healing effect, nutritional value and easy to digest. Apart from being given to those who were recovering from an illness or a fasting period, grain amaranth was considered sacred and was used in the pagan rituals of worship among the Aztecs of Mexico because of these attributes (Rodale, 1986). However, the colonizers detested the rituals of the Aztecs using the amaranth in the sixteenth century and they decided to eradicate the use of this crop by drastically reducing its cultivation (Rodale, 1986).

Today, with the help of modern genetics, amaranth grain is believed to have what it takes to become a modern agricultural wonder crop for many reasons. One, it has high protein content (13-19%) with high levels of the essential amino acid lysine (3.2-6.4%) as compared with (2.2-4.5%) found in most common cereals (Bressanni, 1989). The amaranth protein is also easily digested with an impressive 90% score that is much higher than in soy, milk and wheat (http:// newfarm.rodaleinstitute.org/may, 2005). Two, amaranth contains 6 – 10% high-quality oil which is predominantly unsaturated and high in the essential fatty acid linoleic (Becker *et al.,* 1981). The oil

content is 1.5-3.0 times more than in some cereals like maize, which represents a higher caloric value (Becker *et al.,* 1981).

Third, in addition to protein and fat content, the amaranth grain, has high levels of calcium, phosphorus, iron, potassium, zinc, vitamin E and B-complex (Bressanni, 1989). Furthermore, the crop can successfully grow in adverse environmental conditions such as drought, high temperature and saline soils. It is also a crop with multiple uses, which include food, forage, silage, green manure and as animal feed (Kauffman, 1992). Amaranth produces a large amount of biomass in a short period of time and therefore, has the potential of contributing to a substantial increase in world food production (Kauffman and Weber, 1990). Grain yield of up to 5,000 kg/ha has been reported (Stallknecht and Schulz – Schaeffer, 1993). The grain amaranth is a nutritious food source and a promising alternative grain for the modern diet (Gebhardt and Thomas, 2007).

In view of the nutrition and health benefits associated with consumption of amaranth grain such as the high quality protein, the high rate of digestion and absorption and absence of allergens, it has the potential for use as a nutrient dense food for the nutritionally vulnerable groups such as children with HIV and AIDS. High quality protein is crucial for HIV and AIDS infected children not only to boost the immune system but also to facilitate growth (FANTA 2006). Thus, the need to investigate the effects of amaranth grain consumption on the nutrition and health status of HIV and AIDS infected children.

1.2 Statement of the Problem

Malnutrition is a predominant feature in people living with HIV and AIDS and it is a co-factor in the disease progression (FANTA, 2006; FANTA, 2008; USAID, 2009). Every year, millions of dollars are pumped into tackling HIVand AIDS including antiretrovirals and research for vaccines and drugs. But poor nutrition remains a major barrier for preventing sickness and death from the virus (Sci Dev Net 2009). A review studies on approaches to nutrition in HIV programmes in Africa concluded that HIV and AIDS policies in operation have tended toward highly "medicalized approaches and called for a comprehensive approach to link strategies with community oriented food-based strategies" (Panagides *et al.,* 2007). Several international agencies are currently re-focusing their interventions but few data exist to help guide the development of effective programmes that integrate HIV care and nutrition. Furthermore, the World Bank calls for a scaling up of action on nutrition and AIDS through "action research" and "learning by doing" (World Bank, 2007).

Childhood malnutrition is a major public health problem throughout the developing world (USAID, 2009). The treatment of HIV-positive children is frequently complicated by high rates of acute malnutrition (WHO, 2009). The effects of malnutrition on children infected with HIV and AIDS are more serious due to the fact the children are trying to keep up to the demands of normal growth and development in addition to the demands of achieving and maintaining a strong immune system (FANTA, 2006; NASCOP, 2006; Robert *et al.,* 2006; WHO,2009).

The requirements for energy dense and high quality protein is high in children living with HIV and AIDS due to the high rate of metabolism and the need to boost,

strengthen and maintain the immune system (Shevitz *et al.,* 1999; FANTA, 2006; NASCOP, 2006; WHO,2009). Whereas, the energy requirements can be met by utilizing the easily available and cheap cereals, meeting the protein requirements is a challenge since the cereals have low protein and are "unbalanced" in terms of essential amino acid composition. They are limited in the essential amino acids like lysine that are essential for optimum growth and health (Bressani, 1990; Tacio, 2009).

The main sources of high quality protein are animal foods, which are relatively expensive and sometimes it is difficult for the care providers to provide for the protein requirements of the HIV and AIDS infected children adequately due to financial constraints (Oldewage *et al.,* 2006). The financial cost of care to individuals also has an important effect on HIV care in resource-constrained environment and development of evidence–based programmatic solutions is essential (Oldewage *et al.,* 2006). There is need, therefore, to explore other available alternatives of enhancing intake of high quality protein for the vulnerable groups of people. The grain amaranth is a nutritious food source and a promising alternative grain for the modern diet (Gebhardt and Thomas, 2007).

Although the nutrition quality of amaranth grain in other countries has long been established, it is an underutilized crop in Kenya and yet it has the potential to broaden the food base, enhance diet diversification and reduce the levels of malnutrition (Mwangi, 2006). This potential is compounded by the lack of sufficient information on the nutritional and medicinal value of amaranth grain for the vulnerable groups of people such as HIV and AIDS infected children.

In Kenya, information on the nutrient composition, organoleptic attributes of food products made from the locally grown amaranth grain varieties and contribution of amaranth grain consumption to the nutrition status is limited and has not been sufficiently documented (Mwangi, 2006). There is need to generate data on the nutrient composition, sensory attributes of food products made from the locally grown amaranth grain varieties and impact of consumption on nutrition status of vulnerable groups. In this study, the proximate composition, mineral content, beta-carotene, ascorbic content of the locally grown *hypochondriacus amaranthus* grain was determined. The sensory attributes of different porridges made from the locally grown *hypochondriacus amaranthus* grain were also evaluated. In addition the contribution of amaranth grain consumption to the nutrition status of the 2 to 5 years old HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital.

1.3 Purpose of Study

The purpose of this study was to determine the nutrient composition of the locally grown *hypochondriacus amaranthus* grain and assess its contribution to the nutritional status of 2 to 5 years old HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital.

1.4 Specific Objectives

The specific objectives of this study were to:

(i) Determine the nutrient composition of the locally grown *hypochondriacus amaranthus* grain using the standard AOAC methods.

(ii) Develop and evaluate the sensory attributes of amaranth unfermented, fermented amaranth, amaranth-maize blend and amaranth-finger millet blend porridges.

(iii) Determine the pre and post dietary intake of selected nutrients among HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital using a 24 hour dietary recall.

(iv) Establish the periodic prevalence of illness among the HIV and AIDS infected children attending the Comprehensive care clinic at Thika District Hospital using time sampling of 2 weeks per month.

(v) Establish the pre and post CD4 counts of HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital.

(vi) Determine the pre and post nutritional status of HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital using anthropometric measurements.

(vii) Determine the contribution of amaranth grain consumption to the nutritional status, prevalence of illness and CD4 counts among HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital.

1.5 Research Questions

i. What is the nutrient composition of *hypochondriacus amaranthus* grain?

ii. What is the rating by evaluation of the sensory attributes of the developed amaranth grain porridges?

iii. What is the pre and post intervention level of dietary intake of selected nutrients by the HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital using a 24 hour recall

iv. What is the pre and post intervention prevalence of illness among the HIV and AIDS infected children attending the Comprehensive care clinic at Thika District Hospital

v. What is the pre and post intervention level of CD4 counts of the HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital

vi. What is the pre and post intervention nutrition status of the HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital

vii. What is the contribution of amaranth grain consumption to the nutritional status, prevalence of illness and CD4 counts among HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital

1.6 Significance of the Study

This study provides information on the nutrient content, sensory evaluation, and effects of consumption on the nutritional status of 2-5 years old HIV and AIDS infected children. The findings may be useful to nutritionists and other health professionals working with HIV and AIDS infected children by expanding the knowledge base in dietary interventions. These findings may also be important to the Ministry of Public Health and Sanitation and Non-Governmental Organisations (NGOs) in developing appropriate policies and programmes to reduce malnutrition in HIV and AIDS infected children. The information may motivate the health professionals mainly doctors, nurses, nutritionists, and caregivers of HIV and AIDS infected persons at community level and at institutional level to explore the use of underutilized foods with potential of providing high quality diets through

diversification. The findings may motivate agronomists to work towards enhancement of cultivation and production of amaranth grain in Kenya. Additionally, the findings will contribute to the on-going research efforts on amaranth grain and dietary interventions for HIV infected children in Kenya.

1.7 Delimitations

The study was confined to the 2 to 5 years old children attending the Comprehensive Care Clinic at Thika District Hospital and did not include those not attending the clinic or not receiving health services.

1.8 Limitations

The nutrition status assessment in this study was based on anthropometric and dietary intake measurements and did not include biochemical and clinical assessment. Though study findings indicated high protein content in the amaranth grain, it was not possible to determine the protein quality in terms of amino acid profile, due to constraints in accessing the required laboratory facilities, equipments and finances.

1.9 Conceptual Framework

The conceptual framework for this study was adapted from the UNICEF (1990) conceptual framework for the determination of nutrition status (Figure 1.1). The conceptual framework illustrates how food and nutrition interventions can lead to changes in knowledge, dietary practices and availability of resources at individual and household level, which in turn influence food access, dietary intake and nutritional status.

Conceptual Framework of Food and Nutrition Interventions Addressing HIV and AIDS

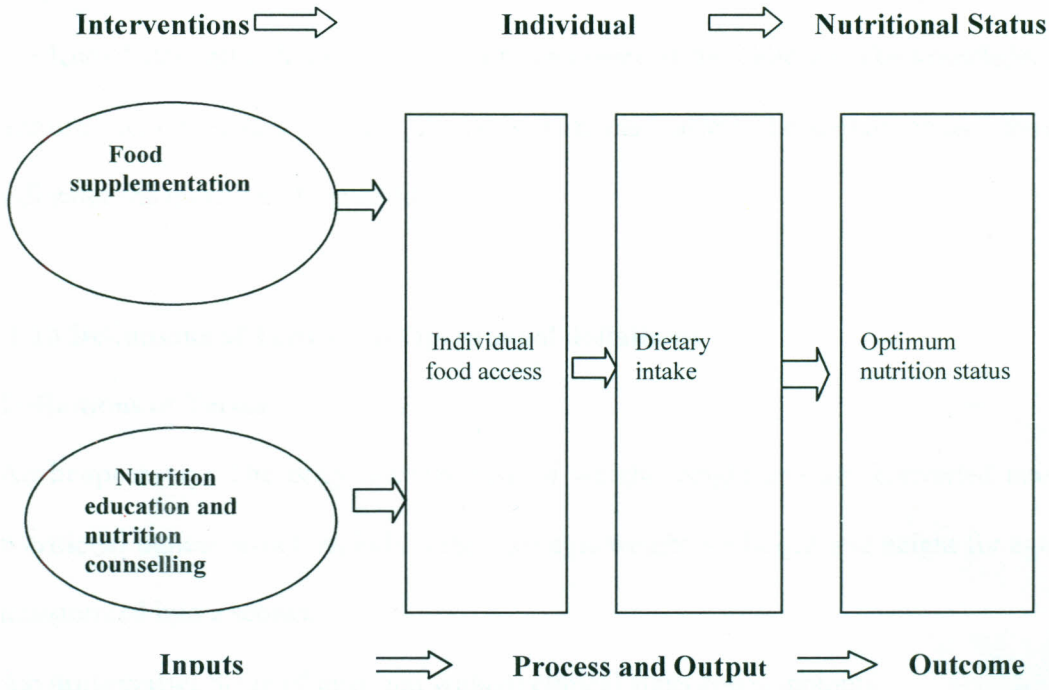

Figure 1.1: Conceptual Framework: (adapted from conceptual framework for the determination of nutrition status (UNICEF, 1990)

While the original framework focuses on the determinants of nutrition status, this framework focuses on how interventions improve the nutrition status of people living with HIV (PLWHIV). The Key intervention in this study was mainly the food supplementation. In addition nutrition education and counselling were also included as supportive strategies. The underlying preconditions to optimal nutrition status include individual food access to meet the dietary requirement of individual. Optimal nutrition results from a balance between the amount of nutrients needed by the body and amount of nutrients being consumed. In this study amaranth grain was used to supplement the diet of the children through enhancing individual food access and dietary intake for optimal nutrition. Adequacy of dietary intake influences the nutrition status of the children. Though nutrition education and counselling were not

part of the objectives of the study, these were mainly employed in the study for the purpose of enhancing compliance. Nutrition education and counselling may influence the Knowledge, attitude and practices of caregivers of the children. The knowledge, attitudes and practices of care givers in turn may affect the dietary intake thus influence the nutrition of the children.

1.10 Definitions of Terms and Operational definitions

Definitions of Terms

Anthropometry: The body measurement of weight, height and age converted into nutritional indices which include weight for age, weight for height and height for age transformed into z scores.

Asymptomatic: Stage of infection without clinical signs and symptoms.

Diet: Amount and kind of food and/or drink taken by an individual.

Exclusive breast feeding: Giving the infant no food, water or drink except breast milk for the first 6 months of life.

***Hypochondriacus* amaranth grain:** A species of amaranth grain characterised with the high yielding capacity and disease-tolerant.

Malnutrition: A condition of the body resulting from inadequate or excess intake of required nutrients or malabsorption which can be classified as wasting, underweight and stunting.

Meal: Food eaten at a particular time.

Nutritionally vulnerable: The extent to which an individual's nutrition status is threatened by a risk or a defined event.

Pseudo cereal: Seeds producing plant that does not belong to the grass family.

Quality of life: Life with minimized burden of illness with respect to daily functioning as valued by individuals.

RDA: Average daily requirement of various nutrients to maintain nutritional status of a healthy person according to international FAO/WHO 1998 standards.

Stunting: Nutrition index of low height-for- age indicating chronic malnutrition when the z-scores are below -2.

Symptomatic: Stage of infection with clinical signs and symptoms.

Underweight: Nutrition index of low weight for age indicating low growth rate with z-scores below -2.

Wasting: Nutrition index of low weight-for-height indicating 'acute' malnutrition when the z-scores are below -2.

Wimbi: Local (*Kiswahili*) name for finger millet.

Operational Definitions

Dietary intake: Consumption of nutrients at pre and post intervention by the study children based on the 24 hour recall

Frequency of illness: The number of times the child suffered from an illness on monthly basis during the study period

Food supplementation: Monthly provision of amaranth flour to the care givers of the HIV and AIDS infected children to be used for the children's porridge on a daily basis for six mosnths.

KEBS 2007 Data: Nutrient composition of cereals obtained from the Kenya Bureau of Standards of the year 2007

Local cereal: Conventional cereals consumed in Kenya such as maize, finger millet (*wimbi)*, sorghum, rice, wheat

Locally grown: Grown in Kenya

Optimal nutrition status: The state of nutritional homeostasis that can facilitate growth, maintenance, health and survival of the HIV and AIDS infected children as influenced by intake and utilization of nutrients

Pure amaranth: Not blended and not fermented

Number of illness: The number of illness the child suffered from monthly during the study period reported.

Number of meals: The number of times the child ate based on the 24 hour dietary recall.

Nutrition Status: A measurement of the health state of an individual as influenced by intake, absorption and utilization of nutrients. The main indicators in this study were wasting, underweight and stunting.

Morbidity: Presences and prevalence of illness or disease.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on the varieties of amaranthus, history of amaranth grain, nutrient content of amaranth grain, utilization of amaranth grain, HIV/AIDS, nutrition and immune system, nutrition and HIV and AIDS, food-based nutrition interventions, therapeutic benefits of amaranth grain and the HIV pandemic in Thika District.

2.2 Amaranthus Varieties

The genus a*maranthus (*L*)* belongs to the family a*maranthaceae* (Kalac and mouldry, 2000). Amaranthus are widely distributed; short-lived annual herbs occurring in temperate and tropical regions (Kauffman and Weber, 1990; Yarger *et al.,* 2008). There are 60 to 70 species and about 6000 varieties within species which are categorized into four categories: grain, vegetable, ornamental or weed (Yarger *et al.,* 2008). Many varieties fall into more than one category. Amaranth is one of the few plants whose leaves are consumed by humans as vegetables while the seeds are used the same way the cereals are used (AAC, 2009; Kauffman and Weber, 1990).

The main species grown as vegetables are *A.tricolor, A. Dubius, A. lividus, A.cruentus, A. palmeri, and A. Hybrdus* while *A.hypochondriacus, A.cruentus and A. caudatus* are the main grain species (AAC, 2009; Teutonic and Knorr, 1985). Vegetable amaranth species have been utilized as food in different parts of the world (Yarger *et al.,* 2008). Amaranth grain is one of the oldest food crops known with evidences of cultivation reaching back as far as 6700 B.C (Bressanni, 1989). Amaranth grain is a non-grass cereal found in its unique class called *pseudo cereal.*

Though it produces seeds that can be used as a cereal, it does not belong to the grass family (Bressanni, 1989; Yarger *et al.,* 2008).) Grain amaranth can be used as whole seeds or as flour to make products such as porridge, cookies, cakes, pancakes and bread. The different varieties of amaranth are shown in Figure 2.1 below.

Figure 2.1: Amaranth varieties

Source: Yarger L, Kelly G. O'Brien, and Martin L. P., (2008). Amaranth Grain and Vegetable types: ECHO Technical Note. http:/ www.echotech.org

In Kenya, the commonly consumed category is the vegetable amaranth *(Muchicha, Terere*). The grain amaranth is also gaining popularity in Kenya as a nutritious cereal (Berkelar and Alemu 2006). Amaranth grain has been incorporated into some local Kenyan cereal flours for dishes such as porridge and the popped grains are chewed alone or added to other dishes (Mwangi, 2006). Three main species of amaranthus are grown for grain in Kenya (Mwangi, 2006). *Amaranthus caudatus* is the species that is mostly grown in Kenya. It takes the shortest season of 45 to 75 days to maturity. Its short growing season makes it good for areas that have a short rainy season. *A. Cruentus* has a mid-length season of 60 to120 days. It is often grown in Mexico and is least sensitive to photoperiod (hours of sunlight each day). *A. hypochondriacus* has the longest season, maturing at 150 days. It also has the highest yields and is disease-tolerant (Berkelar and Alemu, 2006).

2.3 History of the Amaranth Grain

Amaranth grain has an interesting history. It was a staple in the diets of pre-Columbian Aztecs, who believed it had supernatural powers and incorporated it into their religious ceremonies (Myers *et al.,* 1999). Before the Spanish conquest in 1519, amaranth was associated with human sacrifice and the Aztecs women made a mixture of ground amaranth grain with honey or human blood then shaped the mixture into idols that were eaten ceremoniously. This practice appalled the conquistadors who reasoned that eliminating the amaranth will eliminate the sacrifices. The grain was forbidden by the Spanish and consequently fell into obscurity for hundreds of years. If not for the fact that the cultivation continued in a few remote areas of the Mexico, it may have been extinct (Myers *et al.,* 1999).

Amaranth grain is a crop that is in its adolescence stage that has generated a lot of excitement in research (AAC, 2009; Yarger *et al.,* 2008). The cultivation and utilization will continue to increase as more information is obtained through research (Berkelar and Alemu, 2006). Consumption of the vegetable amaranth (*muchicha*) is common in Kenya but scientific knowledge on grain amaranth began in the 1990s when a Kenyan scientist, Davidson Mwangi began working on the development of varieties (Berkelaar and Alemu, 2006). By 1999, the grain amaranth had been introduced to two communities in Eastern Kenya through the efforts of some organizations like the Christian Reformed World Relief Committee (CRWRC) (Berkelaar and Alemu, 2006). Between 2000 and 2001, a grain amaranth pilot project training centre was started with the rural Masaai at Ngong. Today, many other groups in Kenya are working with amaranth grain (Berkelaar and Alemu, 2006). Amaranth International Limited (AIL) has developed the capacity to process grain amaranth into flours and breakfast cereals that are now available in the local market (AAC, 2009).

2.4 Amaranthus Consumption

Out of the various species of amaranths, three have been selected over the years as the choice for human and animal consumption (AAC, 2009; Yarger *et al.,* 2008). Amaranthus *hypochondriacus* and amaranthus *cruentus* are commonly grown for grain and amaranthus *tricolor* is grown primarily for the leaves (AAC, 2009; Yarger *et al.,* 2008). Production and consumption of amaranth grain in Kenya is a relatively recent phenomenon hence the need for research focusing on both production and consumption (Mwangi, 2006). This study focused on the effects of consumption of *hypochondriacus amaranthus* grain on the nutrition status of the HIV/AIDS infected children attending the Comprehensive Care Clinic. There are phenomenal claims of

improvement in general wellbeing of individuals using amaranth grain in their diets including: reduction in symptoms of severe malnutrition among children, and increased body mass index of adults formerly wasted by HIV and AIDS ((Berkelar and Alemu, 2006). However, there is limited scientific documentation of such claims and there is need for research on effects of consumption by vulnerable groups.

2.5 Composition of Amaranth Grain

Amaranth grain has characteristics and properties similar to those of the monocotyledonous cereal grains (Teutonic and Knorr, 1985). Cereals contain an abundant starchy endosperm with small amounts of lipids and proteins found in the embryo (Teutonic and Knorr, 1985). Amaranth grain has a starchy portion but the starch is stored in the perisperm since the embryo occupies a greater proportion of the grains, (Myers *et al.,* 1999). Amaranth seed protein differs from other cereals by the fact that 65% of the protein is found in the germ and 35% in the endosperm as compared to an average of 15% in the germ and 85% in the endosperm for other cereals (Teutonic and Knorr, 1985). Since it is dicotyledonous and not a true cereal, it is technically referred to as pseudo cereal (Teutonic and Knorr, 1985). Amaranth seeds are unique in that the nutrients are concentrated in a natural "nutrient ring" that surrounds the centre starchy section, protecting the nutrients during cooking (Myers *et al.,* 1999).

2.6 Nutritive Value of Amaranth Grain

The nutritive value of amaranth grain has been extensively studied (Bressani, 1988; Meyers *et al.,* 1999; Teutonic and Knorr, 1985; Gebhardt and Thomas, 2007). The grain has a unique composition of protein, carbohydrates and lipids. Along with the

protein, amaranth provides a good source of dietary fiber and minerals including iron, zinc, magnesium, phosphorous, copper and manganese (Tacio, 2009). There is limited information on the nutritive value of the locally grown amaranth grain varieties.

Geographical variations do influence nutrient content of amaranth grain crop (Bressani, 1989). The nutrient composition of amaranth grain has been established for varieties grown elsewhere but not in Kenya (Mwangi, 2006). There is therefore need for data on nutrient composition of the locally grown varieties and part of this study was to determine the nutrient composition of the *hypochondriacus amaranthus* grain variety grown in Kenya. Currently a number of studies are going on to establish the nutrient composition for varieties grown locally and they are yet to be documented.

2.6.1 Protein

Grain amaranth contains approximately 18% protein compared to other cereals like maize, rice, wheat, sorghum, oats and millet which contain 7.5%-13.8% (Bressani, 1989). Besides the high protein quantity, amaranth grain exhibits a high quality protein with a score of 75-82 in a theoretical score of 100 (Tacio, 2009; Bressani, 1989). This makes grain amaranth come closer to the perfect balance of essential amino acids for human nutrition as established by FAO/WHO, (Tacio, 2009; Bressani, 1989).

Cereals are generally "unbalanced" in terms of essential amino acids composition. Grain amaranth protein provides the limiting amino acids in most commonly used cereals. (Tacio, 2009). These are lysine, methionine and tryptophan which are essential for optimum health. However, amaranth is limited in the amino acid leucine.

A comparison of essential amino acids content in amaranth grain and other cereals is shown on Table 2.1. In this study, the protein content of the *hypochondricus amaranthus* grain was determined but amino acid profile was not determined due to constraints in laboratory facilities.

Table 2. 1: Essential Amino Acid Content of Amaranth and Other Cereals

Essential aminoacids g/100g	Amaranth	Wheat	Soya Bean	Sorghum	Finger millet	Maize	FAO/WHO standard
Lysine	5.95	0.23	2.30	2.5	2.5	2.8	5.40
Leucine	4.20	0.71	2.80	13.5	7.8	12.3	7.00
Isoleucine	2.71	0.36	1.67	4.0	4.0	3.6	4.00
Phenylalanine	4.70	0.52	1.80	4.9	4.1	4.9	6.00
Methionine	0.64	0.18	0.45	1.3	5.0	2.1	3.50
Threonine	3.25	0.28	1.50	3.3	3.1	3.8	4.00
Tryprophan	1.82	0.13	0.50	1.0	1.3	0.7	1.00
Valine	3.85	0.42	1.70	5.0	6.4	5.1	5.00

Source: Bressani, 1989; Saunders and Becker, 1984

A number of studies have concluded that amaranth grain has high protein content and high protein quality therefore, has the potential to substitute expensive animal protein sources by complementing other cereals (Tacio, 2009, Lotter, 2005 and Bressani, 1989). When amaranth grain is combined with other cereal grains, the resulting amino acid complement can increase the protein value score of the blend to nearly 100, the ideal protein balance for human needs (Tacio, 2009; Bressani, 1989). The potential complementary nature of amaranth protein has been studied in Mexico by combining amaranth with oats, wheat, maize, and sorghum flours (Tacio, 2009; Bressani, 1989).

The flour mixtures provided nutritionally superior source of protein that can satisfy the FAO/WHO protein specifications of young children and provide approximately 70% of energy (Tacio, 2009; Bressani, 1989).

Mixtures of proteins from various cereals and amaranth can be used for food product formulation so as to maximize the protein quality of the ingredient of poorer protein quality (Tacio, 2009; Bressani, 1989). However, information on the complementary characteristics of the locally used cereal such as acceptability and nutritive value needs to be investigated. This study determined the acceptability of amaranth –maize and amaranth –finger millet blended porridges but more studies are needed on the development of other food products using amaranth grain.

Amaranth's digestibility score is an impressive 90% (Lotter, 2005). A study on digestibility of amaranth protein, absorption and retention indicated that amaranth grain is better utilized by the body systems as compared to other cereal proteins like wheat, maize and rice (Teutonic and Knorr, 1985). Digestibility is a big challenge in most plant proteins due to the presences of trypsin inhibitors. The amount of trypsin inhibitors in grain amaranth is lower (8,000 units/gram) as compared to the amount in soya bean (15,000-110,000 units/gram) that has long been used as the best alternative source of plant protein (Bressani, 1989). The digestibility and protein efficiency ratio are improved if the grain is heat processed (Bressanni *et al.,* 1987; Garcia *et al.,* 1987). The removal of lectins by heat processing has been reported to improve protein efficiency ratio of the amaranth flour (Bressani and Elias, 1986).

Animal feeding studies on amaranth grain indicate relatively high protein qualities and weight gains (Bescharrt *et al.,* 1981; Saunders and Becker, 1984). Information on similar studies in humans is limited. There is therefore need to conduct similar studies on human subjects. This study determined the effect of amaranth grain consumption on the nutrition status of the children using weight for height as one of the indicators.

2.6.2 Carbohydrates

Carbohydrates content of amaranth grain is approximately 60-68 % (Saunders and Becker, 1984). Starch is the major component of amaranth carbohydrate constituting about 50-60% of total dry weight. The starch granules are much smaller than those found in other cereals grains, present mainly as amylopectin. The amylose fraction ranges from 4.8% - 7.2% of total starch, the balance (95.5% - 92.8%) being the amylopectin fraction (Saunders and Becker, 1984).

The unique size and composition of amaranth starch is the reason why the starch exhibits unique gelatinization and freeze/thaw characteristics which are of benefit to the food industry (Lehman, 1988). Considerations for use of amaranth starch in food preparations of custards, pastes and salad dressings have been studied and indicate great potential due to the unique gelatinization properties of amaranth starch (Singhal and Kulkarni, 1990).

Amaranth grain is also a good source of fibre both crude and dietary fiber (Bressani, 1990). The fibre content is approximately 3.4 - 5.7% on moisture free basis (Bressani, 1990). The percent soluble to the total dietary fibre present in grain amaranth varies between 18-48.1 % (Bressani, 1990). The grain amaranth fibre is gluten free which is

beneficial for those suffering from gluten intolerance (Okuno and Sakaguchi, 1981). This study determined both the carbohydrate and dietary fibre content in the local *hypochondriacus amaranthus* grain.

2.6.3 Amaranth Seed Oil

Grain amaranth contains 7-8% oil, which is twice as much as the common cereals like maize (Becker, 1989). The unsaturated oil forms 77% of amaranth seed oil as compared to 72% of wheat, 72% in oat, 75% of in brown rice, 83% in corn oil and 87% in olive oil (Becker, 1989). Amaranth oil is high in linoleic acid, which is an essential fatty acid in human nutrition (Becker, 1989).

The other important constituent in amaranth seed oil is squalene which constitutes about 7-8% of amaranth seed oil. Squalene is an important ingredient in skin cosmetics, lubricants and pharmaceutical preparations. It is a powerful antioxidant used as supplement for diabetics, hypertension and metabolic disorders as it inhibits oxidation (Lyon and Becker, 1987).

Amaranth seed oil contains high levels of squalene whose levels are close to those of fish species. The characteristics of squalene from grain amaranth can be compared with that found in shark liver oil, which is usually given to children to strengthen their immune system and control coughs (Lyon and Becker, 1987). Present in the amaranth oil fractions are tocotrienols (forms of vitamin E), which are known to effect lower cholesterol levels in mammalian systems and acting as antioxidants (Becker 1989). In this study, the locally grown amaranth grains of the hypochondriacus variety was analysed for the fat content.

2.6.4 Minerals

Grain amaranth contains twice the level of calcium in milk, five times the level of iron in wheat, higher amounts of sodium, potassium and phosphorous than other cereals grains (Becker *et al.,* 1981). It also has significant amounts of magnesium and zinc when compared to other cereals (Becker *et al.,* 1981). The mineral content of grain amaranth is higher when compared to other cereals as shown in Table 2.2. Similar information for the local Kenyan grown varieties is scanty and there is need for more studies to determine the levels of micronutrients in the local varieties. In this study the locally grown amaranth grains of the *hypochondriacus* variety was analysed for minerals including calcium, iron, zinc, selenium, magnesium and phosphorus.

Table 2.2 Mineral content of amaranth compared to other cereals (mg/100gms dry matter)

Minerals	Grain Amaranth	Maize	Wheat	Soya Bean	Rice	Finger Millet	Sorghum	Oat
Phosphorus	570	234	383	690	130	250	363	546
Potassium	532	320	-	-	130	314	220	-
Calcium	250	8	39	240	32	358	21	54
Magnesium	319	142	288	-	130	140	140	183
Iron	21	3	3.5	11.5	0.9	9.9	5.7	4
Copper	0.86	0.35	0.9	-	0.25	0.5	1.8	
Zinc	3.4	2.5	1.0	-	1.2	1.5	-	35
Manganese	2.9	0.55	-	-	1.1	1.9	-	

Source: Octavio Paredos – Lopez, (1994). Amaranth: Biology, Chemistry and Technology; pg 189

2.6.5 Vitamins

Studies on the water-soluble vitamins content of amaranth grain indicate levels shown on Table 2.3. Amaranth grain provides good levels of B complex vitamins but care should be taken during processing to reduce the rate of destruction ((Bressani and

Elias, 1986). In this study, one the locally grown amaranth grain of the *hypochondriacus* variety was analysed to establish the content of vitamin A, ascorbic acid, thiamine, niacin, and riboflavin.

Table 2.3: Vitamin Content in Grain Amaranth (mg/100g)

Vitamin	Amaranth grain content/100g
Thiamine	0.10 - 0.25mg
Riboflavin	0.19 - 0.32mg
Niacin	1.0 - 1.45mg
Biotin	42 - 51.3mg
Folic acid	42.1 - 43.8mg
Ascorbic acid	2.8 - 4.9mg

Source: Saunders *et al.*, 1985

2.7 Anti-Nutritional Factors

In many developing countries like Kenya, diets are composed primarily of plant foods (cereals and legumes) which are high in compounds that inhibit proper absorption of micronutrients (Walingo, 2009). The main anti-nutritional factors present in grains include tannins and phytates (Martine and Junk, 1987). These compounds are known to lower digestibility and mineral bioavailability by forming complexes and thereby making the nutrients unavailable to the system (Martine and Junk, 1987). The tannin levels of grain amaranth is less (0.08%) compared to other cereals like millet (0.17%) and wheat (0.20%) (Martine and Junk, 1987). Indigenous food processing methods like soaking, drying, fermentation, roasting and boiling usually reduce the levels of anti-nutrients in plant diets thus increasing nutrient bio- availability (Walingo, 2009).

Enhancing bioavailability of nutrients is critical for nutritionally vulnerable groups like the HIV and AIDS infected children. Some studies have shown that the content and activity of phytates and tannins can be controlled by fermentation of flour (Okoth *et al.,* 2005) and soaking of the grains respectively (Martine and Junk, 1987). Fermentation reduces phytate content by releasing endogenous phytases and soaking enhances enzymatic hydrosis of phytates (Gibson and Hotz, 2001). To enhance bioavailability of nutrients in grain amaranth, the flour for children's porridge in this study was fermented and it was acceptable based on the sensory evaluation conducted on different porridges.

2.8 Utilization of Grain Amaranth

Amaranth grain is very versatile in food product development besides its high nutritional value. There are a number of viable methods for processing amaranth grain including popping, flours milled from raw and toasted grain, heat-rolled flakes, extrusion and wet cooking as gruel (Gebhardt and Thomas, 2007). However, excessive thermal processing particularly using hot dry heat (toasting and popping) has been shown to reduce the nutrient quality of amaranth grain especially the water soluble vitamins (Bressani and Elias, 1986). Depending on the product, amaranth grain can be used alone or incorporated with other cereals. In the USA amaranth products are being produced by specialized companies, which cater for the health-conscious market (Gebhardt and Thomas, 2007).

Consumption of amaranth grain products is slowly gaining popularity in Kenya with the amaranth grain flour being used in porridge and popped seeds used to enrich other dishes like salads, boiled rice and bread spread (Berkelaar and Alemu, 2006). Field

trials in countries like India, South Africa and Zimbabwe indicate that overall acceptability of amaranth based foods is good (Amaranth Newsletter, 2003). Amaranth grain being a versatile food, there is needed to develop more amaranth based food products in Kenya and assess their acceptability. This study determined the organoleptic attributes of four different samples of amaranth based porridge. The porridges investigated included fermented amaranth porridge, non-fermented amaranth porridge; amaranth-maize blend porridge and amaranth-millet blend porridge. Amaranth grain is used in various cultures in a number of ways and Table 2.4 shows a description and names of some traditional grain amaranth foods from different parts of the world.

Table 2.4: Some traditional amaranth grain foods around the world

Food	Country /Region	Description of Food
Alegria	Mexico	Confection of popped seeds with molasses or syrup.
Atole	Mexico	Beverage or gruel of roasted ground seeds, with syrup and water
Bollos	Peru	Confection of popped ground seeds and syrup.
Laddoos	India	Confection
Satto	Nepal	Gruel of parched, ground seeds and water
Pinole	Mexico	Popped, milled flour
Chicha	Peru	Popped, milled flour
Alboroto	Guatemala	Confection of sorghum and amaranth, similar to Algeria.

Source: Teutonico and Knorr , 1985

Since the rediscovery of amaranth grain as a high-quality protein source, various efforts have been made to introduce it into the market mainly as a food ingredient because of its higher price as compared to other cereal grains (Bressani, and Elias, 1986). Though there is still much ground to cover in food product development using amaranth grain, studies indicate that amaranth can be well-utilized in improving the

nutritional quality of other cereal products and hence the nutritional status of the consumers. In formulations, the purpose of amaranth grain is to increase the protein quality of the cereal used and hence nutritional status (Tacio, 2009).

Protein content in amaranth grain alone is higher than that of other grains. The combination of amino acids in amaranth grain (75 -78 score) comes close to a perfect protein (100 score) compared to rice (44), wheat (60) and soybeans (68), (Tacio, 2009). A combination of amaranth and corn for instance, scores an almost perfect score of 100. In a short-term feeding trial of 3 months with 1-3 years old children, the percentage weight gain reported was 4.1% for the group given amaranth containing food and was significantly superior to the control group of 0. 3% weight gain (Del, *et al.,* 1987). Another study conducted in Mexico showed that daily consumption of 20gm amaranth grain can decrease rates of malnutrition in children by more than 60% (Bressani, 1989).

A study of food product development using 100% amaranth grain indicated that due to the relatively high protein and oil content of whole amaranth flour, 100% amaranth flours were a high-quality food to be used for complementary feeding of children (Bressani, 1989). Documentation of information on the impact of utilization of amaranth grain in local diets is limited. This study focused on the effect of consuming amaranth porridge on the nutritional status of HIV/AIDS infected children.

2.9 Therapeutic Attributes of Amaranth Grain and Impact on Nutritional Status

Amaranth's medicinal history dates back to 1741 when a scientist called Rumphius investigated the crop in relation to healing internal haemorrhage (Teutonic and Knorr,

1985). Since then, a number of investigations have indicated that amaranth may offer certain therapeutic benefits in the management of various health conditions. Amaranth has been used as food for people with allergies to other grains (Jones, 1984). The amaranth grain being a pseudo-cereal is unrelated to the other cereal crops that are commonly consumed. This makes it less likely to cause problems to people who have built up allergies due to repeated consumption of the same foods (Jones, 1984).

In Mexico, amaranth was traditionally given to those recovering from an illness or a fasting period because it is easy to digest (Teutonic and Knorr, 1985). Some human feeding studies indicated that the balance of carbohydrates, fat and protein in amaranth grain, gives amaranth the opportunity to achieve a balanced nutrient uptake with lower amounts of consumption than with other cereals (Cheeke and Bronson, 1980). In the same study, using milled and toasted amaranth products, digestion and absorption was found to be high (Cheeke and Bronson 1980).

The high digestibility and absorption rate in amaranth grain is beneficial for people with HIV and AIDS who require nutrient dense diets without necessarily having a bulk diet. HIV and AIDS infected people are prone to problems of poor appetite, poor digestion and mal-absorption (NASCOP, 2006). These problems increase susceptibility to illness and opportunistic infections. There is, therefore, need to employ feeding regimes that can maximize on nutrient uptake especially during periods of less severe symptoms and patients are relatively well. There have been claims of phenomenal improvements in general wellbeing of individuals including amaranth grain in their diets (Berkelar and Alemu, 2006).

Tagwira *et al.,* (2006) document perceived benefits of consuming grain amaranth among communities in Zimbabwe. Specific health improvements noted included improvement in appetite, fast healing of mouth sores and herpes zoster and weight gain for PLWHAs (Tagwira *et al.,* 2006). Consumption of grain amaranth is reported to have nutritional and health benefits, ranging from general improvement of specific ailments and symptoms including recovery of severely malnourished children and an increase in body mass index of people formerly wasted by HIV and AIDS (Sustainable Rural Livelihoods Program, 2005; Tagwira *et al.,* 2006).

In other studies amaranth seed oil has been shown to reduce total triglycerides and levels of low density lipoproteins (LDL) in animal studies (Esculedo *et al.,* 2006). Similar effects have been reported in humans (Martirosyan *et al.,* 2007). From the studies done so far, it is clear that grain amaranth has the potential to contribute to the improvement of nutritional status of vulnerable populations such as children and the sick. This study determined the effects of consuming amaranth grain porridge on the nutrition status of HIV and AIDS infected children attending the comprehensive care clinic at Thika District Hospital. During the six months period, monitoring of weight, CD4 counts and prevalence of opportunistic infections and symptoms was done.

2.10 HIV and AIDS Aetiology

Human Immunodeficiency Virus (HIV) is a virus that causes Acquired Immune Deficiency Syndrome (AIDS) (FANTA, 2005; USAID, 2009). The HIV virus invades the genetic core of the cells that are principal agents involved in the protection against infection (Daniel, 2007). The Human Immunodeficiency Virus (HIV) weakens the immune system, making the body susceptible to opportunistic diseases (FANTA,

2005; USAID, 2009; Sci Dev Net, 2010). During HIV infection, the virus attacks and destroys the defence cells commonly known as the CD4 counts. The CD4 cells are a subset of specialized lymphocytes that are essential in fighting infections and they are used as a marker for HIV progression (Daniel, 2007).

The CD4 cells are critical to the immune system functions of the body (NASCOP, 2006; USAID, 2009). The HIV infection causes a progressive depletion of the CD4 cells, which eventually leads to immunodeficiency and secondary infection (USAID, 2009). HIV and AIDS is an important cause of morbidity and mortality in Sub-Saharan Africa (UNAIDS 2007). In Kenya HIV and AIDS was declared to be a national disaster that required a multispectral approach in its control (NACC, 2000).

HIV and AIDS was first discovered in Kenya in the early eighties (NACC and NASCOP, 2009). While Kenya has made great strides in reducing the growth of incidences of HIV and AIDS over the recent years, as reflected in decline in prevalence from prior years, it is still one of the Sub-Saharan countries hardest hit by the HIV and AIDS epidemic (NACC and NASCOP, 2009).

2.11 Nutrition and the Immune System

The body defends itself against microbial invasion by activating its quite complex immune system and the respiratory burst whose central role is the intracellular killing of pathogenic organisms by oxidation (Daniel, 2007). This in turn relies on the availability of energy stored in the energy-yielding fuels, carbohydrates and fats to fuel the respiratory burst (Daniel, 2007). This critical chain of complex mechanisms (involving regulatory hormones, neuropeptides, cytokines and neurotransmitters) is

obviously undermined if the infected person is not kept supplied with adequate energy-laden macronutrients (Daniel, 2007). In the HIV and AIDS context, the resting energy expenditure in HIV- infected individuals is increased by at least 10% compared with non-infected persons (Shevitz *et al.,* 1999; Daniel, 2007). Micronutrients are equally important as part of the nutritional landscape for optimal function of the immune system (Menon *et al.,* 2007; Katona and Katona, 2008). They play the parallel and important role of serving as antioxidants whose function is to limit and contain the destructive effects of oxidants on the host cells (Daniel, 2007; Katona and Katona, 2008).

Nutrition is a critical determinant of cellular immune responses as certain nutrients play important roles in nucleic acid synthesis and metabolism (Paton *et al.,* 2006). Studies have confirmed that impaired immunity is a critical adjunct factor in malnutrition –associated infections (Menon *et al.,* 2007; Katona and Katona, 2008). When the immune system is functioning optimally, the rate of progression of HIV to AIDS is slowed and this prolongs survival. The development of an optimal functioning immune system requires an array of essential micronutrients and macronutrients obtained through good nutrition (Menon *et al.,* 2007; Katona and Katona, 2008). Immunological dysfunctions associated with malnutrition have been termed as Nutrition Acquired Immune Deficiency Syndrome (NAIDS), (Hanifa *et al.,* 2006). Generalized protein energy malnutrition, vitamin A and zinc deficiencies are characterized by lymphoid tissue atrophy and depressed cellular immunity (Hanifa *et al.,* 2006; Paton *et al.,* 2006). Generally, studies have shown that immune suppression responds rapidly to nutrition intervention (Paton *et al.,* 2006).

2.12 Nutrient Requirements for People Living with HIV

The nutritional needs of people with HIV and AIDS (PWHIV) are influenced by several factors including age, physiological changes, levels of physical activity and an individual clinical state (WHO, 2003). Energy requirements increase by 10% to maintain body weight and physical activity in asymptomatic HIV- infected adults, and growth in asymptomatic children (WHO, 2003; UNICEF, USAID and FANTA, 2006). During symptomatic HIV, energy requirements increase by approximately 20% to 30% to maintain adult bodyweight. Energy requirements intakes for HIV-infected children experiencing weight loss need to be increased by 50% to 100% over established requirements for otherwise healthy uninfected children (WHO, 2003; UNICEF, USAID and FANTA, 2006).

According to WHO, there is insufficient evidence to support the need to increase protein requirements for PWHA over and that of non-infected persons which is between 12 to15 percent (WHO, 2003). However, it is important to ensure adequate intake of essential amino acids which maintain body cell functions by appropriate selection and combinations of protein food sources (UNICEF, USAID and FANTA, 2006). Table 2.5 shows the energy and protein requirements of people living with HIV and AIDS.

Table 2.5 Energy and Protein Requirements

Group of People	Energy requirement(kcal/day)	Asymptomatic Energy requirements(kcal/day)		Symptomatic Energy requirements(kca/day)		Protein requirement(g/ day)
		10% +	Energy	20%-30%	Energy	
ADULTS						
Male(Light activity)	2580	260	2840	520-780	3100-3360	57
Male (Moderate activity)	2780	280	3060	560-840	3340-3620	57
Female(Light activity)	1990	200	2190	400-600	2390-2590	48
Female(moderate)	2240	220	2460	440-660	2680-2900	48
Pregnancy	2280(290+)	200	2480	400-600	2680-2880	55
Lactation	2490(500+)	200	2690	400-600	2890-3090	68
				20%+		
CHILDREN						
BOYS						
6-11 months	760-970	80-100	840-1070	150-190	910-1160	10
1-3 years	1200-1410	120- 140	1320-1550	240-280	1440-1690	25
2-5 years	1410-1690	140-170	1550-1860	280-340	1690-2030	26
5-10 years	1810-2150	180-220	1990-2370	362-430	2170-2580	35
10-14 years	2500-2800	250-280	2750-3080	500-560	3000-3360	64
15-18 years	3000-3100	300-310	3300-3410	600-620	3600-3720	84
GIRLS						
6-11 months	720-910	70-90	790-1000	140-180	860-1090	10
1-3 years	1140-1310	110-130	1250-1440	230-260	1370-1570	25
2-5 years	1310-1540	130-150	1250-1440	260-310	1570-1860	26
5-10 years	1630-1880	160-190	1780-2070	330-380	1960-2260	35
10-14 years	2300-2450	230-250	2530-2700	460-490	2760-2940	62
15-18	2340-2500	230-250	2570-2750	470-500	2810-3000	65

Source: Energy and protein requirements. Report of a joint FAO/WHO Technical Consultation. WHO ,Geneva, May 2003.

Adequate intake of micronutrient is critical for PWHA as micronutrients like iron, selenium, zinc, iodine, magnesium and calcium play a significant role in immune system functions. World Health Organization recommends consumption of one RDA of all micronutrient for both people infected with HIV and those not infected as there is insufficient evidence to support increased intake of micronutrient requirements for PWHA. However, therapeutic intervention should be considered for those PWHA who are vulnerable to micronutrient deficiency. HIV-infected 6-59-month-old children living in resource-limited settings should receive period (4-6 months) Vitamin A supplements (100 000IU for infants and 200 000IU for children > 12 months). The micronutrient requirements for children are as shown in Table 2.6.

Table 2.6: Micronutrient requirements for HIVand AIDS infected children

Micronutrient	0-3 months	4-6 months	7-9 months	10-12 months	1-3 years	4-6 years
Vitamin A (µg RE)	375	375	400	400	400	450
Vitamin B_1 (mg)	0.2	0.2	0.3	0.3	0.5	0.6
Vitamin B_2 (mg)	0.3	0.3	0.4	0.4	0.5	0.6
Vitamin B_3 (mg)	2	2	4	4	6	8
Vitamin B_6 (mg)	0.1	0.1	0.3	0.3	0.5	0.6
Vitami B_{12} (µg)	0.4	0.4	0.5	0.5	0.9	1.2
Vitamin C	25	25	30	30	30	30
Vitamin D (µg)	5	5	5	5	5	5
VitaminE (mg)	2.7	2.7	2.7	2.7	5	5
Folic acid (mg)	80	80	80	80	160	200
Vitamin K (µg)	5	5	10	10	15	20
Calcium (mg)	300	300	400	400	500	600
Iodine (µg)	15	15	135	135	75	110
Iron (mg)	ns	ns	ns	10	6	6
Zinc[b] (mg)	2.8	2.8	4.1	4.1	4.1	5.1
Magnesium (mg)	26	26	53	53	60	73
Selenium (µg)	6	6	10	10	17	21

Source:FAO/WHO: Human vitamin and mineral requirements. Report of a joint FAO/WHO Technical consultation. WHO Geneva, 2003.
ns Neonatal iron stores
b Based on high dietary bioavailability

2.12 Relationship between HIV/AIDS and Nutrition

Under nutrition (including deficiencies in micronutrients as well as macronutrients) and HIV and AIDS overlap and have additive effects (Louise, 2009). HIV infection increases nutrient requirements and at the same time impairs nutrient intake and absorption (Daniel, 2007; Louise, 2009). By altering the food intake, absorption and utilization HIV and AIDS infection increases the risk of malnutrition (NASCOP, FANTA, 2006). Poor nutritional status suppresses the immune system and increases the risk of opportunistic infections thus accelerating the progression of HIV to AIDS.

Malnutrition and HIV and AIDS are synergistic and together create a viscous cycle that together weakens the immune system (FANTA, NASCOP, 2006). Nutrition interventions can help break the synergistic cycle between HIV and malnutrition. The effects of malnutrition on the immune system include decrease in the T-cells and abnormal B-cell responses (Scrimshaw and San Giovan 1997). The immune suppression caused by protein –energy malnutrition is similar in many ways to the effects of HIV infection (Beisel, 1996). Good nutrition helps to boost the compromised immune system and hence slow the degeneration rate (FANTA, 2006).

The nutritional status of an individual is known to play an important role in decelerating the progression of HIV/AIDS, improving quality of life and decreasing the prevalence and severity of the infectious complications of HIV/AIDS (NASCOP, 2006). The length of time it takes for untreated and asymptomatic HIV infection to become symptomatic depends on several factors which include nutritional status of the person before and during infection (NASCOP, 2006).

There is evidence from a longititudinal study that micronutrients play a role in the HIV disease progression (Heirik, 2007. The study showed HIV –infected men with high intake of vitamin A, thiamine, riboflavin, niacin, B6 and had less disease progression and or mortality (Heirik, 2007). It would therefore require us to reason that nutritional interventions for people living with HIV infection will improve survival and or quality of life thus the need for more research based evidence.

2.14 Food and Nutrition interventions in HIV and AIDS

There has been a growing recognition of the important role nutrition plays in the care and support of people living with HIV (FANTA, 2008; WHO, 2009). The recognition has led to substantial growth in efforts to integrate food and nutrition interventions into the HIV care and treatment services by government, donors, non-governmental organizations and community groups (FANTA 2008). The growth in nutrition care and support for people living with HIV involves both the scaling up of ongoing food and nutrition interventions and the development of new approaches (Cohen, 2005; ANSA, 2006; WHO, 2009). Intervention programmes integrate a range of nutrition interventions into HIV services. These include nutrition assessment, nutrition education and counselling, food assistance, micronutrient supplementation and activities to strengthen household food access (FANTA, 2008).

Nutrition assessment, education and counselling are among the most common food and nutrition interventions used to address HIV. Sometimes, they are implemented singly and sometimes in combination with other food and nutrition interventions (FANTA, 2008). Food and nutrition interventions are critical components of the comprehensive responses to the HIV pandemic (FANTA, NASCOP, 2006; FANTA, 2008). The comprehensive care package that includes nutrition is a key issue and is in the strategic plan for HIV and AIDS (NASCOP and FANTA, 2006).

Targeted food and nutrition assistance to individuals with HIV infection and their families has the potential to improve nutrition and the course of HIV disease in developing countries (Cohen, 2005; ANSA, 2006). The main goals of nutrition intervention for HIV-infected children are 1) promote optimal growth and

development, 2) prevent malnutrition, 3) enhance quality of life by providing adequate energy and nutrients and 4) increase resistance to infections (Cohen, 2005; ANSA, 2006).

There is growing scientific consensus that food sufficiency is a critical component of treatment of both malnutrition and malnutrition-mediated disease outcomes and that sufficiency requires close attention to diet quality not merely quantity. Several food and nutrition interventions are ongoing but few data exist to help guide the development of effective programmes that integrate HIV care and nutrition. There is urgent need to evaluate the efficacy of locally appropriate, sustainable food-based strategies on nutritional status and the potential impact of improved nutritional status on the disease progression.

This study involved complementing the diets of the HIV and AIDS infected children with amaranth grain porridge for six months and assessing the effects on the nutrition status of the children. Amaranth grain is nutrient dense yet it is underutilized in Kenya (Alemu, 2008). It has the potential of not only broadening the food base but also improving the quality of diets which is critical for the nutritionally vulnerable groups like HIV and AIDS infected children.

2.15 Impact of Food Assistance on Nutrition and HIV and AIDS status

Studies from developing countries consistently show the overlap between food insecurity, malnutrition and HIV and AIDS with malnutrition being a strong predictor of mortality among people with HIV (WHO, 2005; Villamor *et al.,* 2005). This evidence resulted in increased funding to HIV care and treatment providers to provide

nutritional support to adults and children with HIV. The hypothesized benefits of food assistance to HIV-infected individuals include: i) improved nutritional status,, ii) improved health status, iii) slowed disease progression, iv) improved food security, v) improved quality of life, and vi) improved ART adherence and probability of survival (Mahlungulu *et al.,* 2007). This study focused on the contribution of amaranth grain consumption to the nutrition status of HIV-infected children attending the Comprehensive Care Clinic at Thika District Hospital.

The evidence base evaluating the benefits of nutrition interventions in developing countries has been limited to efficacy studies of micronutrient supplementation and more recently, specialized ready –to-use foods (Linneman *et al.,* 2007). Two recent reviews on the effects of macronutrient supplementation (with or without nutritional counselling) on various clinical outcomes of people living with HIV offer inconclusive evidence of the positive impact on weight gain and CD4 count in developing countries (Koethe *et al.,* 2009 and Mahlungulu *et al.,* 2007). Recent published studies that evaluated the impact of macronutrient supplementation to HIV infected individuals in resource-constrained setting include a quasi-experimental study in Zambia (Cantrell *et al.,* 2008). According to the study, food supplementation was associated with better adherence to ART, after adjusting for age, sex, baseline CD4 count, WHO stage and haemoglobin.

In a randomized controlled trial from Malawi, comparing supplementary feeding with a ready- to- use fortified spread compared to corn-soy blended flour with similar energy composition, patients receiving fortified spread had greater increase in BMI and fat-free body mass than those receiving corn-soy blend (Ndekha *et al.,* 2009). In

this study, the association between amaranth grain flour supplementation and nutritional status, morbidity and CD4 counts of the study children was analysed.

2.16 Morbidity in HIV Infected Children

Like adults with HIV infection, children with HIV develop life-threatening opportunistic infections (OIs) although the incidence of various OIs differs in adults and children (Read, 2007). Many children with HIV infection do not gain weight or grow normally (Lesley *et al.,* 2007; Read, 2007). HIV- infected children frequently are slow to reach important milestones in motor skills and mental development (Read, 2007; Lesley *et al.,* 2007).

Children with HIV suffer the usual childhood infections but more frequently and more severely than uninfected children. The infections can cause seizures, fever, pneumonia, recurrent colds, diarrhoea, dehydration, mouth and throat infection and many others (Read, 2007). The three most common diseases among the HIV and AIDS children include bronchitis, diarrhoea and ENT (Walenda, 2009). A study on morbidity among Kenyan HIV infected infants reported that infants manifested various symptoms including pneumonia, lymphadenopathy and dehydration (Richard *et al,* 2008).

The high prevalence of preventable childhood diseases deteriorates children's health increasing childhood mortality (Lesley *et al.,* 2007). The fourth millennium development goal is to reduce child mortality. Children die from preventable or treatable cases. Most of these children could be saved by expanding existing programmes that promote simple and low cost solutions (KAIS, 2007). In the

developing countries there is an overlap between food insecurity, malnutrition and HIV and AIDS with malnutrition being a strong predictor of mortality among people with HIV (WHO, 2005; Villamor *et al.,* 2005). Nutrition care and support for people living with HIV involves both the scaling up of ongoing food and nutrition interventions and the development of new approaches (Cohen, 2005; ANSA, 2006; WHO, 2009).

The purpose of this study was to supplement the diets of the HIV/AIDS infected children registered at the Thika District Hospital Comprehensive Care Clinic with amaranth grain flour for porridge and determine its contribution to the nutrition status of the children. In addition this study investigated the prevalence of opportunistic infections and associated illnesses among the study children.

For optimal growth, WHO recommends that infants from non-infected mothers be exclusively breastfed for the first six months (WHO, 2006). Exclusive breastfeeding in the first six months is strongly correlated with increased child survival and reduced risk of morbidity. Exclusive breastfeeding means to feed the infant with only breast milk and no other foods or liquids, for six months (WHO, 2006).

From the HIV context, WHO earlier recommendation was: "Exclusive breastfeeding for HIV-infected women for the first six months of life unless replacement feeding is acceptable, feasible, affordable, sustainable and safe for them and their infants before that time. When replacement feeding is acceptable, feasible, affordable, sustainable and safe, avoidance of all breastfeeding by HIV-infected women is recommended" (WHO, 2006). HIV can be transmitted via breast milk and the risk of transmission

from breast milk is about 15% for infants who are breastfed up to six months and about 20% for children breastfed to their second year (WHO, 2006; NASCOP, 2006). New evidence suggests that HIV transmission through breastfeeding can be significantly reduced if a mother breastfeeds her child exclusively and if she or the baby receive antiretroviral therapy (ART) at the same time. Based on latest scientific findings, the World Health Organization (WHO) in 2010 revised its guidelines on HIV and infant feeding. The new guidelines now recommends, that mothers with HIV breastfeed their baby exclusively for the first six months and continue to breastfeed up to 12 months while introducing complementary food in settings where breastfeeding is judged to be the safest infant feeding option.

The promotion of breastfeeding has been ranked as the most cost-effective intervention for child's survival and could prevent 13- 15% of child deaths in low income countries (Jones *et al.,* 2003). Previous estimates that the risk of postnatal transmission is between 10% and 20%, do not distinguish between exclusive and mixed breastfeeding (Jones *et al.,* 2003). However, some studies indicate that when HIV-infected mothers breastfeed exclusively, their babies have only a low risk of postnatal infection with HIV and early introduction of complementary foods increases the HIV transmission risks (Holmes and Sevage, 2007).

A similar study concluded that exclusive breastfeeding for up to six months was associated with 3-4 fold decreased risk of HIV transmission compared to non-exclusive breast feeding (Coovadia, *et al.,* 2007). This study investigated the diet and breastfeeding history of the study children to establish the feeding options that they

were placed on in their early stages of life as these influences the nutritional status of the children in the subsequent stages of life.

2.18 HIV and AIDS Pandemic in Thika District

The first recorded case of HIV and AIDS in Thika was in 1986 (Kinyanjui, 2007). In the last decade, Thika District was leading in the prevalence rate (34%) in the country which was higher than the National level of 14% (NACC, 2008). Thika has had a vibrant industrial sector since 1920s made up of agro-processing, chemical and textile industries. Consequently it has highly mobile population as migrants come to seek employment (Barnett and Whiteside 2002). According to Barnett and Whiteside (2002) migration and mobility leading to concentration of large numbers of unaccompanied spouses in parts of the district created patterns of sexual behaviour and mixing which are perfect for the spread of STDs. The high prevalence rates in Thika can be elucidated by presence of high migrant labour among many other factors (Kinyanjui, 2007).

Following the alarming prevalence rate, a major advocacy campaign on the fight and prevention of HIV and AIDS was unveiled and through concerted efforts by stakeholders the prevalence rate dropped drastically to 4% in 2006 (NACC, 2008). However, the impact of the scourge is still being felt at all levels of the district's economic, social and health circles (NACC, 2008). There is need for continued multi-sectoral interventions in the district to control and manage the pandemic (Medical Supritendant -Thika District Hospital, October, 2006). The main objective of this study was to complement the diets of the HIV/AIDS infected children registered at

limited scientific documentation of such claims and there is need for research on effects of consumption by vulnerable groups. In addition documentation of information on the impact of utilization of amaranth grain in Kenyan diets is limited. This study focused on the effects of consumption of *hypochondriacus amaranthus* grain porridge on the nutrition status of the HIV and AIDS infected children attending the Comprehensive Care Clinic.

Fourth, while food assistance programmes to HIV affected households are widespread and several food and nutrition interventions are ongoing, studies evaluating the impact of these programmes are just emerging and few data exist to help evaluate the efficacy of locally appropriate, sustainable food-based strategies on nutrition status and the potential impact of improved nutritional status on the disease progression. In this study, the relationships and associations between amaranth grain flour supplementation and nutritional status, morbidity and CD4 counts of the study children were analysed.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Design

The study was a longitudinal experimental study with a pre-test post-test single group design (Fanta, 2006; Swindle *et al.,* 2005). This type of design is used when the available study sample is small or when a researcher is not able to get a matching control group so that each person becomes his /her own control (Swindle, Baker and Auld, 2005). The design compares outcomes in population before and after the implementation, with statistical treatment of determinants and known confounding factors (Fanta, 2006). The study design was appropriate since the sample frame was small (55) (Fanta, 2006; Swindle *et al.,* 2005).

The study was conducted in two phases. Phase one (6 months) comprised laboratory analysis of the *Hypochondriacus amaranthus* grain from one source. The laboratory analysis included determining the proximate composition and micronutrient content in duplicates and sensory evaluation of four samples of amaranth based porridge. Phase two comprised collection of baseline data and the intervention to determine the impact of amaranth grain porridge consumption on the nutritional status, CD4 counts and morbidity prevalence of 2–5 year old HIV and AIDS infected children attending the comprehensive care clinic at Thika district hospital. Baseline information collected included demographic characteristics, dietary intake, anthropometric assessment and morbidity prevalence. Phase two (10 months) was the intervention. This comprised of monthly provision of adequate amaranth flour to be consumed by the children on a daily basis (six months per child). Secondly the intervention included group nutrition education and face to face nutrition counselling. A schematic representation of the study phases is shown in Figure 3.1.

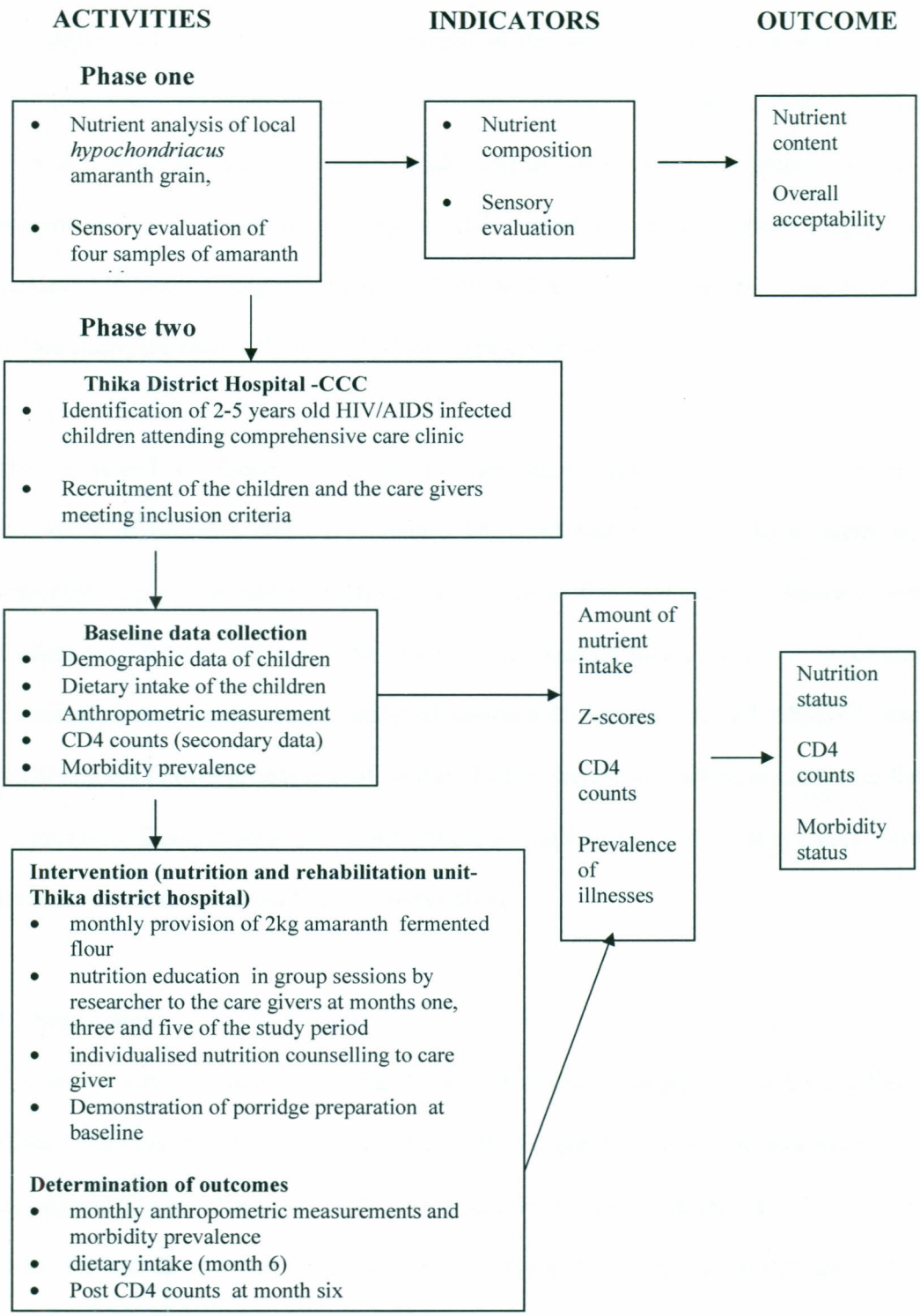

Figure 3.1: Data Collection Phases

3.2 Variables

The dependent variable (primary outcome) in this study was nutrition status while morbidity and CD4 counts were the secondary outcomes. The independent variables were demographic variables, dietary intake and use of ARVs. Demography captured age and sex of child, nature of caregiver and number of siblings. Dietary intake was measured by determining the amounts of selected nutrients consumed by the children. In this study, the main determinant of nutrition status measured was diet.

The measured confounding factors to nutritional status included number and frequency of illnesses and CD4 counts. The confounding factors were controlled statically using regression analyses to estimate the associations between the confounding factors and nutritional status. The baseline data on dietary intake and nutritional status on the single group of children (2-5years) infected with HIV and AIDS and the known probable confounding factors were collected before and after the intervention. Comparisons on the pre- and post- intervention nutritional status were made to establish the impact of the intervention

3.3 Study Site

The study was conducted at Thika District Hospital Comprehensive Care Clinic. Thika District is one of the seven districts in the Central Province of Kenya which had the highest (34%) HIV and AIDS prevalence in the province (KDHS, 2003). The Thika District Hospital provides healthcare services to the entire district and to the neighbouring districts like Machakos. The Comprehensive Care Clinic at the Thika District Hospital started in June 2003 as a cost sharing service (Medical Supritendant -Thika District Hospital, October, 2006). By 2004, the Comprehensive Care Clinic at

the Thika District was a continuum of care centre for all HIV positive patients accessing care at the Thika District Hospital. The services offered by the clinic include provision of ARVs, provision of prophylaxis (septrin) to all patients accessing care, treatment of opportunistic infections, laboratory services and prevention of mother to child transmission (PMTCT). In 2005, NASCOP in partnership with Liverpool Voluntary Counselling and Testing (VCT) unit sponsored the first training of personnel that comprised one physician, two medical officers, one clinical officer one pharmacist, one lab technologist two nurse counsellors and one nutritionist. The services offered at the clinic included voluntary counselling and testing, post-exposure prophylaxis, diagnostic counselling and testing (DCT).

In 2006 with the input of other partners particularly the International Centre for AIDS Care Treatment Programs ICAP from Columbia University, the Comprehensive Care Centre was constructed and more services were being offered to the registered clients. The services included provision of ARVs, laboratory services, provision of prophylaxis, free treatment for the opportunistic infections and counselling services.

The other special services included Prevention of Mother to Child Transmission (PMTCT) and Early Infant Diagnosis (EID). By 2007, a total of 1673 adult and a total of 157 children were actively attending the Comprehensive Care Clinic. (Medical Supritendant -Thika District Hospital, October, 2007). The paediatric clinic runs once a week on Wednesday and the total paediatric attendance at the Comprehensive Care Clinic (CCC) was 157 in September, 2006. The number of 2-5 years old children registered at the Comprehensive Care Clinic was 55 at that time. These formed the sampling frame of the study.

3.4 Target Population

The target population was children 2-5years old infected with HIV and AIDS, registered and attending the comprehensive care clinic at Thika District Hospital. Children under five years old are nutritionally a vulnerable group. The 2- 5 years age group was zeroed in by taking into consideration the HIV infection diagnostic challenges in infants and young children. HIV infection is often difficult to diagnose in younger children since the readily available diagnostic tests rely on detection of antibodies to the HIV virus. The tests are not reliable in infants and children below eighteen months because of the persistence of trans-placentally acquired maternal antibody (Read, 2007). Children born to infected mothers have antibodies to HIV made by the mother's immune system that crosses the placenta to the baby's blood stream before birth and persists for up to eighteen months. Hence this study included children in the age group of 2 -5 years old.

3.5 Inclusion and Exclusion Criteria

Inclusion criteria

All 2-5 years old HIV/AIDS infected children registered and regularly attending the Comprehensive Care Clinic at Thika District Hospital and whose guardians were willing to participate in the study.

Exclusion criteria

The children who were hospitalized/bedridden or too sick to participate (clinical stage 4) and children not in the age range of 2- 5 years old were excluded from the study.

3.6 Sample Size

This was a clinic based study and the sample size was based on the number of 2- 5 years old HIV/AIDS infected children registered and regularly attending the Comprehensive Care Clinic. The sampling frame comprised 55 HIV and AIDS infected children (2-5 years old) registered at the Comprehensive Care Clinic within the first three months of the study. The entire sampling frame was included due to its small size. However, by the end of the first month, three orphans were relocated upcountry and thus the final sample was 52 HIV/AIDS infected children. There were no other dropouts during the six months study period.

3.7 Sampling Technique

Comprehensive sampling technique was used to include all the 2-5 years old HIV/AIDS infected children attending the Comprehensive Care Clinic at Thika District Hospital. All the children within the sampling frame were included in the study.

3.7.1 Recruitment of the children

The recruitment was done at the Thika District Hospital Comprehensive Care Clinic during the first three months of the study. All 2- 5 years old HIV/AIDS infected children and the guardians who met the inclusion criteria were recruited to participate in the study upon their informed consent. Baseline data of the children were collected which comprised the demographic characteristics, dietary intake (24 hour dietary recall), CD4 counts and morbidity before conducting the intervention.

3.8 Intervention

This involved monthly provision of 2kg fermented amaranth flour per a child, continuous nutrition education to the caregivers by the researcher and assistants at two months interval (month 1, 3 and 5) and individualised nutrition counselling to care givers whenever the need arose during the monthly visits. The nutrition education was done in group sessions. The education covered the basic nutrition principles like the role of nutrients in the body, nutrition and HIV and AIDS and the nutritional attributes of the amaranth grain.

A demonstration was conducted by the researcher to the guardians on the preparation of the amaranth porridge at the Thika District Hospital Rehabilitation Centre kitchen. The demonstration was followed by the monthly provision of the fermented amaranth flour. Where there were more children in the family the child came from, extra provision of the flour was given (2kg per the extra child) to take care of the possible leakages. By the assistance of the hospital management, the study children were exempted from other existing food programmes like the food by prescription during the entire study period.

The study aimed at supplementing the daily diets with two and half exchange (60g) of amaranth flour for two cups of (250ml each) which was based on the average obtained from the baseline consumption of porridge by the children. This was equivalent to 218 kilocalories if consumed alone without additives. The Food by Prescription *FIRST FOOD* given to HIV infected is equivalent to 435 kilocalories per 100g. The recommended serving is two and half cups of 300ml per day. Figure 3.2 shows the intervention components.

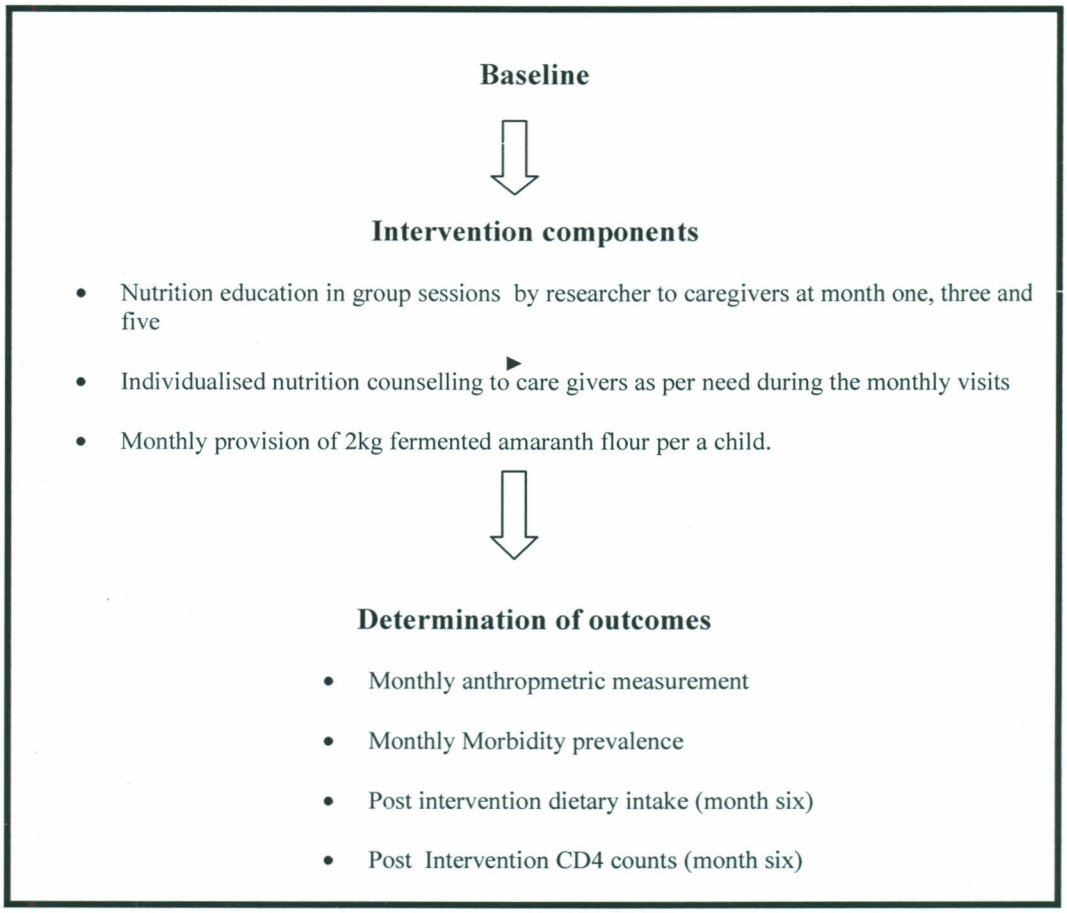

Figure 3.2: Intervention Components

3.9 Data Collection

Data were collected in two phases. In phase one, data on nutrient composition of the locally grown *Hypochondriacus amaranthus* grain in duplicates samples and sensory evaluation of four amaranth based porridges were collected. Samples were labeled with the laboratory ID which was keyed in the Laboratory Information System (LIS). Results were reviewed by researcher before entering the to the data base. Copies of results were kept in a manual and an electronic laboratory note book.

In phase two, anthropometric data, morbidity, CD4 counts dietary intake and morbidity were collected. The time line of data collection in both phases is shown in Figure 3.3 and the details of data collection are described under the two specific phases. The laboratory data comprised the amaranth grain nutrient analysis done at the Jomo Kenyatta University of Agriculture and Technology, Department of Food Science and Technology laboratory and at the University of Nairobi, Department of Nuclear Science laboratory. The sensory evaluation was done at the Nutrition and Rehabilitation Unit at the Thika District Hospital. The phase two data were collected at the Nutrition and Rehabilitation Unit at the Thika District Hospital.

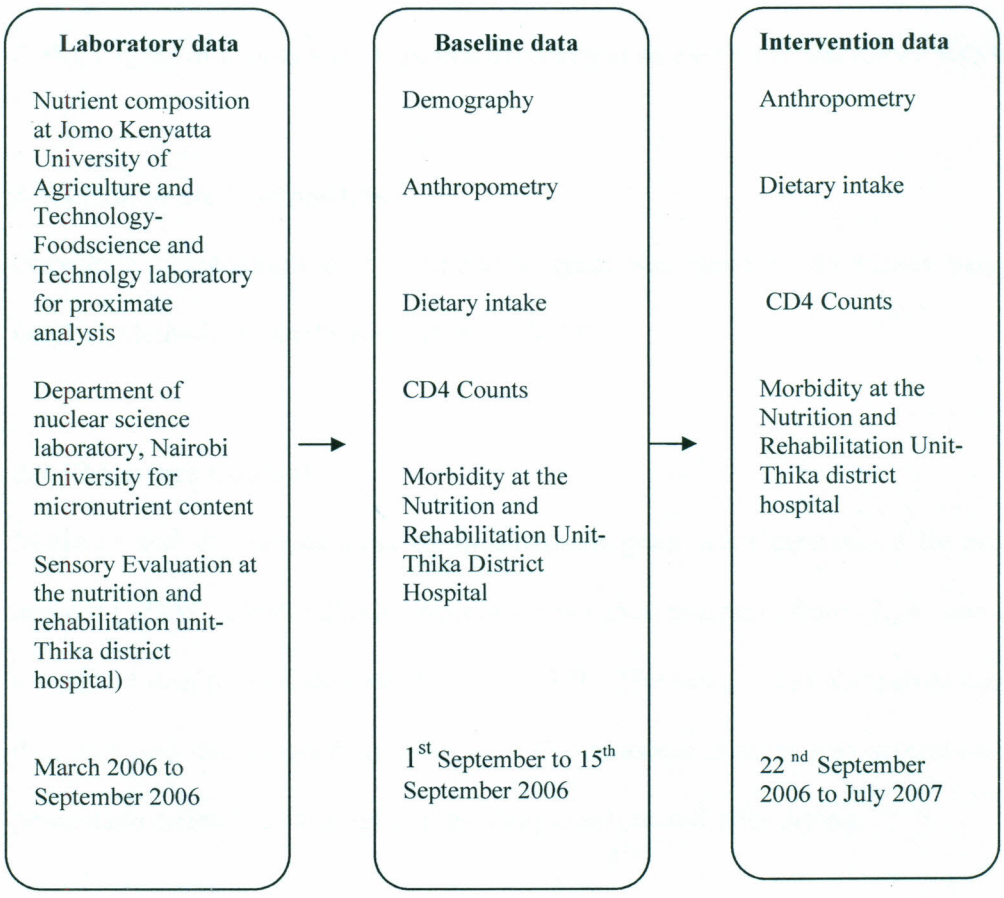

Figure 3.3: Data collection time line

3.9.1 Phase One Data Collection (Laboratory Procedures)

3.9.2 Data Collection Instruments

Data collection instruments included the common laboratory glassware, Incinerator, analytical balance, Auto Analyzer and Energy Dispensive X-rays Flourences (EDXRF) spectrometer.

3.9.3 Reagents, Chemicals and Samples

The chemicals, reagents and the standards used for nutrient content analysis were of the analar grade from Fisher Scientific and Merck pharmaceuticals. Samples were labeled with the laboratory ID which was keyed in the Laboratory Information System (LIS). Copies of results were kept in a manual and an electronic laboratory note book.

3.9.4 Proximate Composition

Proximate composition of the amaranth grain was done in duplicates using the Official Methods of Analysis of AOAC, (2000).

3.9.5 Moisture Content

Moisture and dry matter contents in amaranth grain were determined by air oven method (AOAC, 2000, 925.10). Accurately weighed amaranth flour (2gm) was put in a weighed dish previously heated to 130 ± 3 ^{o}C. The sample was allowed to cool in a desicator and the weighed immediately. The moisture content was determined as a percentage difference in weight of the sample before and after drying.

3.9.6 Protein Content

Crude protein in amaranth grain was determined by Kjeldhal method using 6.25 as the coefficient of conversion of total nitrogen to protein (AOAC 2000, 920.87). Two grams amaranth flour was put in a digestion flask and 0.7gm of metallic mercury (Hg), 15gm of potassium sulphate and 25ml of sulphuric acid were the added. The flask was heated gently while in an inclined position until frothing cleared. The contents were then boiled briskly until solution cleared. A few granules of Zinc (Zn) were added to prevent bumping and the flask was then tilted and a layer of NaOH was added without agitation to make it alkaline. The flask was immediately connected to a distilling bulb on a condenser immersed in standard acid and 5 drops indicator in the receiver. The flask was rotated to mix the contents thoroughly. This was then heated until all the ammonia (NH_3) was distilled off. The excess standard acid was titrated with standard NaOH solution. Nitrogen percent was calculated as follows:

N% = (V1- V2) ×1.4007g test portion × 6.5 = gm% protein

Where:

V1 = Volume (ml) standard acid molarity

V2 = Volume (ml) standard NaOH molarity

3.9.7 Crude Fat

Crude fat was determined by the acid hydrolysis method (AOAC 2000, 922.060]. Two grams of amaranth flour were placed in 50ml beaker and 2ml alcohol was added and stirred to moisten all the particles. Ten millitres concentrated hydrochloric acid (HCl) was added and mixed well. The beaker was then set on a water bath held at 70 – 80^{0}C while stirring frequently for 40 minutes. Ten millitres alcohol was then added and cooled and the mixture transferred to fat extraction apparatus. The beaker was

rinsed into the extraction tube with 25ml petroleum ether added in three portions. The flask was stoppered and shaken vigorously for 1 minute and then left to stand until the upper liquid was practically clear.

The ether-fat solution was filtered through a cotton pledged packed firmly in funnel stem to let the ether pass freely into weighed 125ml beaker flask containing porcelain chips. Before weighing beaker flask, it was dried in oven at 110°C and then left to stand to a constant weight. The ether was evaporated slowly on a steam bath; then fat was dried in the oven at 100°C to constant weight. The flask was removed from the oven and let to stand in air to constant weight. The weight was corrected by blank determination on reagents used and then recorded as percent fat.

3.9.8 Total Dietary Fibre

Total dietary fibre was determined according to AOAC method (AOAC 2000, 991.43]. 225ml of 95% ethanol was added to the digested amaranth grain sample using concentrated hydrochloric acid in the ratio of 4:1 (v/v). The mixture was covered with sheets of aluminium foil. The precipitate was left to form for one hour at room temperature. A celite bed was wetted and redistributed in a previously tarred crucible using 15ml 78% ethanol. Suction was applied to the crucible to draw celite into fritted glass as even mat.

The alcohol treated enzyme digestate was filtered through a crucible. Using wash bottle with 78% ethanol and rubber spatula, all remaining particles were transferred to the crucible. The residue was washed by vacuum twice each with 15ml portions of 78% ethanol, 95%ethanol and acetone. The crucible containing the residue was oven

dried overnight at 105 degrees centigrade. The crucible was cooled in a dessicator for one hour. The crucible with the dietary fiber and the other with celite were weighed. The residue weight was calculated by subtracting weight of the dry crucible with celite.

3.9.9 Ash

The ash content was determined by incinerating the second duplicate obtained from total dietary fiber analysis for 5 hours at 525^0C. This was then cooled in a dessicator and then weighed. The weight of the ash was determined by subtracting weight of the crucible and celite.

3.9.10 Carbohydrate

Available carbohydrate was estimated by difference using the AOAC, (2000) method after analysing for all the other components. This was estimated as follows:

100 – (Weight in grams of (protein + fat + water + ash + dietary fibre) = % carbohydrate in 100grams amaranth grain sample.

3.9.11 Minerals

Determination of iron, potassium, calcium, zinc, copper, selenium, potassium, and manganese was carried out using the Energy Dispensive X-rays Flourescence (EDXRF) Analysis (Holysynka *et al.,* 1987). One gram of dried amaranth grain was digested in 250 ml of high purity concentration nitric acid by heating the mixture for approximately 40 minutes until all the brown fumes of nitrogen oxides disappeared. After cooling, 10ml of 70% of perchloric acid was added and the solution heated again approximately for 40 minutes until it became colourless and clear. After cooling

and diluting the solution with 250 ml of double distilled water, the PH was adjusted to 5 using gaseous ammonia (NH3). This was done by placing a beaker with a solution in a dessicator filled in the bottom with concentrated ammonium hydroxide.

The PH was checked every 15 minutes with PH paper. The pre-concentration of the elements was done by precipitating the metal ions using sodium diethyldithiocarmate (NaDDTC) (Holysynka *et al.,* 1987). The precipitate was allowed to stand for 20 minutes before filtering through nuclepore filter. The filtrate was analysed using EDXRF spectrometer. Quantitative analysis was done using AXILand QXAS software (Molho, 1990). Standards were made using 5, 10, 20 and 50 ppm and then a calibration curve constructed. A blank sample of distilled water was used and the reading for the blank was subtracted from the samples reading to control for contamination.

3.9.12 Vitamins

In this study the locally grown *hypochondriacus amaranthus* grain was analysed for its ascorbic and beta carotene content.

Arscobic Acid

The amaranth sample was ground to pass 40 mesh sieves. A portion of the sample (5gm) was weighed accurately into a plastic cup and then dispensed with 100ml of 2% metaphosphoric acid extraction solvent. Into a quartz spectrophotometer cuvette, an aliquot of sample filtrate and ascorbic acid standard solution was mixed with M/30 phosphate buffer, gualacol peroxidase in phosphate buffer containing 1.8mM EDTA and 0.13 mM 2-mercaptoethanol. The initial absorbance at 265nm was recorded with

a spectrophotometer and the reaction was initiated by adding 50mM hydrogen peroxide. Temprature was controlled at 37 ^{0}C by circulating water around the cuvette. The decrease in absorbance at 265nm due to oxidation of ascorbic to dehydroascorbic acid was recorded until absorbance reached the final value. The difference between initial and final absorbance corresponding to ascorbic acid concentration range of 0.2-1.0mg/100ml using pH 7.0 phosphate buffer and 0.005mg/ml peroxidise at 37 ^{0}C was recorded. The calibration graph was linear with the range of 0-20µg ascorbic acid/ml.

Beta Carotene

The sample was ground to pass No. 40 sieve and two grams of sample accurately weighed into 100ml volumetric flask. 30ml extractant was pippeted into the flask, stoppered and swirl for one minute. The mixture was left to stand in the dark for 16 hours. Two ml of 40% methanoic KOH was added to the flask and swirl for one minute and then left to stand in the dark for one hour. 30 ml of hexane was added into the flask and the contents swirl again for one minute. The mixture was diluted to volume with 10% Na_2SO_4 solution and shaken vigorously for one minute and let to stand in the dark for one hour before chromatographic separation in a column packed with silica gel.

The vacuum was then released and the carotene solution was placed in the dark until it reached room temperature. It was then diluted to volume in 100ml volumeted flask with carotene elutant. The flask was inverted several times to mix and then vitamin A was determined immediately. Absorbance of carotene at 450nm was determined on uv visible spectrophotometer using carotene standard.

3.9.13. Sensory Evaluation of Amaranth and Blend Porridges

Preparation of Sample

The grains (*Hypochondriacus amaranthus* grain, *Zea mays* (maize) and *Eleusine coracana* (finger millet/*wimbi*)) were cleaned by sorting and removing damaged grains and dirt, sundried and milled to obtain fine flour which was stored in low density labelled polythene bags. The flours were divided into four portions used to prepare different porridges. The first portion of the amaranth flour was used to make the pure unfermented amaranth porridge. The other portion of the amaranth grain was fermented for 72 hours. The slurry was then oven-dried at 80 C^0 and then ground into flour using a grinder for the fermented amaranth porridge. The third portion of the amaranth flour was mixed with maize flour (50:50) which was used to make amaranth maize blended porridge. The fourth portion of flour was blended with finger millet (*wimbi)* flour (50:50) and this was used for the amaranth finger millet blended porridge.

Preparation of the Porridges

A hundred gram of each of the flour samples was weighed into a saucepan. One hundred and twenty millitres (120ml) cold water was added to each flour sample and mixed to form slurry. Twenty grams (two table spoons) of sugar were added to the mixtures. Each mixture was added to 250ml boiling water, stirred for five minutes and left to boil for a further five minutes. The porridges were left to cool to 40 degrees centigrade as the serving temperature. The porridges were separately kept in different flasks in order to maintain the serving temperature. The method of preparation of the different porridges mixes was the same.

Sensory Evaluation Test

Sensory evaluation of the fermented amaranth porridge, unfermented amaranth porridge, unfermented amaranth maize blend porridge and unfermented fingermillet blend porridge was carried out using the hedonic scale test adapted from Larmond, (1977). The four samples of amaranth grain based porridge were organoleptically evaluated by a 17 member untrained sensory panel using a 9-point hedonic scale. The number was limited to only 17 after screening the 52 caregivers for age and health factors. The remaining 35 caregivers were disqualified due to various limitations for sensory evaluations (Lawless *et al.,* 1998; Meilgaard *et al.,* 1999). Among the limitations were food allergies, presence of colds, sinus problems, mouth sores, antibiotic medications, dental and gum diseases and cigarette smoking. No caregiver was disqualified by the age factor as they were all below sixty-five years old.

Attributes of the porridge samples evaluated included appearance, texture, flavour, consistency and overall acceptability. The panellists were briefed on the objective of the study. All the porridges were coded and were presented simultaneously. The porridges together with an evaluating sheet (Appendix 4) were presented to the sensory panellists and they were asked to evaluate each of the porridges independently using the hedonic scale. The 9-point hedonic scale had anchor terms as follows:1-dislike extremely, 2-dislike much, 3-dislike moderately, 4-neither dislike nor like, 5-like, 6-like moderately, 7-like much, 8-like very much, 9-like extremely. Panellists chose a term that best describes the attributes of the different porridges. The panellists were presented with water at room temperature to rinse their mouths after each sample. The results were used to establish the acceptability of the four samples of porridges based on the mean ratings.

3.10 Phase Two Data Collection

A pre-tested researcher-administered questionnaire (Appendix3) was used to collect both primary data and secondary data. The primary data included demographic and infant and young child feeding characteristics, dietary intake, anthropometry and morbidity prevalence. The secondary data used were the CD4 counts. Data collection began with baseline measurements and then continued as the intervention was initiated. The children were observed six times at different intervals. Measured outcomes included nutritional status by anthropometry (monthly), dietary intake (twice at baseline and twice at month six), morbidity (monthly), and CD4 counts (baseline and month six).

3.10.1 Training of research assistants

Two research assistants were trained to assist in data collection and interpretation of the local language for the respondents who could not respond in English or Kiswahili. The research assistants were holders of a diploma certificate. The training was conducted at the Thika District Hospital Nutrition and Rehabilitation Unit. The training covered the purpose and objectives of the study, the data collection technique used (interview), the component of the questionnaire and how to take the anthropometric measurements.

3.10.2 Demographic and Child Feeding Characteristics data

Information on the demographic characteristics of the children including date of birth/age, sex, number of siblings, location of home, and nature of caregiver were obtained. This information was obtained from the caregiver and confirmed with the children's hospital card. Information on the infant and young child feeding

characteristics of the child including breastfeeding, duration of breastfeeding, types of foods used in complimentary feeding and use of amaranth grain were obtained from the caregiver.

3.10.3 Anthropometric Data

Anthropometry is widely recognized to be an important tool for assessing children's nutritional status (Waterlow *et al.,* 1977; WHO, 1995). Weight for height is particularly sensitive to short-term growth changes as influenced by various factors such as food intakes and illness. It represents a current estimate of nutritional status and can exhibit considerable variations over short periods of time. In this study, weights and heights of the children were measured monthly for a period of six months by the researcher and two trained research assistants. A bathroom scale and height board were used for measuring weight and height respectively. For weight, the weighing scale was calibrated to zero before weighing a child and recalibrated after every measurement. A child was asked to stand on the scale with minimal clothing and then the weight was recorded to the nearest 100g. For height, a child was asked to stand straight along the board with the feet parallel to the moveable board; the sliding board was then moved to compress the hair and the reading taken to the nearest centimetre. Both the height and weight were taken twice at each visit and an average computed to ensure accuracy of measurement.

3.10.4 Dietary Intake Data

The dietary assessment consisted of a repeated 24hour dietary recall. Dietary data from two consecutive interviews (one week apart) were collected at baseline and at month six of the intervention. Interviews were conducted primarily in Kiswahili. The

caregiver was asked to state all the foods and drinks that the child had taken in the previous day starting from the time the child woke up to the time the child went to sleep. The respondent was then asked to state the quantities of each food and drink taken by the child. Quantities of foods consumed were estimated using household measures and food models. House hold measures such as cups, spoons bowls were used to help in estimating the quantities of food consumed. Incase of casseroles and mixed dishes, the respondents were asked to estimate the individual food constituents. The cup volume was later used to measure/estimate the quantities. The values of these measurements were then converted to grams. The most commonly eaten foods like fried rice were reproduced in the rehabilitation center to improve accuracy. Using the food composition tables (FAO, 2002) and Nutrisurvey software (1999) foods consumed were converted into nutrients consumed per day by averaging the two recalls of one week apart at baseline and at month six. The amount of kilocalories, protein, calcium, iron, zinc, vitamin A and vitamin C consumed by the children was established and then compared to the RDAs to establish adequacy of consumption.

3.10.5 Morbidity Characteristics

Morbidity characteristics focused on prevalence of opportunistic infections, the CD4 counts and use of the ARVs. Information regarding use of ARVs was obtained by enquiring from the caregiver and confirming with the clinic card. Morbidity was summarized as periodic prevalence using time sampling of 2 weeks per given month. Morbidity data were collected for two weeks every month for six months. The caregiver was asked to state the illness (es) the child suffered two weeks prior to the time of the visit. This was then confirmed by cross checking the child's clinic/hospital card. Information on the CD4 counts of the children before and after the intervention

was obtained from the medical/laboratory records on the request and contribution to the blood kit by the researcher for blood analysis of the children in the study.

3.11 Reliability

The instruments (questionnaires) were pretested to check the relevance of the instrument to the study objectives. The pretesting was carried out on caregivers with children two to five years old attending the Maternal Child Clinic (MCH) at Thika district hospital. These were not included in the study. The data obtained were useful for correction and modification of the questionnaire. The weighing scales were calibrated to zero before weighing the children and recalibrated after every measurement. Height and weight were taken twice at each visit and the average weight recorded to ensure accuracy of measurement

3.12 Validity

Two research assistants were trained prior to data collection. For the sensory evaluation and nutrient content, standard methods and tests were used including AOAC methods.

3.13 Data Quality Control

In phase one, samples were labeled with the laboratory ID which was keyed in the Laboratory Information System (LIS). Results were reviewed by researcher before entering the to the data base. Copies of results were kept in a manual and an electronic laboratory note book. In phase two, the questionnaires were pre-tested by the researcher and a trained research assistant on six caregivers of children who were not in the study sample. This helped to improve the instrument by making it clear and

focused after incorporating the omissions and the corrections. This enhanced the reliability of the instrument. In addition, data recording sheets and questionnaires were cross-checked by the researcher regularly during data collection phase and any arising queries such as contradicting information was followed up by the researcher by rechecking with the respondents while still in the field.

3.14 Data Collection Logistical and Ethical Issues

The clearance to carry out the study was obtained from research committee at the Ministry of Education, Science and Technology through the School of Postgraduate Studies, Kenyatta University. The research purpose and protocol was explained in detail to the hospital management and the guardians and their informed consent obtained. Confidentiality was maintained during and after the study. For the laboratory work, a letter of introduction from the department of Foods Nutrition and Dietetics was obtained and presented to the authorities of the laboratories where nutrient analysis was carried out. The research permit from the Ministry of Science and Technology and research authorization letter from the Ministry of Health are attached (Appendix 1 and 2).

3. 15 Data Management

In phase one, samples were labeled with the lab ID which was keyed in the Laboratory Information System (LIS). Both laboratories had a LIS. Copies of results were kept in a manual and an electronic laboratory note book. In phase two, the questionnaires were ordered numerically and edited by the researcher before data

entry. The variables were coded and entered in the computer using the Statistical Package for Social Sciences (SPSS).

3.16 Data Analyses

Specific data analyses were carried out for the different type of data.

3.16.1 Nutrient Composition: For nutrient content of *hypochondriacus amaranthus* grain, means and the standard deviations of the various nutrients analysed were calculated and descriptively compared to the composition obtained by other studies to highlight differences and similarities.

3.16.2 Sensory Evaluation

For the sensory evaluation of the different amaranth based porridges, Analysis of Variance (ANOVA) was done and then the Tukey's Studentized Range Test was done to measure if there was any statistical difference among samples in appearance, texture, flavour, consistency and overall acceptability whereby all the other samples were compared to the fermented amaranth porridge.

3.16.3 Dietary Intake

Dietary data from two consecutive interviews (one week apart) were collected at baseline and at month six of the intervention. Using the Food Composition tables (FAO, 2002) and Nutrisurvey Software (1999), foods consumed were converted into nutrients consumed per day by averaging the two recalls of one week apart at baseline and at month six. The amount of kilocalories, protein, calcium, iron, zinc, selenium, vitamin A and vitamin C consumed by the children was established and then compared to the RDAs to establish adequacy of consumption. Further, Paired T-test

was run to establish the differences in pre- and post- intervention mean nutrient intakes by the children.

3.16.3 Nutritional Status

Anthropometrical data were analysed by use of the EPI INFO software. The data were transformed into to Z-score and medians of percentiles. This was used to determine the nutritional status of the children in terms of those who were normal, stunted, wasted and underweight. Those with Z- score of less than (<) -3 SD based on their weight for height, height for age and weight for age were classified as severely malnourished. Those who had >-3 SD to <-2 SD were classified as moderately malnourished while those with Z-score of more than (>-2 SD) were classified as normal. There were no overweight and obese cases in the sampled children.

Paired t-test was run to compare nutrition status at baseline and at the end of the six months intervention period. Further, Pearson Product Moment correlation co-efficient (r) value was calculated to test the statistical association and differences between nutritional statuses of the children and dietary intake of selected and other dependent variables. The continuous outcome (nutrition status) coefficients with corresponding 95% confidence interval were used to assess the significance and magnitude of the contribution of a given factor. The variables that showed a significant relationship in bivariate analysis were subjected to regression analysis in order to establish their contribution to nutrition status. Regression analysis was done to determine the contributions of the independent variable of diet (kilocalorie and number of meals), the number of illness, frequency of illness to the nutrition status. The variables that

were measured during the study included kilocalorie intake, number of meals, number of illness and frequency of illnesses.

3.16.4 Morbidity Prevalence

Morbidity data was summarized as period prevalence using time sampling of two weeks per given month. Prevalence of and frequencies of illnesses were established to describe the morbidity trends among the children.

3.16.5 CD4 Counts

For the CD4 counts, Pearson product moment correlation co-efficient (r) value was calculated to test the statistical association between intakes of selected nutrients and the CD4 counts. In addition, Paired t-test was done for pre- and post- intervention CD4 counts in the children to investigate the differences.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents results and discussions of research findings under the following subheadings: Nutrient composition of the locally grown *hypochondriacus amaranthus* grain, sensory evaluation of the amaranth based porridges, demographic characteristics of the children who participated in the study, infant and young child feeding practices, baseline and after intervention dietary intake, baseline and after intervention nutritional status, baseline and after intervention CD4-counts and morbidity characteristics of the children.

4.2 Nutrient Composition of *Hypochondriacus Amaranthus* Grain

4.2.1 Proximate Composition

Locally grown *hypochondriacus amaranthus* grain was analysed for its proximate composition and the results were as shown in Table 4.1.

Table: 4.1: The Percentage nutrient composition of amaranth grain

Nutrient	(% w/w) in amaranth grain (DMB)
Moisture(g)	11.00±1.04
Crude protein(g)	15.29±0.80
Total lipids(g)	8.50±0.90
Total dietary fibre(g)	5.50±0.20
Total ash(g)	2.51±0.20
Carbohydrate(g)	57.20 - 60

DMB – Dry matter basis

The moisture content of the grain was at 11.0% indicating that it was fairly dry probably due the climatic and storage conditions. The 11.0% moisture content is within the 6% – 11% range reported by Teutonic and Knorr, (1985) and Singhal and Kulkani (1988). However, the moisture level is lower than in local cereals like *Eleusine corocana* (Finger millet) (13%), *Zea mays* (Maize) 14%, *Sorghum boicolour (L.) Moench* (Sorghum) 13%, *Triticum spp.* (Wheat) 15.5% and *Avena sativa* (Oats) 12.0%, (KEBS, 2007).

Crude protein content of the grain was found to be at 15.29%, higher than the 8.5% - 14.0% reported in most cereals (Bressani, 1987). However, it falls within the 15.2% - 17.8% range reported by Bressani, (1987) but higher than the levels in most local cereals like finger millet (6.8 – 8.5%), sorghum (8.5%), wheat (10.5%) and oats (11.0%), (KEBS, 2007) and lower than the 17.9% reported by Singhal and Kulkani, (1988).

The total lipids content of the local *hypochondriacus* was 8.50% dry matter which was higher than in finger millet (2 – 5%), maize (3 – 5.0%) and sorghum (4.7%), (KEBS, 2007). The content is slightly lower than the 8.8% - 12.1% reported by Bressani, (1987) but higher than 4.8% - 7.7% reported by Singhal and Kulkani, (1988).

The carbohydrate content of local amaranth (57.20%) falls within the 57.0% - 67.9% range reported by Singhal and Kulkani, (1988) but it is slightly lower than the 62% reported by Saunders and Becker, (1984). The total dietary fibre was 5.5%. This is more than double the level of the 2.2% reported by Singhal and Kulkani, (1988) but

falls within the 3.4% – 5.7% found by Bressani, (1990). The 5.5% dietary fibre content of the local *hypochondriacus amaranthus* grain is also higher than the content of local cereals like maize (1.0 - 3.0%), finger millet (1.8 – 3.0%), sorghum (2.5%) and oats (2.5%) (KEBS, 2007). The local amaranth grain is high in dietary fibre.

Total ash of the local *hypochondriacus* was found to be at 2.51%. The content was lower than the 3.3% - 4.1% range reported by Singhal and Kulkani, 1988 and the 2.6% - 4.4% by Teutonic and Knorr, 1985. The ash content is slightly higher than in some of the local cereals like maize (1.8 – 2.0%), sorghum (1.5%), wheat (1.3%) and oats (1.8%) (KEBS, 2007). From these findings, there are slight variations in the proximate composition of the local *hypochondriacus amaranthus* grain compared to findings of other studies. This can be attributed to factors like the genetic composition, agronomical/environmental conditions and soil variations (Bressani, 1987).

4.2.2 Micronutrient Content in the Local Amaranth Grain

The local amaranth grain was analyzed for its micronutrient content and the results are as shown in Table 4.2. The iron content of the local amaranth grain was 20.00 ± 0.8 mg/100g. The content is lower than the 53mg/100g reported by Bressani, (1987), but falls within the 9.1 – 21.7mg/100g range by Becker *et al.,* (1981). However, the content is much higher compared to most common grains like maize (3mg/100g), wheat (3.5mg/100g), finger millet (9.9mg/100g), sorghum (5.7mg/100g), oat (4mg/100g), rice (0.9mg/100g) and soya bean (11.5mg/100g) (Becker *et al.,* 1981).

Table 4.2: Mean of Micronutrient Content in Local *Hypochondriacus* Grain

Micronutrient	Mg/100g (dry weight basis)
Iron	20.00 ± 0.8
Zinc	4.00 ± 0.6
Selenium	0.87±0.2
Calcium	250.00 ± 1.0
Magnesium	246.00± 1.1
Phosphorous	450.00± 0.9
Potassium	428.80± 1.2
Manganese	0.81± 0.6
Copper	2.80±2.0
Beta carotene	0.01±0.4
Ascorbic acid	1.49± 1.4

The zinc content was 4.0 ± 0.6 mg/100g dry matter basis and is slightly higher than the 3.8mg/g reported by Bressani, (1987) and the 3.6 – 3.9mg/100g by Becker *et al.,* (1981). The zinc level is also higher than the levels in maize (2.5mg), wheat (1.0mg) rice (1.2) and finger millet (1.5mg). The selenium content was 0.87 mg/100g.

Calcium content was 250 ± 1.0mg/100g, and is above the 137 – 167mg/100g reported by Becker *et al.,* (1981) and the 244mg/100g by Bressani, (1987). The calcium level is lower than that found in finger millet (358mg) but higher than the levels in soybean (240mg), oats (54mg), rice (32mg), wheat (39mg), sorghum (21mg) and maize (8mg), Bressani,(1987).

Magnesium level was 246mg±1.1 /100g. This is less than the 342mg/100g reported by Bressani, (1987) and the 292 – 363mg/100g by Becker *et al.,* (1981). This level is also

lower than that found in wheat (288mg) but higher than in maize (142mg), rice (130mg), finger millet (140mg), sorghum (140mg) and oats (183mg), Bressani, (1987).

The phosphorous content was 450mg±0.9/100g. The phosphorous content is also lower than the 570mg/100 reported by Bressani, (1987) and the 600mg/100g by Becker et al., (1981). The 450mg/100g level of phosphorous in the local amaranth grain is higher than the level found in maize (234mg), finger millet (250mg), sorghum (363mg), wheat (383mg) and rice (130mg) (Bressani,1987). However, the content is lower than in soyabean (690mg) and oats (546mg) Bressani, (1987).

Potassium level was 428 ± 1.2 mg/100g which is less the 532mg/100g reported by Bressani, (1987) and the 563mg/100g by Becker *et al.,* (1981). This level is quite high when compared with the levels found in common cereal grains like maize (320mg), finger millet (314), sorghum (220mg) and rice (130mg) Bressani, (1987).

Manganese content was 0.81±0.6mg/100g, much lower than the 2.9 mg/100g reported by Bressani, (1987) and the 1.9 – 2.9 mg/100g reported by Becker *et al.,* (1981). This level is also lower than the levels found in cereals like rice (1.1mg) and finger millet (1.9mg) but higher than that found in maize (0.55mg) (Bressani, 1987).

The copper level was 2.8 mg/100g which was high compared to the 0.86 – 2.40mg/100g reported by Bressani (1987) and the 0.6 – 0.8 mg100/g reported by Becker et al., (1981). This is also very high when compared to that found in cereals like maize (0.35mg), wheat (0.9mg), rice (0.25mg), finger millet (0.5mg) and

sorghum (1.8mg) (Bressani,1987). The high copper levels in the local amaranth grain may be associated with levels in the soil where it was grown. The beta carotene content was 0.05±0.4mg/100g and ascorbic acid was 1.49±4.0 mg/100. The ascorbic acid content was below the 2.8 - 3.0mg/100g reported by Saunders and Becker, (1984).

The findings show variations which are slight in some cases but wide in some micronutrient levels of the local amaranth grain as compared to the available data from similar studies of the same variety from other countries. The variability may be due to variations in locality, environmental factors and agricultural methods used (Bressani, 1987). The levels of phosphorus, calcium, potassium, magnesium, and iron were generally higher than the levels found in common cereal grains.

4.3 Sensory Evaluation of the Amaranth Based Porridge Samples

Different porridges made from pure plain amaranth, fermented amaranth, amaranth maize blend and amaranth finger millet blend porridges were tasted with respect to appearance, texture, flavour, consistency and overall acceptability. The sensory evaluation was done by a panel of 17 untrained panellists and the results were as shown in Table 4.4.

4.3.1 Appearance

The appearances of amaranth and blended amaranth porridges were liked on the hedonic scale of between 1 and 9, with 1 being dislike extremely, 2-dislike much, 3-dislike moderately, 4-neither dislike nor like, 5 liked 6-like moderately, 7-like much,

8-like very much, 9-like extremely and 9 being highly likely. Amaranth maize blend had the highest mean score (6.44±0.73) meaning that the amaranth maize blend was liked moderately based on the hedonic scale. Fermented amaranth and pure amaranth had mean scores of 5.56±0.96 and 5.69±1.58 respectively and this meant that the two were also liked moderately with regard to appearance. Finger millet amaranth blend scored the least (5.25±0.86) with regard to appearance and was liked based on the hedonic scale.

Table 4.3: Panellists' Mean Scores on the Sensory Attributes of the Porridge Samples

Attribute	*Porridge sample*	*Mean scores±SD*
Appearance	Pure plain amaranth	5.69±1.58
	Fermented amaranth	5.56±0.96
	Amaranth maize blend	6.44±0.73
	Amaranth *wimbi* blend	5.25±0.86
Texture	Pure plain amaranth	5.41±1.23
	Fermented amaranth	5.59±1.00
	Amaranth maize blend	6.18±0.88
	Amaranth wimbi blend	5.35±1.17
Flavour	Pure plain amaranth	5.35±1.27
	Fermented amaranth	5.56±0.96
	Amaranth maize blend	6.82±0.39
	Amaranth wimbi blend	5.35±0.79
Consistency	Pure plain amaranth	5.76±1.15
	Fermented amaranth	5.47±0.62
	Amaranth maize blend	6.41±0.51
	Amaranth wimbi blend	5.59±0.94
Overall acceptability	Pure plain amaranth	5.71±1.10
	Fermented amaranth	5.76±0.44
	Amaranth maize blend	6.88±0.33
	Amaranth wimbi blend	5.65±0.70

4.3.2 Texture

Results showed that the highest mean score (6.18±0.88) for texture was for the porridge made from the amaranth maize blend followed by fermented amaranth with a

score of 5.6. The pure amaranth and the finger millet amaranth blend had a mean score of 5.4 each. The results indicate that amaranth maize blend porridge and fermented porridge were liked moderately while the pure plain amaranth and the *wimbi* amaranth blend porridges were liked based on the hedonic scale.

4.3.3 Flavour

With regards to flavour, amaranth maize blend porridge had the highest mean scored of 6.8 which indicated that it was liked much. Fermented amaranth had a mean score of 5.6, which means that it was liked moderately. The pure plain amaranth and finger millet amaranth blend porridge shared a mean score of 5.4 each, which meant that the three porridge samples were liked.

4.3.4 Consistency

The highest mean score of 6.4 for amaranth maize blend indicated that the porridge was liked moderately in terms of consistency. Pure plain amaranth porridge followed with a mean score of 5.8 (liked moderately), finger millet amaranth blend porridge with a mean score of 5.6 (liked moderately) and finally fermented amaranth porridge with a mean score of 5.5 (liked moderately). These results indicate that the pure amaranth porridges, finger millet amaranth blend and fermented amaranth porridges were liked moderately with regards to consistency.

4.3.5 Overall acceptability

The overall acceptability in the four porridge samples showed that amaranth maize blend porridge rated highest with a mean score of 6.9 meaning that the porridge was liked much. The other porridges: fermented amaranth porridge with a mean score of

5.8, pure plain amaranth porridge with a mean score of 5.7 and finer millet amaranth blend porridge with a mean score of 5.6 were moderately liked in terms of overall acceptability.

4.3.6 Differences in Porridge Samples

Analysis of variance and the Turkey's Studentized Range Test on the mean scores were done to measure statistical difference in appearance, texture, flavour, consistency and overall acceptability of fermented amaranth porridge from all the other porridges. The fermented amaranth porridge was used as the reference porridge since it was the porridge to be for the intervention because studies have shown that there is enhanced nutrient bioavailability in fermented porridges. (Okoth *et al.,* 2005) The Turkey's Studentized test compares the means of every treatment to means of every other treatment and finds wether the difference between any two means is greater than the standard error would be expected to allow. When there are multiple comparisons being made, the probability of making type 1 error increases but the Turkey's test corrects it and is thus more suitable for multiple comparisons. The formula for the Turkey's Studentized test is as follows:

$$\underline{Q_s = Y_A - Y_B}$$

$$SE$$

Where:

Q_s: Is the minimum significant difference

Y_A: Is the larger of the two means being compared

Y_B: Is the smaller of the two means being compared

SE: Standard error of the data

If the Qs value is larger than the Q critical value obtained from the distribution, then the two means are significantly different. The four different porridges were tested with respect to appearance, texture, flavour, consistency and overall acceptability as shown in Table 4.4.

Table 4.4: Differences in porridge samples by Sensory Attribute

Variable	*Sample porridge*	*Mean score*	*Difference from reference*	*Minimum sig. Difference(critical value from distribution)*	*P- value*
Appearance	Amaranth maize blend	6.44	0.88	1.01	0.0217
	Pure amaranth	5.69	0.13		
	Fermented amaranth	5.56			
	Wimbi amaranth blend	5.25	0.31		
Texture	Amaranth maize blend	6.18	0.59	0.98	0.1136
	Fermented amaranth	5.59			
	Pure amaranth	5.41	0.18		
	Wimbi amaranth blend	5.35	0.24		
Flavour	Amaranth maize blend	6.82	1.41*	0.79	< .0001
	Fermented amaranth	5.61			
	Pure amaranth	5.35	0.06		
	Wimbi amaranth blend	5.35	0.06		
Consistency	Amaranth maize blend	6.41	0.94*	0.76	0.0088
	Pure amaranth	5.76	0.29		
	Wimbi amaranth blend	5.59	0.12		
	Fermented amaranth	5.47			
Overall acceptability	Amaranth maize blend	6.88	1.12*	0.64	< .0001
	Fermented	5.70			
	Pure amaranth	5.61	0.06		
	Wimbi amaranth blend	5.55	0.12		

*Indicates the differences that are larger than the critical value obtained from the distribution hence a significant difference between the means

Appearance

Based on the Turkeys' student test, the fermented amaranth porridge was not significantly different from the amaranth maize blend porridge, amaranth finger millet blend porridge and unfermented amaranth porridge. However, there was significant

difference between finger millet amaranth blend and amaranth maize blend as shown in Figure 4.1.

Texture

The overall p-value was 0.11 indicating that the samples of porridges did not explain the texture as significantly different. The minimum significant difference was 0.98 and this means that the fermented amaranth was not significantly different from amaranth maize blend porridge, amaranth finger millet blend porridge, and unfermented amaranth porridge (Figure 4.1).

Flavour

The overall p-value for flavour was < .001 indicating that the samples of porridges explained the flavour as significantly different. The minimum significant difference was 0.79. This means the amaranth maize blend porridge was statistically different from the fermented amaranth porridge as the difference from the reference porridge (fermented amaranth porridge) was higher than the minimum significant difference (critical value from the distribution). However, the fermented amaranth was not significantly different from amaranth finger millet blend porridge and unfermented porridge as shown in Figure 4.1.

Consistency

The overall p-value for consistency was 0.0088 indicating that the samples of porridge were significantly different. The minimum significant difference was 0.76; hence the amaranth maize blend porridge was significantly different from the fermented amaranth porridge. The amaranth finger millet porridge and the

unfermented amaranth porridge were not statistically different from the fermented amaranth porridge as shown in Figure 4.1.

Overall Acceptability

The overall acceptability of the four different porridges had an overall p-value of 0.0001 indicating that the samples of porridge were significantly different. The minimum significant difference was 0.64 showing that it was only the amaranth maize blend porridge that was statistically different from the fermented amaranth porridge. The amaranth finger millet blend porridge and the unfermented amaranth porridges were not statistically different from the fermented amaranth porridge (Figure 4.1).

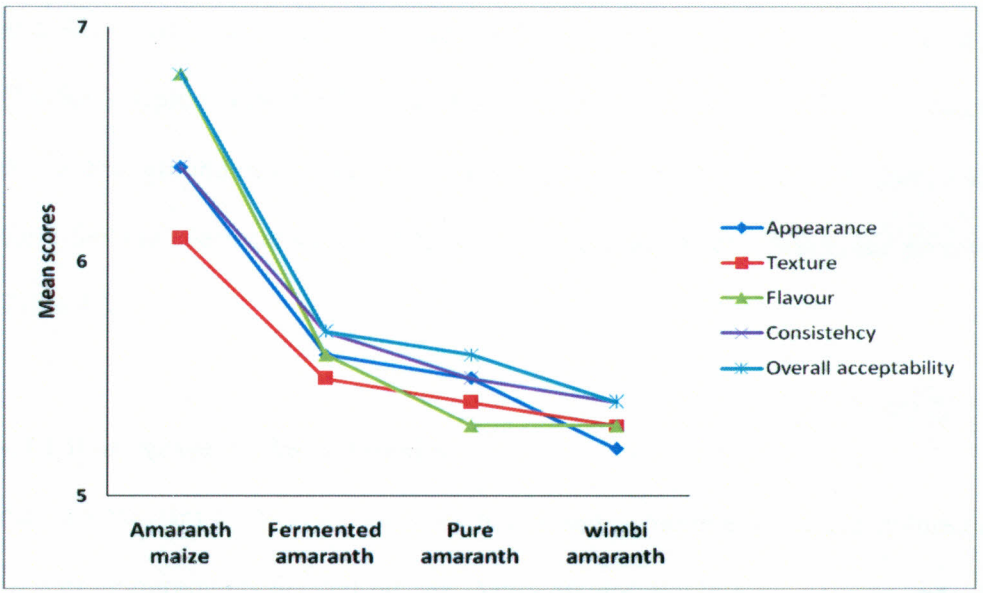

Figure 4.1: The Ratings of the sensory atrributes in the different porridges

The results show that the amaranth maize blended exhibited higher sensory qualities in all the tested attributes; meaning it was most preferred followed by the fermented amaranth porridge. The amaranth maize blend was most preferred probably due to the long held dietary practice of consuming maize and maize-based products by the

panellists. The amaranth finger millet porridge exhibited the lowest sensory qualities probably due to its dull colour. However, the fermented amaranth porridge was recommended and used for the intervention for two reasons. The first reason is documented evidence of enhanced nutrient bioavailability in fermented porridges (Okoth *et al.,* 2005). Enhancing nutrient bioavailability is very critical for nutritionally vulnerable groups such as the children infected with HIV and AIDS. The second reason is that in addition to enhanced bioavailability the porridge did achieve acceptability based on the hedonic scale ratings of its attributes as discussed earlier.

4.4 Background Information of the study children at baseline

The background information and demographic characteristics of the 2-5years old HIV and AIDS infected children that attended the Comprehensive Care Clinic at Thika District Hospital were established. These were crucial as they provided information on the background of the children such as age, sex, and birth rank, number of sibling, child feeding characteristics and nature of the caregiver. The results are presented in Table 4.5.

4.4.1 Demographic Characteristics

Age is important in the considerations of nutrient requirements for the children as the nutrient requirements depend on age. Nutrients are required to meet the growth and development needs of the children depending on their respective ages (Briend *et al.,* 2003). As presented in Table 4.5, the age of the children ranged between 23-59 months. Slightly more than one third (38.5%) of the children were between 55 -59 months. The ages 24 -30 months and 31 -36 months constituted less than ten percent (3.8% and 7.7%) respectively.

Table 4.5: Background information and Demographic Characteristics of the Children (N=52)

Variable	*Category*	*Frequency (n)*	*Percentage (%)*
Age(months)	23 - 30	2	3.8
	31 - 36	4	7.7
	37 - 42	9	17.3
	43 - 48	11	21.2
	49 - 54	6	11.5
	55 - 59	20	38.5
Sex	Male	25	48.1
	Female	27	51.9
Birth rank	1	12	23.1
	2	21	40.4
	3	8	15.4
	4	8	15.4
	5	2	3.8
	7	1	1.9
Number of siblings	0	8	15.4
	1	22	42.3
	2	9	17.3
	3	9	17.3
	4	2	3.8
	5	1	1.9
	6	1	1.9
Nature of caregiver	Biological mother	36	69.2
	Biological mother and father	3	5.8
	Grandparents	9	17.3
	Others	4	7.7
Infant and young child feeding practices	Ever breastfed	48	92.3
	Breastfed up to six months	36	69.2
	Breastfed up to 24 months	12	23.1
Age of introduction of complimentary foods	<2 months	11	21.0
	2-4 months	24	46.0
	5-6 months	17	32.6

The children in the study comprised 48.1% male and 51.9% female. On birth rank more than one third (40.4%) of the children were 2nd borns. The 1st borns were slightly less than quarter (23.1%). Those who ranked 3rd and 4th were represented by

15.4% each. The rest 5th and 7th borns both constituted less than 10 % (3.8% and 1.9%) respectively. Birth rank of a child is important as it determines the level of care and attention a child is given. If the number of siblings ahead of a child is small, then the attention given to the child is better both in quantity and quality (Lansana, 2005). This can have an impact on the nutritional status of a child.

The number of siblings was established because this may influence the kind of care and attention given to the child. It also enabled the researcher to provide adequate flour to households with siblings so as to prevent leakage during the intervention. Large households are associated with inadequate intake of nutritious foods (Lansana, 2005). The food that is available has to be shared by many children and since it is little, it will hardly meet the nutritional requirements of the child (Lansana, 2005). From the study, more than a third (42.3%) of the children had only one sibling. Less than 10% of the children had four and more siblings. The rest had two siblings (17.3%) and 17.3% had three siblings (Table 4.5).

The nature of the relationship of caregiver to a child may influence the kind of care given to the child. Children depend on other people to provide food. For many reasons, HIV may result in children being cared for by someone other than the mother or father. Studies have shown that this situation may put the child at risk of undernutrition (Kikafuda and Namusoke, 2006). The way the food is given to the child is important as the type of food offered and can significantly influence both the child's nutritional status and overall health (Kikafuda and Namusoke, 2006).

A care giver should be responsive to the child cues for attention and play an active role in encouraging the child to feed. A caregiver who is responsive ensures that the child is well-fed (Lansa, 2005). In this study, the nature of the care giver was established by asking the respondent to describe the nature of the relationship between her/him and the child.

From the study, slightly more than two thirds (69.2%) of the children were under the care of biological mothers. Those who were under the care of both biological mother and father were only 5.8%. Less than a quarter (17.3%) of the children was under the care of the grandparents. The rest (7.7%) were under the care of other relatives.

4.4.2 The Infant and Young Child Feeding Practices

The diet and nutrition history of the children was established by interviewing the care givers to obtain background information related to breastfeeding and complementary feeding practices. The information is important as feeding practices in the early stages of life have a bearing on the nutrition status of the subsequent stages of life (WHO, 2006). The information on the breastfeeding and complementary feeding of the children is shown in Tables 4.5.

Breastfeeding history

Earlier, WHO recommended exclusive breastfeeding for HIV-infected mothers for the first 6 months of life unless replacement feeding is acceptable, feasible, affordable, sustainable and safe (AFASS) (WHO, 2006). New evidence suggests that HIV transmission through breastfeeding can be significantly reduced if a mother breastfeeds her child exclusively and if she or the baby receive antiretroviral therapy

(ART) at the same time (WHO, 2010). Based on latest scientific findings, the World Health Organization in 2010 revised its guidelines on HIV and infant feeding. WHO now recommends that mothers with HIV breastfeed their baby exclusively for the first six months and continue to breastfeed up to 12 months while introducing complementary food in settings where breastfeeding is judged to be the safest infant feeding option (WHO, 2010).

In this study, most (92.3%) of the children had been breast fed and the remaining 7.7% were not breastfed at all. However, none (0%) of the breastfed children was exclusively breastfed. This finding agrees with the findings by Kabba (2005) who indicate that exclusive breast feeding was not being practised by mothers in Maragwa and Nairobi though the study was not focussing on the HIV context. In terms of duration of breastfeeding, the findings of this study indicate that about a quarter (69.2%) of the children were breastfed for a period of six months and those that breastfed up to twenty four months constituted 23.1%.

World Health Organisation recommends that at six months, mothers with HIV should continue to breastfeed up to 12 months while introducing complementary food in settings where breastfeeding is judged to be the safest infant feeding option (WHO, 2010). The mother and baby should continue to be regularly assessed. Despite strong evidence that infant feeding practices are one of the most significant determinants of child survival, supporting optimal infant feeding practices has also been a challenge for health systems even in countries where HIV is not a problem probably because the national and international commitment has not been matched by funding and action.

Complementary Feeding Practices

The age at which other foods other than milk were introduced was established and the findings are as in Table 4.5. This study found that 21.0% of the children were introduced to complementary foods by the age of two months. Slightly less than half (46.0%) of the children were introduced to other foods at the age of four months and a third (32.6%) of the children were introduced to other foods at the age of six months. These findings indicate that complementary foods were introduced at an early age contrary to the WHO/UNICEF (2006) which states that during the first six months of life of an infant, no food or liquid other than breast-milk is required to meet the nutritional requirements of an infant. From the HIV context, complementary foods should be introduced after six months of age with continued breastfeeding or replacement feeding until a nutritionally adequate diet can be sustained without breast milk (WHO, 2006).

Among the foods that were first introduced to the children included potato mash, ripe banana, blended fruits, pumpkin, pawpaw and porridge. The study established that, slightly more than a third (34.6%) of the children were given potato mash. These were followed by another third (30.7%) that were given pumpkin. Those that were given ripe banana constituted 13.4%. About ten percent of the children were given porridge, while those who were give pawpaw and blended fruit constituted for less than ten percent (3.8% and 7.6%) respectively. From the findings, the nutritional adequacy of the foods is wanting as they were predominantly carbohydrates. Complimentary foods should be made from nutrient-enriched family foods introduced at the appropriate age. The study established the extent of consumption of porridge by the children and the types of flours used for porridge. The results are as in Table 4.6 below.

Table 4.6: Consumption of different types of porridge at baseline (N=52)

Type of flours used for porridge	*n*	*%*
Maize flour	2	4.1
Finger millet flour	15	30.6
Sorghum flour	4	8.2
Mixed flour	28	57.1
Amaranth flour	-	-
Not consuming porridge	3	5.8
Total	52	100

Majority (94.2%) of the children consumed porridge made from different flours (Table 4.6). Those who did not consume porridge constituted less than ten percent (5.8%). The flours used for the porridge included` mixed flours, finger millet flour, maize flour and sorghum flour. Slightly more than half (53.8%) of the children used mixed flours for porridge and about a quarter (28.8%) of the children used finger millet flour. Use of maize flour and sorghum flour constituted less than ten percent each (3.8% and7.7%) respectively. It is important to note that introduction of amaranth grain flour for porridge for the HIV and AIDS infected children attending the Comprehensive Care Clinic at the Thika District Hospital was a new idea as none of the children had ever used amaranth flour before.

4.5 Pre and post dietary intake by the children

Based on the 24 hour dietary recall, consumption of various nutrients and total kilocalories by the children was established. Food consumption and nutrient intake has a bearing on the nutritional status of the children. The caregiver was asked to state the meal, describe ingredients and the quantity of each meal taken by the child. By using proxy measures, the amounts of foods consumed by the child were calculated.

House hold measures such as cups, spoons bowls were used to help in estimating the quantities of food consumed. Incase of casseroles and mixed dishes, the respondents were asked to estimate the individual food constituents. The cup volume was later used to measure/estimate the quantities. The most commonly eaten foods like fried rice were reproduced in the rehabilitation centre to improve accuracy. The nutrient intake was then calculated by using Nutrisurvey software (2000).

The amounts of selected nutrients were compared with the RDA table. Where the amounts consumed were less than the RDA, the intake was considered to be inadequate and where the intake corresponded to the RDAs was considered adequate. Table 4.7 shows the proportion of children who consumed adequate amounts of selected nutrients at pre and post intervention.

Table 4.7: Proportion of the children consuming adequate amounts selected nutrients (N= 52) at pre and post intervention

Nutrient	RDA(FAO/WHO, 2003)	Pre- intervention		After intervention	
		n	%	n	%
Energy (Kcal)	1550-1860	15	28.8	28	53.8
Protein (g)	26g	43	82.7	51	98.1
Calcium(mg)	500- 600mg	4	7.7	15	28.8
Iron (mg)	6mg	50	96.2	52	100.0
Vitamin A	400 -450µg	12	23.1	24	46.2
Vitamin C	30mg	35	67.3	39	75.0
Zinc	4.1-5.1mg	40	76.9	42	80.8
Selenium	60-73µg	34	65.4	37	71.2

The study findings at baseline revealed that only about a quarter (28.8%) of the children consumed adequate kilocalories in terms of the RDA and nearly three

quarters (71.2%) consumed insufficient calories. For age 2-5year, the RDA for the asymptomatic period ranges from 1550kcal to 1860kcal and during the symptomatic period, it ranges from 1690kcal to 2030kcal (FAO/WHO, 2003). Adequate energy intake is critical due to the increased metabolic needs that arise from the infection in addition to the needs for physical activity and growth (WHO, 2009). When the caloric intake is inadequate, the body reserves are depleted to provide for the deficit and this predisposes the children to wasting (WHO, 2009; NASCOP, 2006). A study done in Central Province of Kenya designing snacks to address micronutrient deficiencies in young children also reported low energy intake among the children at the baseline assessment (Suzanne *et al.,* 2007). Though, the study was not dealing the HIV infected children, it indicated that micronutrient deficiencies were also prevalent among the non infected children and amaranth grain supplementation may be beneficial to such groups of children.

Protein intake was adequate for majority (82.7%) of the children. When the total calorie intake is inadequate as was in the case of nearly three quarters (71.2%) of the children, some of the protein was likely used for energy and was not being utilized to the maximum for growth and regeneration resulting to wasting (FANTA, 2006). The RDA for the 2 -5 years HIV-infected children is the same (26g/day) as for the non-infected children (WHO/FAO, 2002).

According to WHO, there is insufficient evidence to support the need to increase protein requirements for PWHA over and that of non-infected persons (WHO, 2003). However it is important to ensure adequate intake of essential amino acids which maintain body cell functions by appropriate selection and combinations of protein

food sources (UNICEF/ USAID /FANTA, 2006). Studies have shown that amaranth grain exhibits a high quality protein with a score of 75-82 in a theoretical score of 100 (Tacio, 2009; Bressani, 1989). This makes grain amaranth come closer to the perfect balance of essential amino acids for human nutrition as established by FAO/WHO, (Tacio, 2009; Bressani, 1989).

The intake of selected micronutrients including vitamin A, vitamin C, iron, calcium, zinc and selenium was also analysed. Vitamin A intake was inadequate for slightly more than three quarter (76.9%) of the children. Vitamin A is necessary for growth and building of the immunity. The RDA for the 2 -5 year old is 400 to 450 micrograms of retinol (Table 4.7). Vitamin C intake was adequate for slightly more than two thirds (67.3%) of the children. Intake of iron was adequate for majority (96.2%) of the children while calcium intake was adequate for only less than ten percent (7.7%) of the children. The intake of zinc at baseline was adequate for more than three quarters (76.9%) of the children while selenium intake was adequate for slightly more than two thirds (65.4%) of the children. Trace elements especially zinc and selenium are important for maintaining a healthy immune system. Zinc deficiency may lead to decline of T cells generation and depresses humoral and cell-mediated immunity (Stambullian *et al.,* 2007). Selenium deficiency is responsible for early progression of disease and mortality in HIV infected people (Kupka *et al.,* 2004).

After intervention, the intakes of some nutrients increased probably perhaps due to the diet complementation with amaranth flour porridge and enhanced nutrition awareness. There was increase in adequate intake of protein (98.1%), iron (100%), zinc (80.8%), selenium (71.2%) and vitamin C (75%) of the children (Table 4.7). Though the intake

of adequate total kilocalorie, vitamin A and that of calcium increased, the intakes were still inadequate for 46.2%, 71.2% and 53.8% of the children for the kilocalorie, calcium and vitamin A respectively.

4.5.1 Mean Intake of Selected Nutrients in Relation to RDA at Pre- and Post-intervention

The mean of consumed amounts of classified foods and nutrients was calculated from the pre and post intervention dietary intake of selected nutrients. At Pre-intervention, the mean intakes of total kilocalories, vitamin A, selenium and calcium were inadequate with reference to the FAO/WHO recommendations for the HIV infected children (2 -5 years old). The mean intakes for protein, iron, zinc and vitamin C were within or above the recommended levels (Table 4.8).

Table 4.8: Mean intake of selected nutrients in relation to RDA at pre and post-intervention

	Pre- intervention		***Post- intervention***			*P-Value Paired t-test*
Nutrients	Mean	Std.Dev.	Mean	Std.Dev.	RDA(FAO/ WHO,2003)	
Energy (Kcal)	1281.10	379.69	1607.72	379.67	1550 – 1860	< 0.001
Protein (g)	39.30	16.48	53.46	16.49	26	< 0.001
Calcium (mg)	412.41	253.79	434.41	253.80	500 – 600	< 0.001
Iron (mg)	26.57	15.53	36.57	15.54	6	< 0.001
Vitamin A (µg RE)	268.35	216.65	428.35	216.60	400 – 450	< 0.001
Vitamin C (mg)	49.01	36.05	59.92	36.06	30	< 0.001
Zinc (mg)	6.50	2.36	8.1	2.37	4.1-5.1	0.022
Selenium (µg)	26.82	12.93	30.19	12.94	60-73	0.187

The mean consumption of the nutrients by the children as at post-intervention was also calculated and the results are shown in Table 4.8 above. The total kilocalorie intake increased after the intervention and the mean intake was within the FAO/WHO recommendation. The mean intake of vitamin A also improved and was within the recommended values. However, though the mean intake of calcium and selenium increased at post intervention, the mean intakes were still below the FAO/WHO recommendation. Based on the paired t–test results, there was significant difference at ($p < 0.0001$) between mean intake of kilocalories, protein, calcium, vitamin A, vitamin C (Table 4.8) and $p = 0.022$ in the case of zinc at baseline and after intervention at 95% confidence level. The results indicate a positive impact of amaranth grain consumption by the children. The increase in the mean intake of selenium was minimal during intervention and the difference in pre- and post-intervention mean intakes was not significant probably due to inadequate consumption of other foods rich in selenium.

4.6 Prevalence of Illnesses among the Children

The nutritional status of the HIV and AIDS infected children is interrelated to morbidity. This study investigated the prevalence of illness and opportunistic infections among the study children. The frequency and number of illness were established. The prevalence of illness through the six months period is shown in Table 4.9. The children suffered various illnesses. At baseline, almost three quarters (71.1 %.) of the children suffered from cough. Half (51.9%) of the children suffered skin rushes and slightly more than a third (38.4%) had poor appetite. Fever was experienced by less than a quarter (19.2%) of the children while cold/flu was experienced by 13.5% of the children.

Table 4.9: Prevalence of opportunistic infections and illness suffered by the children=52

Disease /symptom	Baseline		Month1		Month2		Month3		Month4		Month5		Month6	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Cough	37	71.1	20	38.4	11	21.2	4	7.7	5	9.6	6	11.5	3	5.8
Skin rush	27	51.92	10	19.2	10	19.2	8	15.4	3	5.8	4	7.7	3	5.8
Poor appetite	20	38.4	17	32.7	10	19.2	3	5.8	0	0	3	5.8	0	0
Fever	10	19.2	11	21.2	3	5.8	2	3.8	3	5.8	5	9.62	3	5.8
Cold/flu	7	13.5	5	9.6	7	13.5	8	15.4	3	5.8	5	9.62	6	11.5
Nausea and vomiting	6	11.5	5	9.6	4	7.7	2	3.8	1	1.9	2	3.8	3	5.8
Diarrhoea	5	9.62	3	5.8	0	0	0	0	1	1.9	0	0	0	0
Oral thrush	5	9.62	6	11.5	3	5.8	2	3.8	0	0	1	1.92	1	1.92
Acute respiratory disease	3	5.8	4	7.6	2	3.8	1	1.9	2	3.8	1	1.9	1	1.9
Pneumonia	1	1.92	1	1.9	0	0	0	0	0	0	0	0	0	0
ENT	1	1.92	0	0	0	0	0	0	1	1.9	0	0	0	0
Convulsions	1	1.92	0	0	0	0	0	0	0	0	0	0	0	0
Boils	1	1.92	0	0	0	0	0	0	1	19	0	0	0	0
Tuberculosis	1	1.92	1	1.9	1	1.9	1	1.9	0	0	0	0	0	0
Headache	1	1.92	0	0	0	0	0	0	0	0	0	0	0	0

ENT= Ear-Nose- Throat -infections

Nausea/vomiting were experienced by 11.5% of the children while oral thrush and diarrhoea occurred in 9.62% of the children. Acute respiratory disease was also suffered by 5.8% of the children. Pneumonia, ear- nose- throat (ENT), boils; tuberculosis and headaches were suffered by 1.92% of the children.

From the study, there was a reduction in the prevalence of the illnesses during the study period which indicates positive responses to both the medical treatment and the children's diet complementation with amaranth grain. Though prevalence of illness reduced over the six months period, the reduction in the prevalence of cold and flu was minimal. Occurrence of colds and flu is common in children with a compromised immunity (Read, 2007). Prevalence of poor appetite reduced to 0% by the end of the sixth month. This may be attributed to the high digestibility of amaranth which allows for rapid uptake and utilization of nutrients (Teutonic and Knorr, 1985). This finding

agrees with reported phenomenal gains in vitality and increased appetite in HIV and AIDS patients in Uganda and Zimbabwe (Alemu and Berkelaar, 2007).

Use of Anti-Retroviral Drugs

The use of antiretroviral drugs before and after intervention was also investigated and from the study more than a third (40.4%) of the children was on ARVs while the rest (59.6%) were not on ARVs. The proportion of children on ARVs after intervention was still the same as at baseline as shown on Table 4.10. The prevalence of selected illness among the children by use of ARVs was established at pre and post intervention and the results are as on Table 4.10.

Table 4.10: Prevalence of selected illness by use of ARV

Illnesses	Pre-intervention (N=52)						Post intervention (N=52)					
	ON ARVs (n=21) (40.4%)		NOT ARVs (n=31) (59.6%)		Not ill		ON ARVs (n=21) (40.45)		NOT ARVs (n=31) (59.6%)		Not ill	
	n	%	n	%	n	%	n	%	n	%	n	%
coughs	8	38.1	29	93.5	15	28.8	-	-	3	9.6	49	94.2
skin rush	9	42.8	18	58.0	25	48.0	1	4.7	2	6.4	49	94.2
Fever	4	19.0	6	19.3	42	80.7	-	-	3	9.6	49	94.2
Nausea& vomiting	6	28.5	4	12.9	42	80.7	3	14.2	-	-	49	94.2
cold/flu	2	9.5	5	16.1	45	86.5	2	9.5	4	12.9	46	88.4
poor appetite	11	52.3	9	29.0	32	61.5	-	-	-	-	52	100.0
Diarrhea	2	9.5	3	9.6	47	90.3	-	-	-	-	52	100.0
Oral thrush	1	4.7	4	12.9	47	90.3	-	-	1	3.2	51	98.0

Both children on ARVs and those not on ARVs presented illness at pre-intervention and post-intervention and we observed decreased proportion of cases at post-

intervention for both. The prevalence of coughs, skin rush, fever, cold/flu, oral thrush was higher in children not on ARVs at pre- intervention. At post- intervention, cases of coughs, fever and oral thrush were reported only among children not on ARVs. Use of ARVs has been shown to reduce incidences of illnesses among HIV and AIDS infected children (WHO, 2009). We also observed that at post-intervention, the cases of nausea and vomiting were only among the children on ARVs. Nausea and vomiting has been cited as one of the common side effect of use of ARVs (NASCOP, 2006). Generally, prevalence of illness for both the children on ARVs and those not on ARVs showed a decline at post intervention.

4.7 CD4 Counts of the Children

The CD4 count of the children was investigated at baseline and after five months of the intervention with the help of the medical, laboratory and clinical staff at Comprehensive Care Clinic who carried out the blood analysis of the children for the CD4 counts. CD4 cells are critical to immune function of the body and they are used as a marker for the HIV progression (NASCOP, 2006). The results are as shown in table 4.11.

The results at baseline indicate that less than ten percent (3.8%) of the children had CD4 counts below 200 cells per micro litre while 1.96% had below 200 after intervention. This level indicates advanced progression of the infection (NASCOP, 2006). Slightly more than one third (38.5%) of the children had CD4 counts ranging from 201-500 cell per micro litre and 32.7% had CD4 counts of between 501 -700 cells per micro litre. One quarter (25.0%) of the children had CD4 counts between

701 -900 cells per micro litre and only 3.8% had CD4 counts of more than 901 cells per micro litre.

Table 4.11: CD4 counts of the children at Pre and Post intervention

CD4 counts(number of cells/μL)	Baseline		After intervention	
	n	%	n	%
<200	2	3.8	1	1.9
201 – 500	18	38.5	12	23.1
501 – 700	17	32.7	16	30.8
701 – 900	13	25.0	18	34.6
>901	2	3.8	5	9.6
Total	52	100.0	52	100.0

Based on paired sample t-test, there was significant improvement (P> 0.001) between pre- and post- intervention CD4 counts (Table 4.11) indicating a positive impact of the intervention on the nutritional status of the children in addition to the positive response to medical treatment.

Table4.12: Differences between Pre and Post intervention CD4 counts

CD4-1	CD4-2	Mean difference	95% C.I	P-value (paired t-test)
555.4231	666.1923	-110.7692 ±87.78	[-135.2077] – [-86.3308]	> 0.001

A pilot study of food ration supplementation in Zambia suggested that food assistance may be associated with better CD4 cell counts though no significant effect was observed (Cantrell et al., 2008). The researchers attributed this to a small sample size and the fact that it takes months of nutritional therapy to revert effects of malnutrition

on CD4 counts but the assessment had been done after three months. In this study, the assessment was done after six months.

4.7.1 CD4 counts and use of Anti-Retroviral Drugs (ARV)

There was improvement in the CD4 counts for the children on ARVs and those not on ARVs. The mean CD4 counts of the children on ARV and those not on ARV at pre and post intervention was determined and results are as shown in Table 4.13. The mean CD4 count of the both children on ARV and those not on ARV increased after intervention.

Table 4.13: CD4 counts and use of ARV at pre and post-intervention

	ON ARV	NOT ON ARV
Mean CD4 counts (pre-intervention)	365.4±171.5	684.1±151.5
Mean CD4 counts(post-intervention)	539.9±180.7	752.7±158.9

The results are further demonstrated by the graph below of the mean values of CD4counts being higher after intervention than at the baseline.

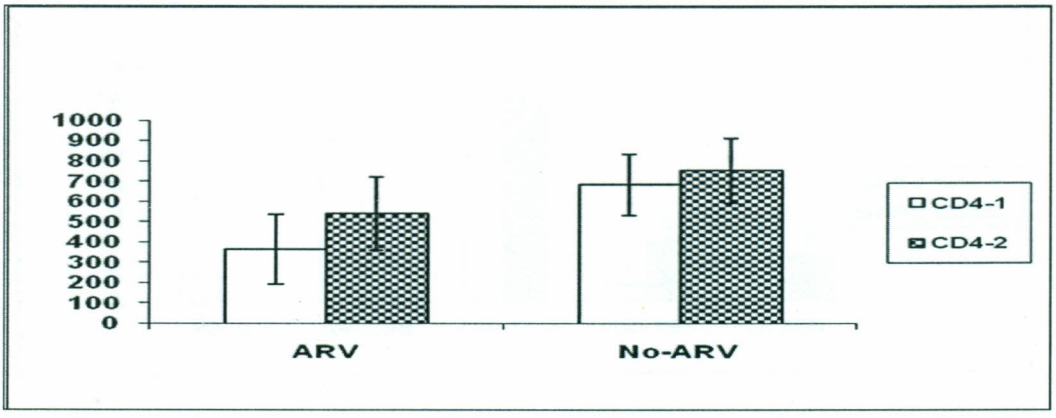

Figure 4.2: CD4 counts and use of ARV at pre and post-intervention

There was a shift in the number of children with higher CD4 counts from low CD4counts at baseline to high CD4 counts after the intervention. This is true for the both children not using ARV and those using ARV thus sowing that the intervention improved CD4 counts of the children. The results are demonstrated by the graphs in Figure 4.4 and 4.5 below.

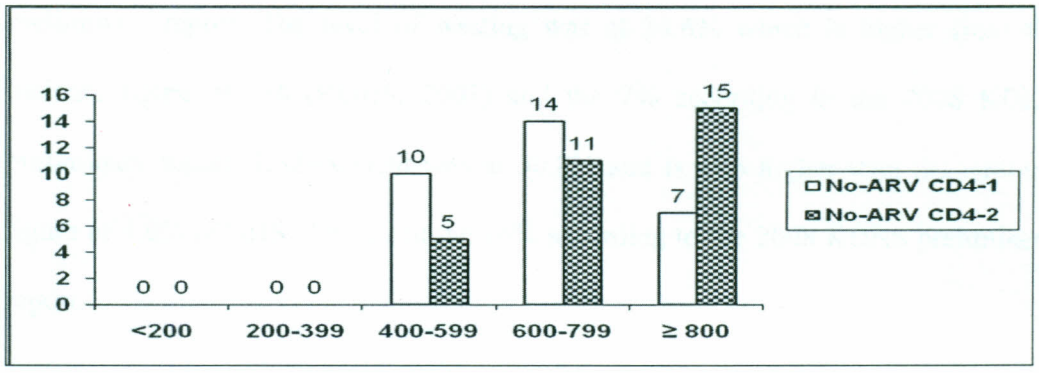

Figure 4.3: CD4counts of children not on ARV at pre- and post- intervention

The results show clearly that after the intervention there were no children with CD4 counts less than 399 while the number of children with CD4 counts above 400 increased after the intervention. This indicates that the intervention improved the CD4 counts for children on ARV.

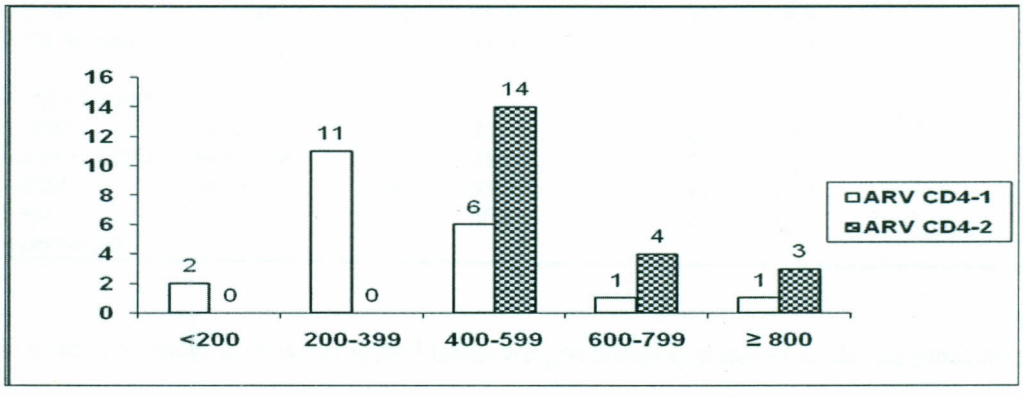

Figure 4.4: CD4 counts of children on ARV at pre- and post-intervention

4.8: Nutrition Status of the Children

The nutrition status of the children was assessed by comparing the prevalence of malnutrition at baseline and the end of the intervention based on the indicators Z-scores. The results are as shown in Table 4.14. At baseline, slightly more than a third (36.5%) of the children were stunted which is slightly more than the national figure (31.0%) according to the KDHS, (2003) and the 35% according to the KDHS (2008) preliminary report. The level of wasting was at 34.6% which is higher from the national figure of 6% (KDHS, 2003) and the 7% according to the 2008 KDHS preliminary report. Underweight was at 30.8% and is also higher than the national figure of 4.0% (KDHS, 2003) and the 16% according to the 2008 KDHS preliminary report.

Table 4.14: Prevalence of malnutrition status at baseline and Post Intervention (N=52)

Z-Scores	Status	Pre-intervention N=52		Post-intervention N=52	
		n	%	n	%
Height for age:					
< -3SD	Severe	5	9.6	4	7.7
-2.99 to -2.0SD	Moderate	14	26.9	13	25
>-2SD	Normal	33	63.5	35	67.3
Total stunted		19	36.5	17	32.7
Weight for height:					
< -3 SD	Severe	6	11.5	3	5.8
-2.99 to -2.0SD	Moderate	12	23.1	8	15.4
>-2 SD	Normal	34	65.4	41	78.8
Total wasted		18	34.6	11	21.2
Weight for age:					
< -3SD	Severe	5	9.6	2	3.8
-2.99 to -2.0SD	Moderate	11	21.2	7	13.5
>-2SD	Normal	36	69.2	43	82.7
Total underweight		16	30.8	9	17.3

The wide variations in wasting and underweight levels compared to the national levels may be associated with the fact that many children with HIV infection do not gain weight or grow normally (Read, 2007). HIV- infected children are frequently slow in

reaching important milestones in motor skills and mental development (Read, 2007). In addition, HIV-infection complicates utilization of nutrients in addition to the dramatic metabolic changes that accompany the disease. These may in turn compromise the normal growth process of the infected children (FANTA, 2006). The findings agree with a study in South Africa that found higher prevalence of underweight among HIV-infected children compared to the average national percentages in a national survey (Lesley *et al.,* 2007). This study established the presence of both chronic and acute malnutrition among the HIV and AIDS infected children attending the Comprehensive Care Clinic at Thika District Hospital at baseline. However, more than two thirds of the children were found to be within the normal height for age, weight for height and weight for age at 63.5%, 65.4% and 69.2% respectively (Table 4.14).

After intervention, prevalence of wasting was at 21.2%, underweight at 17.3% and stunting at 32.5%. The study revealed improvement in the nutrition status of the children. The prevalence of the wasting, underweight and stunting among the children reduced after intervention. The levels of wasting reduced from 34.6% at baseline to 21.2%, after intervention, underweight from 30.8% at baseline to 17.3% and stunting from (36.5%) at baseline to 32.5% after intervention (Table 4.14). More than two thirds of the children were found to be within the normal height for age, 78.8% within the normal weight for height and 82.7% within the normal weight for age (Table 4.14). Figure 4.6 shows the comparisons of the pre- and post- intervention and national figures. Though the levels of wasting and underweight among the children reduced after intervention, the levels are still much higher than the national figures.

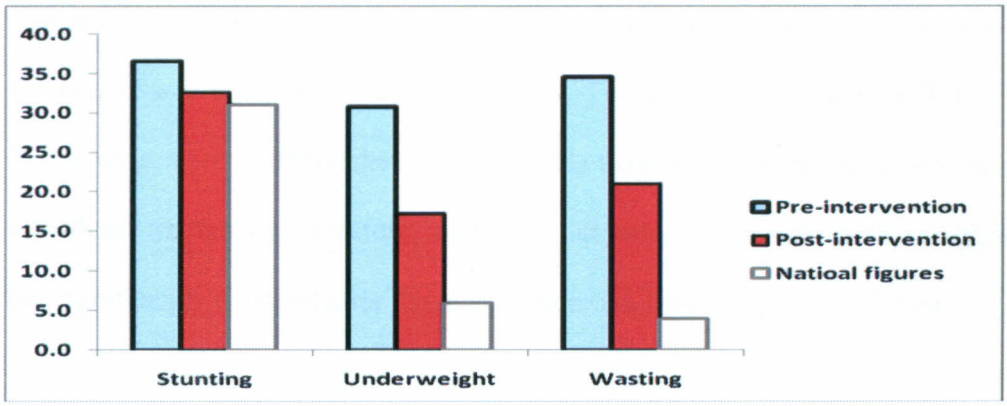

Figure 4.5: Comparisons for pre- and post- intervention status and national figures

4.8.1 Trends in Nutrition status over the six months study period

The trends in wasting using the mean weight for height among the study children over the study period was generated and is as shown on Figure 4.7. Generally there was an upward trend in mean weight for height during the six months study period indicating a reduction in wasting hence improved nutrition status. Weight for height is an important indicator of the health and nutrition status of the HIV/AIDS infected children as literature indicate that children with HIV infection do not gain weight or grow normally (Read, 2007) .

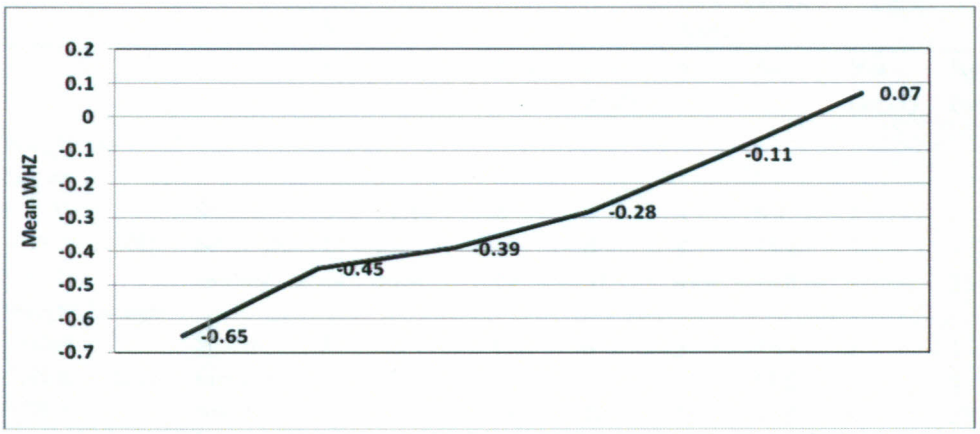

Figure 4.6 Monthly trends in mean weight for height (WHZ) of the study children

4.8.2 Nutrition status by sex

The nutritional status of boys and girls in the study using Z-scores based on weight for height was compared after intervention. The results are shown in Table 4.15. There were more malnourished (wasted) girls than boys but the difference was not significant (p= 0.676). Therefore, the nutritional status between the boys and girls was not significantly different after the intervention based on independent T- test.

Table 4.15: Post intervention Nutrition status by sex (Weight for height) N=52

Z-score	Boys	Girls	P-value (Independent T- test)
<-3SD	2	1	
-2.99 to-2SD	3	5	0.676
>-2SD	20	21	

4.8.3 Nutrition status and use of ARVs

The nutrition status based on weight for height and weight for age of the study children on ARVs and those not on ARVs was compared and the results are as on Table 4.16.

Table 4.16: Prevalence of malnutrition and use of ARVs

Z-Scores	Status	Pre-intervention N=52		ARV		Post-intervention N=52		ARV	
		n	%	Yes n=21	No n=31	n	%	Yes (n=21)	No (n=31)
Weight for height									
< -3 SD	Severe	6	11.5	2	4	3	5.8	1	2
-2.99 to -2.0SD	Moderate	12	23.1	6	6	8	15.4	3	5
>-2 SD	Normal	34	65.4	13	21	41	78.8	17	24
Weight for age									
< -3SD	Severe	5	9.6	1	4	2	3.8	1	1
-2.99 to -2.0SD	Moderate	11	21.2	6	5	7	13.5	2	5
>-2SD	Normal	36	69.2	14	22	43	82.7	18	25

The cases of severe malnutrition were more on the children not on ARV at pre – intervention as well as at post intervention but the differences were not significant. Based on Independent T-test, there was no significant difference (Table 4.16) between nutrition status and ARV intake in terms of weight for age (p=0.981) and weight for height (p=0.119). Use of ARVs should improve nutritional status but in some cases, they may have side effects like loss of appetite, nausea/vomiting and loss of taste (NASCOP, 2006).

Severe side effects have been cited as critical factors leading to the development of drug resistance and decreased therapeutic efficacies with ARV drugs. In addition, the issues related to poor adherence and compliance of use of ARV may complex the effectiveness of the treatment and hence compromises the nutrition status. However, in most cases, careful selection of food, well-planned meals and drug schedule can minimize the effects (NASCOP, 2006).

Table 4.17: Nutrition status and ARV intake

	Mean	**Mean difference**	**95% C.I of difference**	**P- value** (Independent T-test)
WAZ				
ARV	-2.1857	.01751	[-1.47730]– [1.51232]	0.981
No ARV	-2.2032			
WHZ				
ARV	-.2358	1.25788	[-.33394] – [2.84969]	0.119
No ARV	-1.4937			

The mean weight of the children on ARVs and those not using ARVs were compared (Figure 4.2). The results indicate that the mean weight gain of the children on ARVs was higher than for the children not on ARVs.

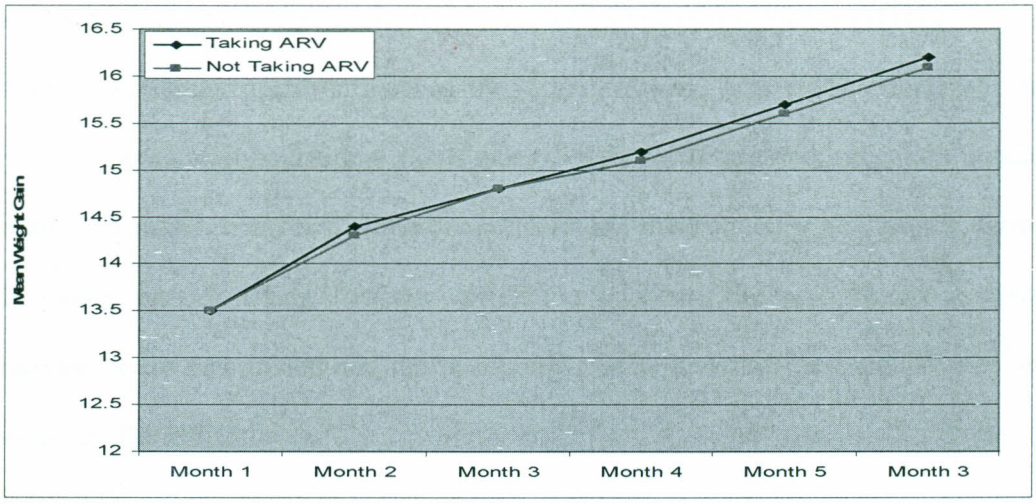

Fig. 4.7: Mean weight over six months by ARV intake

4.9 Difference of pre and post nutrition status

The paired sample t-test (Table 4.18) shows that the level of wasting and underweight reduced significantly (P= 0.001 and P = 0.001) respectively, indicating a positive impact of diet complementation with amaranth porridge on the nutritional status. However, in the case of stunting, there was no significant difference (P= 0.083) between pre- and post- intervention. The six months study period was not long enough to experience big changes in terms of height. Wasting was therefore used as the main indicator of nutritional status.

Table 4.18: Difference of pre and post nutrition status

Indicator	Mean-1	Mean-2	Mean	95% CI	P-value (paired t-test)
Weight for height	2.5385	2.7308	-.1923± .39796	[-.3031] - [-.0815]	0.001
Height for age	2.5385	2.5962	-0.577±.235	[-.1232] – [.0079]	0.083
Weight for age	2.5962	2.7887	-.1925± .39796	[-3031] – [-.0815]	0.001

4.9.1 Correlations between selected variables and nutrition status (WHZ)

Nutritional status can be influenced by various factors. This study established the relationship between nutritional status using weight for height and kilocalorie intake, number of meals, number of illnesses suffered and the frequency of illnesses during the study period. Using Pearson correlation analysis, the associations between variables were determined and the results for r-value and statistical significance are shown in Table 4.19.

Table 4.19: Correlations between selected variables and nutrition status (WHZ)

Variable	r- value (n=52)	P – value (Pearson correlation analysis)
Kilocalories	0.47	0.030
Number of meals	0.26	0.042
Number of illness	-0.24	0.045
Frequency of illness	-0.21	0.044

There was moderate positive relationship (r =0 .47) which was significant at (p= 0.030) between kilocalorie intake and nutritional status. This shows that increase in the amount of the kilocalorie consumed, led to better nutritional status based on weight for height. There was weak positive relationship (r =0.26) which was significant at (p= 0.042) between the number of meals consumed per a day and nutritional status. This shows that the more the number of meals, the better the nutrition status in terms of weight for height. There were weak negative relationships (r = -0.21) and (r = -0.24) between the number of illness and the frequency of illnesses and nutritional status respectively. This shows that the more illnesses and the

more frequent the illnesses one suffers, the lower the nutritional status based on weight for height.

4.9.2 Contributions of selected variables to nutritional status at post-intervention

By use of linear regression analysis, the continuous outcome (nutrition status) coefficients with corresponding 95% confidence interval were used to assess the significance and magnitude of the effect of a given variable. The variables that showed a significant relationship in bivariate analysis (correlations) were subjected to regression analysis in order to establish their contribution to the nutrition status of the children. Regression is a statistical analysis assessing significance and magnitude of the association between two variables. The formula is as follows

Regression Equation (Y) = a+bx

X = explanatory variable

Y = dependent variable

b = slope

a = intercept

The explanatory variables that were measured during the study included kilocalorie intake, number of meals, number of illness and frequency of illnesses. These were analysed and their level of association with nutritional status (dependent variable) using weight for height was established. The R^2 values obtained were interpreted as the proportion of response variation "explained" by the regressors in the model. The results are as shown in Table 4.20.

Table 4.20: Contributions of selected variables to nutritional status (WHZ) at Post - Intervention

Simple linear regression	R^2	%	Std. Error of the Estimate	P- value ((Y) = a+bx) linear regression
Kcal	0.2209	22.09	1.39800	0.031
Number of meals	0.068	6.8	1.51892	0.042
Number of illness	0.0576	5.76	1.51954	0.045
Frequency of illness	0.0441	4.44	1.52050	0.044
Multiple linear regression				
Kilocalories ,number of meals, number of illness and frequency of illness	0.383	38.3		0.043

The results indicate significant associations ($p < 0.05$) between kilocalorie intake, number of meals, number of illnesses, frequency of illnesses and nutritional status. The amount of kilocalories consumed contributed to nutritional status by 22.09% and this was significant ($p = 0.031$). The number of meals consumed contributed to 6.8% of the nutritional status and was significant ($p = 0.042$). Number of illnesses contributed to 5.76 % of the nutritional status significantly ($p = 0.045$) while the frequency of the illnesses contributed to 4.44% of the nutritional status of the children significantly ($p = 0.044$).

The results show that the kilocalorie intake, the number of meals, number of illnesses, and frequency of illnesses all contributed to 38.3% of the nutritional status and the contribution was significant ($p=0.043$). The rest (62%) could be due to other factors like birth weight, nature of caregiver, feeding practices, medical treatment hygiene and sanitation, physical activity, disease progression and socio-psychological factors

that were not captured in this study (Kabubo-Mariaraa *et al.,* 2009). The significant association between the kilocalorie intake and number of meals agrees with the findings of a number of studies which state that adequate caloric intake and increased appetite contribute significantly to reduced loss of body mass (wasting) which in itself is a significant risk factor for HIV and AIDS related mortality (McDermott *et al.,* 2003, Wig, Bhatt *et al.,* 2008).

The significant association between number of illnesses and frequency of illnesses also agrees with findings of some studies which state that infections of any type put a physical and physiological stress on the body systems by reducing the efficiency of nutrient absorption and utilization (de Waal and Whiteside, 2003; Katona and Katona, 2008). These studies showed that both decreased food intake and chronic diarrhoea were significantly associated with poorer mean WAZ score ($p<0.05$). The importance of nutritional status in HIV and AIDS patients is well-known and has been widely documented. This study shows the association between caloric intakes, number of meals, number and frequency of illnesses and nutritional status, indicating that diet and morbidity are significant predicators of nutritional status of the HIV infected children.

4.9.3: Correlations between Amount of Nutrients Consumed and the CD4 Counts

The study established the relationship between the CD4 counts and amounts of nutrients consumed using Pearson's Correlation analysis and the results are as shown in Table 4.21. There were weak positive relationships which were significant at ($p< 0.005$) between the amount of kilocalories ($r =0.42$), protein ($r =0.28$), vitamin A (r

=0.38), vitamin C (r =0.32), iron (r =0.41), calcium (r =0.36), zinc (r =0.43) and selenium (r = 0.40) consumed and the CD4 counts.

Table 4.21: Pearson's Correlation results for nutrient intakes and CD4counts

Nutrient	r – value (n =52)	P – value (Pearson's Correlation analysis)
Kcal	0.42	0.049
Protein	0.28	0.047
Vitamin A	0.38	0.045
Vitamin C	0.32	0.039
Iron	0.41	0.042
Calcium	0.36	0.048
Zinc	0.43	0.041
Selenium	0.40	0.046

The results indicate that the more the amount of nutrients, the higher the CD4 counts. This conclusion is in line with available information on the relationship between nutrition and the immune capacity (Paton *et al.,* 2006). Nutrition is a critical determinant of cellular immune responses as certain nutrients play important roles in nucleic acid synthesis and metabolism (Paton *et al.,* 2006). Trace elements especially zinc and selenium are important for maintaining a healthy immune system (Stambullian *et al.,* 2007). Zinc deficiency can decline Tcells generation and depresses humoral and cell-mediated immunity. Selenium deficiency also has several medical implications on the immune system including impaired immune response (Stambullian *et al.,* 2007).

Studies have confirmed that impaired immunity is a critical adjunct factor in malnutrition –associated infections (Menon *et al.,* 2007; Katona and Katona, 2008). Findings from other studies reported a moderate correlation (r = 0.6926) between serum zinc and CD4 counts (Malviya and Hussain, 2009) and a strong correlation (r = 0.8078) between serum selenium and CD4counts. This study checked the correlation of nutrient intakes but not serum levels of the nutrients.

The relationship between nutritional status and CD4 counts at pre- and post-intervention was also established and the results are as on Table 4.22. There was a weak (r = 0.21, r = 0.33) relationship but significant (p= 0.025, p= 0.031) between CD4 counts and nutritional status (WHZ), both in pre-and post-intervention respectively.

Table 4.22: Pearson's correlation results between nutrition status and CD4 counts

	r-value	**p- value (Pearson's correlation)**
Pre-intervention(WHZ)	0.21	0.031
Post-intervention (WHZ)	0.33	0.025

The significant relationship between CD4 counts and nutritional status concurs with a number of studies that have looked at the immunosuppression which results from malnutrition. In India, the authors found that reduced CD4 counts were a natural physiological effect of malnutrition, (Hedge *et al.,* 1999). Another study states that malnutrition causes a marked repression of cell-mediated immunity and function of the T- lymphocytes (Beisel, 1996). However, the weak relationship is probably

because it takes months of nutrition therapy to restore the effects of malnutrition - induced immunodeficiency (Chandra, 1997).

4.9.4 Contributions of intake of selected nutrients to the CD4 Counts

By use of linear regression analysis, the study investigated the contributions of selected nutrient intakes to the CD4 Counts after intervention and the results are on table 4.23. Results indicate significant associations (p= <0.05) between nutrient intake and CD4 counts. The amount of kilocalories consumed contributed to 17.64% of the CD4 counts. Protein contribution to the CD4 counts was at 7.84%, vitamin A at 14.44% and vitamin at C 10.04%. Iron and calcium contribution to the CD4 counts was 16.81% and 12.96% respectively.

Table 4.23: Linear regression results on nutrients to CD4 counts

Simple linear regression Variables	R^2	Std. Error of the Estimate	%	P- value ((Y) = a+bx) (linear regression)
Kcal	0.176	179.6	17.6	0.002
Protein	0.078	190.0	7.8	0.045
Vitamin A	0.144	183.1	14.4	0.006
Vitamin C	0.102	187.5	10.2	0.021
Iron	0.168	180.5	16.8	0.003
Calcium	0.129	184.6	12.9	0.009
Zinc	0.185	178.6	18.5	0.001
Selenium	0.160	181.4	16.0	0.003
Multiple linear regression				
Kcal, protein, vitamin A, vitamin C, iron, calcium, Zinc and Selenium	0.288		28.8	0.044

When all the six variables are combined, they contribute to 28.8% of the CD4 counts. The rest of the 71.2% may be due to factors like, medical treatment, disease progression and, adherence to treatment. The significant association between the nutrients and the CD4 counts may due to the fact that most of the nutrients analysed

play an essential role in nucleic acid synthesis and metabolism (Beisel 1996, Chandra, 1997). Studies have shown that deficiencies of single essential nutrients with important roles in nucleic acid synthesis and metabolism appear to cause derangements in immunological functions (Beisel 1996, Chandra, 1997). The development of an optimal functioning immune system requires an array of essential micronutrients and macronutrients obtained through good nutrition (Menon *et al.*, 2007; Katona and Katona, 2008).

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The study findings have been summarized as by the study objectives to include nutrient composition, sensory evaluation, dietary intake, morbidity prevalence, CD4 counts and nutrition status.

5.1.1 Nutrient Composition

The study findings indicate variations in the nutrient composition of the locally grown *hypochondriacus amaranthus* grain when compared to available data on the variety grown outside Kenya. This may be due to geographical variation, agricultural practices and soil variations (Bressani, 1987). When comparing the proximate composition of grain amaranth with that of the common local cereals and grains, the content of the local *hypochondriacus amaranthus* grain was higher in protein, total lipids and crude fibre.

The protein content was 15.29% and that of the local cereal grains ranges from 8.5% to 11.0% (KEBS, 2007). The total lipids were 8.5% and that of the local cereal grains ranges from 2% to 5.5% (KEBS, 2007). The 5.5% dietary fibre content of the local *hypochondriacus* amaranth grain is also higher than the content (1.0% - 3.0%) in local cereals (KEBS, 2007). The carbohydrate composition was 60.07% and the range in the local cereal grains is from 57.0% to 67.7% (KEBS, 2007). The moisture content (11.0%) in local *hypochondriacus amaranthus* was lower than in the local cereals (12 % - 15%) (KEBS, 2007) probably due to storage conditions.

The highest variation with regard to micronutrients was in the iron content. The level of the local *Hypochondricus* amaranth grain was 20.0mg/100g which is much lower than the 53mg/100g reported by Bressani, (1987). However, the level was much higher than the 3.0 to 11.0 mg/100g (KEBS, 2007) found in the common local cereal grains such as 0ats rice, wheat, maize, finger millet and sorghum.

5.1.2 Sensory Evaluation of Amaranth Based Porridge

The amaranth maize blend (50:50) porridge exhibited higher sensory qualities in all the tested attributes; meaning it was most preferred followed by the fermented amaranth. The amaranth maize blend and the fermented amaranth porridge were both liked moderately based on the hedonic scale with regard to overall acceptability. The fermented amaranth porridge was used in the intervention because of the better bioavailability of nutrients in addition to it passing the acceptability mark. The third in overall acceptability was the unfermented amaranth porridge and the fourth was the unfermented amaranth *wimbi* blend porridge. Based on the Turkey's Studentized test, only the amaranth maize blend porridge was statistically different from the fermented porridge with regard to overall acceptability.

5.1.3 Dietary Intake of the Children

Based on the 24hr dietary recall, majority (94.2%) of the children consumed porridge made from mixed flours. However, none of the children had used the amaranth grain flour before the intervention. At baseline, the study findings indicated inadequate mean intake of total kilocalories, vitamin A, calcium and selenium. This was mainly due to inadequate consumption of foods that provide the nutrients and poor appetite in the children. The mean intake of nutrients by the children improved after the

intervention. The intake of total kilocalories and vitamin A increased after intervention and the mean intake were within the FAO/WHO recommendation for the group.

The study also established that the dietary profile (kilocalorie intake and number of meals) had a significant association with nutritional status of the study children and hence a significant predicator of the nutritional status of HIV-infected children. The results also indicate significant associations between nutrient intakes and CD4 counts meaning that nutrient intake is a significant predictor of the CD4 counts in HIV infected children.

5.1.4 Morbidity Prevalence and Health Related Variables

The children suffered from various illnesses. At baseline, the prevalence of coughs was the highest at 71.0% followed by skin rush (50.0%), poor appetite (38.0%) fever (19.2%) cold/flu (13.5%) nausea and vomiting (11.5%), diarrhoea (9.6%) oral thrush (9.62%) acute respiratory diseases (5.8%) with pneumonia, ENT, convulsions, boils, tuberculosis, headache taking 1.92% each. The prevalence of most illnesses reduced during the intervention period. Though most illnesses reduced significantly, the reduction in the prevalence of cold and flu was minimal. Occurrence of colds and flu is common in children with a compromised immunity. The study established that the number and frequency of illnesses suffered had a negative significant relationship with the nutritional status and that morbidity is a significant predictor of nutritional status of the study children.

On the use of ARVs among the study children, the study found that that 40.4% of the children were on ARVs and the proportion was constant through the intervention period. Both children on ARVs and those not on ARVs presented illness at pre-intervention and post-intervention and we observed decreased proportion of cases at post- intervention for both. The prevalence of coughs, skin rush, fever, cold/flu, oral thrush was higher in children not on ARVs at pre- intervention. At post- intervention, reduced cases of coughs, fever and oral thrush were reported only among children not on ARVs. Use of ARVs has been shown to reduce incidences of illnesses among HIV and AIDS infected children (WHO, 2009). We also observed that at post-intervention, the cases of nausea and vomiting were only among the children on ARVs. Nausea and vomiting has been cited as one of the common side effect of use of ARVs (NASCOP, 2006). The children on ARVs had a higher mean weight gain and better nutritional status based on weight for height than the children not using ARVs but the difference was not statistically significant.

5.1.5 CD4 Counts

For the CD4 counts, the study found that at baseline 3.8% of the children had CD4 counts of less than 200, 38.5% of the children had CD4 counts of between 201 to 500, 17% of children had CD4 counts of between 501 to 700, 25% of the children had CD4 counts of 701 to 900 and 3.8% had CD4 counts of more than 901. There was significant improvement in the CD4 counts in majority (90.3%) of the children by end of the intervention. The study also established that there were weak but significant relationships between nutrient intakes, nutritional status and CD4 counts and significant associations between nutrient intakes and CD4 counts. For the children

who were on ARVs (40.4%), more than three quarters (85.7%) indicated improved CD4 counts.

5.1.6 Nutrition Status of the Children

The HIV and AIDS infected children attending the Comprehensive Care Clinic at Thika District Hospital had poor nutritional status. This was depicted by the high levels of malnutrition particularly wasting and underweight which were much higher than the national figures. The children suffered from acute and chronic malnutrition. This was mainly due to inadequate consumption of nutrients that promote optimal nutrition and due to the adverse effects of the HIV infection on nutritional status (FANTA, 2006). At baseline, stunting level was at 36.5%, wasting level at 34.0% and underweight at 30.8%. There were significant differences in the pre-and post-intervention levels of wasting and underweight but not so for stunting. The study also found out that there were more malnourished girls than boys but the difference was not significant.

5.1.7 Contribution of amaranth consumption to the nutritional Status of the study children

The paired sample t-test shows that the level of wasting and underweight reduced significantly ($p= 0.001$ and $p= 0.001$) at 95% confidence level, indicating a positive impact of diet complementation with amaranth porridge on the nutritional status. However, in the case of stunting levels, there was no significant difference ($p= 0.083$) between pre- and post- intervention. The study established that there was moderate, positive and significant relationship between intake of kilocalories and a weak, positive and significant relationship between the number of meals consumed and the nutritional status of the children based on weight for height. There was a negative

significant relationship between the number and frequency of illnesses suffered by the study children and the nutritional status based on weight for height. The study findings indicate significant associations between the kilocalorie intake, number of meals, number of illnesses, frequency of illnesses and the nutritional status of the study children based on weight for height. The findings indicate that kilocalorie intake and morbidity are significant predicators of nutritional status of HIV infected children.

5.2 Conclusions

The local Kenyan amaranth grain (*hypochondriacus)* has higher content of proteins, total lipids, dietary fibre, iron, zinc and potassium when compared to the common local cereals. This means that the amaranth grain is more nutrient dense than the local cereals commonly consumed in Kenya and can be recommended for the nutrition management of the nutritionally vulnerable groups such as the HIV-infected children.

Porridge preparations consisting of amaranth maize, fermented amaranth and pure amaranth were acceptable with regard to overall acceptability based on the hedonic scale. The most preferred porridge in all the attributes tested by the panellists in the sensory evaluation of different amaranth based porridges was the amaranth maize blend. Future formulations may consider using this combination as long as the aspect of enhanced nutrient bioavailability is worked out. The second in overall acceptability was the fermented amaranth porridge. The least preferred was the amaranth and finger millet blend in all the attributes tested.

The nutrient intake by the children infected with HIV and AIDS at the Comprehensive Care Clinic Thika District Hospital was low as indicated by inadequate mean intakes of total kilocalories, vitamin A, selenium and calcium with reference to the FAO/WHO at baseline. This is probably due to poor appetite among the children, poor utilization and inadequate provision of food that supplies the nutrients. The mean intake of nutrients by the children improved after the intervention. The kilocalorie intake and number of meals had a significant positive relationship with nutrition status of the children. There is the need for continued nutrition education to care givers of children infected with HIV and AIDS so as to enhance adequacy in nutrient intake.

The HIV and AIDS infected children attending the Comprehensive Care Clinic suffered various HIV and AIDS related opportunistic infections and illnesses. The most frequent illness reported by the children at baseline included, cough, skin rush, poor appetite and fever. The incidences of most illnesses reduced during the intervention and notably lack of appetite reduced to Zero. The number and frequency of illnesses suffered had a negative significant relationship with the nutritional status. Both children on ARVs and those not on ARVs presented illness at pre-intervention and post-intervention and we observed decreased proportion of cases at post-intervention for both.

Pre and post CD4 counts of the HIV and AIDS infected children attending the Comprehensive Care Clinic at Thika District Hospital were significantly different ($p > 0.001$). There was a shift in the number of children with higher CD4 counts from low

CD4counts at baseline to high CD4 counts after the intervention. This is true for the both children not using ARV and those using ARV indicating an improvement in the CD4 counts by the end of the intervention for both the children.

The pre- intervention nutritional status of the HIV and AIDS infected children attending the Comprehensive Care Clinic at Thika District Hospital was poor as depicted by the high levels of wasting, underweight and stunting. There were significant differences in the pre-and post-intervention levels of wasting and underweight but not so for stunting. The levels of wasting and underweight among the HIV and AIDS infected children reduced significantly after intervention but were still higher than the national figures.

On the contributions of the intervention to nutrition status, post intervention dietary profile (kilocalorie intake and number of meals) and morbidity (number and frequency of illnesses) were significant contributors to the nutritional status of the study children. An increase in the amount of the kilocalorie consumed, led to better nutritional status based on weight for height. The more the number of meals, the better the nutrition status in terms of weight for height, the more illnesses and the more frequent the illnesses one suffered, the lower the nutritional status based on weight for height.

5.3 Recommendations

The following recommendations are necessary for practice and policy towards improving the utilization of amaranth grain and the nutrition status of HIV and AIDS infected children.

Recommendations for practice

(i) Promotion of public awareness and education on the nutritive value, and nutritional benefits of amaranth grain by nutritionists, relevant government ministries and non-governmental organisations.

(ii) Development of standards for local amaranth based food products by food scientist's and nutritionists and development and standardization of recipes of amaranth based dishes at household level by nutritionists.

(iii)HIV and AIDS infected persons should be encouraged to include amaranth grain in their diets by the administrators of Comprehensive Care Clinics and the care givers at community and institutional level.

Recommendations for policy

(i) Promotion of consumption of amaranth grain as one of the strategies in alleviating malnutrition by nutritionist and the relevant government ministries including Ministry of Public Health and Sanitation and Ministry of Agriculture.

5.4 Suggestions for Further Studies

The following are suggestions for further studies;

(i) There is need for further research to determine the amino acid profile of the local *hypochondriacus* amaranth grain and establish the lysine content which is the limiting amino acid in most cereals.

(ii) Similar studies on nutrient composition are needed for the other varieties of amaranth grain grown in Kenya to be able to identify varieties for use by nutritionists.

(iii)Studies on acceptability and effects of incorporation of amaranth grain in the local dishes and other food products should be undertaken.

(iv)Similar studies are needed for children from other locations and Comprehensive Care Clinics that serve HIV and AIDS infected children for a wider coverage and comparisons.

(v) A similar study to be carried out on the impact of consumption of amaranth grain on the nutrition status of adults living with HIV and AIDS.

REFERENCES

African Agricultural Capital (AAC) (2009). AAC Annual Report and Financial Statements. http://aac.co.ke/

Alemu, J., (2008). The African Excutive Development. Artsvisval. www.africanexecutive.com/modules/ma. 28/04/2008

American Dietetic Association (2004). Nutrition intervention in the care of persons with HIV infection *J Am Diet Assoc.; 104:1425-1441.*

Association of Analytical Chemists, AOAC (2000). *Food composition, additives and natural contaminants. Vol.2.*

Association of Nutrition Services Agencies (ANSA) (2006). *The power of nutrition.* Washington, DC: ANSA.

Barba del lar Rosa A.P, Inge S. Fomsgaard, Bente Laursen, Anne G. Mortensen, L. Olvera-Martinez, C. Silva-Sanchez, A. Mendoza-Herrera, J. Gonzalez-Castanedc and A. De Leon-Rodriguez (2009). Amaranth (Hypochondriacus) as an alternative crop for sustainable food production: Phenolic acids and flavinoids with potential impact on its nutraceutical quality. *J Sci,* vol 49, issue 1, Pages 117-121.

Barnett T.and Whiteside A. (2002). *AIDS in the twenty-First century: Disease and Globalisation.* New York: Palgrave Mac millan.

Becker, R (1989). Preparation, composition and nutrition implications of amaranth seed oil. *Cereal Foods World Vol. 34 950 -95.*

Becker, R, E.L; Wheeler, K; Lorenz, A.E; Stafford, O.K; Grosjean, A.A; Betschart, R.M and Saunders (1981). A compositional study of amaranth grain. *J.Food sci.* vol. 46 (1175 -1180).

Beisel, W. (1996). Nutrition in pedriatic HIV infection: setting the research agenda. Nutrition and immune function: overview. *J Nutr;* 126:2611S-5S.

Berkelaar D., and Alemu J., (2006). Grain Amaranth. http:/ www.echotech.org

Betschart A., Irving D.W., Shepherd A.D., and Saunders,R.M., (1981). Amaranthus cruentus: milling characteristics, distribution of nutrients within seed components and the effectsof temprature on nutritional quality. *J. Food Sci.* 46:1181-1187.

Bressani R., (1989). The proteins of grain amaranth. *Food review International* Vol. 5(1), 13.

Bressani R., (1990). Grain amaranth chemical composition and nutritive value. In Proc. Fourth Amaranth symp. Minnesota.

Bressani R., Gonzalez J.M., Zuniga J., Breuner M., and Elias L.G., (1987). Yield, selected chemical composition and nutritive value of 14 selections of amaranth grain representing four species. *J. Sci. Food Agric*., 42,325.

Bressani, R., (1988). Amaranth: The nutritive value and potential uses of the grain and by- products. *Food Nutrition Bulletin, 10(2), 49*,

Bressani, R., and Elias L.G. (1986). Development of 100% amaranth foods. Inc: Proc. Third Amaranth Conference. Inc., Emmaus, PA. *Rodale Pres.,*

Briend, (2003). Complementary food supplements to achieve micro- nutrient adequacy or infants and young children. *J, Paed Gastro and Nutr* vol.36 (316 – 328)

Cantrell RA., Sinkala M., Megazinni K., Lawson-Marriot S., Washington S., Chi BH., Tambatamba-Chapula B., Levy J., Stringer EM. (2008). A pilot of food supplementation to improve adherence to an.tiretroviral therapy among food insecure adults in Lusaka, Zambia. *J Acquir Immune Defic Syndr*; 49:190-5.

Cheeke, P.R. and Bronson, J. (1980). Feeding trials with amaranthus grain, forage and leaf protein concentrates. In: Proc.Second Amaranth Con. Inc., Emmaus,PA. *Rodale Press.*

Collins S, Dent N, Binns P, Bahwere P, Sadler K, Hallam A. (2006). Management of severe acute malnutrition in children. *Lancet*; 368: 1992-2000.

Coovadia HM, Rollins NC, Bland RM, et al., Mother to child transmission of HIV-infection during exclusive breastfeeding in the first 6 months of life: *Lancet.* 2007, vol.369 : (1107-1116)

Daniel J Ncayiyana (2007). HIV and AIDS, TB and Nutrition. ASSAF report. *South Afri Med J*; 2007.

de Waal A, Whiteside A. (2003). New variant famine: AIDS and food crisis in southern Africa. *Lancet*; 362:1234-7.

Escudero N,L., Zirulnik F., Gomez N.N., Mucciarelli S.I., Ginenez M.S., (2006). Influence of protein concentrate from Amaranthus cruentus seeds on Lipid metabolism. *Exp. Biol. Med.* 23: 50-59.

Food and Agricultural Organisation, (2002). Regional Food Composition Tables. INFOODS. http:/www.fao.org/infoods.

Food and Nutrition Technical Assistant (2006). Recommendations for Nutrient Requirements for People Living with HIV/AIDS. www.fantaproject. org

Food and Nutrition Technical Assistant (FANTA) project (2004). HIV/AIDS . A guide for nutritional care and support, 2nd edition. Academy for Educational Development Washington DC.

Food and Nutrition Technical Assitance (2008). A guide for monotoring and evaluation of nutrition assessment, education and counseling of People Living with HIV. www.fantaproject. org

Garcia, L.A., Alfaro, M.A. and Bressani, R. (1987b.) Digestibility and protein - quality of raw and heat- processed defatted and non-defatted flours prepared with amaranth species .*J. Agric. Food Chem.* Vol. 35(604-607).

Gebhardt S.E., Thomas R.G.,(2007). Nutrient composition of amaranth grain. http:// ars. Usda.gov/research/publications.htm.

Gibson R., Hotz C., (2001). Dietary diversification/modification strategies to enhance micronutrient content and bioavailability of diets in developing countries. *Br J Nutr*; 85 (suppl):2: S159-S166.

Hanifa B., Thorkild T., Robert D. And James K.T., (2006). Severe malnutrition with and HIV-1 infection in hospitalised children in Kampala,Uganda: Differences in clinical features, haematological findings and CD4+ cell counts. *Nutrition Journal* 2006, 5:27doi:10. 1186/1475-2891-5-27.

Holmes W.R. and Sevage F., (2007). Exclusive breastfeeding and HIV. *Lancet* 2007, vol 369: 1065 -1066.

Holynska B., Ostachowicz B., Ostachowicz J., Samek L., Wachniew P., Obidowicz A., Wobrauschek P, Streli C. And Halmetschlager G. (1998). Characterization of 210_{pb} dated peat Core by various X-ray fluorescence techniques.

Jones Jones M.H. (1984). The allergy self- help cookbook. Inc., Emmaus, PA. Rodale Press.

Kabba M.M. (2005). Breast feeding practices among women (15-49 years). A case study of Kibera Slum,Nairobi, Kenya; AMREF,Kenya, p.15.

Kabubo-Mariaraa J., Ndegeb K.G. and Mwabuc K.D., (2009). Determinants of Children's nutrition status in Kenya: Evidence from demographic and health surveys. *J Afr Econ* 18(3): 363-387.

KAIS (2007). Kenya Aids Indicator Survey. Ministry of Health. Government of Kenya.

Kalac P. Moudry J. (2000). Chemical Composition and Nutritive value of amaranth grains *J. Foodscience* 18, 201-206.

Katona P, Katona- Apte J, (2008). The interaction between nutrition and infection. *Clin Infect Dis* 46: 1582-8.

Kauffman C.S. (1992). Realizing the potential of grain amaranth. *Food Rev.Int, 8 (1), 5.*

Kauffman C.S. and Weber L.E. (1990). Grain amaranth in: *Advances in New Crops*, J.Janick and J.E. Simon (Eds). Portland, Oregon: pp. 127 – 139. Timber Press.

KEBS (2007). Kenya Standards, Cereals KSS23-1-2007

Kenya Demographic and Health Survey. Ministry of Health. Government of Kenya, 2003.

Kenya Demographic and Health Survey. Ministry of Public Health and Sanitation. Government of Kenya, 2008.

Kikafuda J, Namsoke H (2006). Nutrition Status of HIV/AIDS orphaned children in households headed by the elderly in Rakai District. *Afri J Food Agri Nutr and Dev.* Vol 6:1.

Kinyanjui, F.K (2007). *Causes of Persistent Rural Poverty in Thika District of Kenya,* c.1953-200.Ph.D thesis: Rhodes University.

Koethe JR, Chi BH, Megazzini KM, Heimburger DC, Stringer JS. (2009). Macronutrient supplementation for malnourished HIV- infected adults: A review of the evidence in resource-adequate and resource constrained settings. *Clin Infect Dis.* 49: 787-798.

Kupka R. Msamanga GI, Donna S , Morris S, Mugusi F, David J, Hunter et al., (2004). Selenium status is associated with accelerated HIV-1 Infected pregnant women in Tanzania. *J Nutr* 134:2556-2560(s).

Lansana F.P (2005). Determinants of nutrional status of children Aged 6-59 months: A Case study of kibera slum, Nairobi,Kenya;AMREF,Kenya.P.15.

Larmond E. (1977). Labaratory methods for sensory evaluation of foods. Canada Department of Agricultural Publications. 1637. Food Research Institute, Ottawa, Ontario.73p.

Lawless H.T and Heymann H, (1998). Sensory Evaluation of Food: Principles and practices. Newyork. Chapman and Hall.

Lesley T. Bourne, Michael K. Hendricks, Debbie Marais and Brian Eley. (2007). Addressing malnutrition in young children in South Africa setting the national context for peadriactric food-based dietary guidelines. *Maternal and Child Nutrition*.3: 230-238.

Linneman Z, Matisky D, Ndekha M, Manary MJ, Maleta K. (2007). Alarge scale operational study of home based therapy with-ready –to-use-therapeutic food in children in Malawi. *Maternal Child Nutri*; 3: 206-15.

Lotter D. (2005). http:// new farm.rodaleinstitute.org

Louise C. Ivers, Kimberly A. Cullen, Kenneth A. Freedberg, Steven Block, Jennifer Coates, Patrick Webb (2009). HIV/AIDS, undernutrition and food insecurity. *Clinl Infec Dis*; 49: 1096-1102.

Lyon C.K. and Recker .R, (1987). Extraction and refining of oil from amaranth seed. *J of Am Oil Chem Society.* Vol. 64(2), 233.

Mahlungulu S, Grobler LA, Visser ME, Volmink J. (2007). Nutritional interventions for reducing morbidity and mortality in people with HIV. Cochrane Database syst. Rev. P. CD004536. (*PubMed*).

Malviya H. Hasan and A. Hussain (2009). Correlation of CD4 + T cell count with serum zinc, copper and selenium in HIV positive individuals. *In J of Epid.* 16: 1540-2614.

Mamlin J, Kimaiyo S, Lewis S, et al. (2009). Integrating nutrition support for food-insecure patients and their dependents into an HIV care and treatment programme in Western Kenya. *Am J Public Health*; 99: 215-21.

Manvelyan E,(2009) http:// Improvement of Nutrition and Health status of children in Body Weight Deficiency in Armenia. www.awhhe.am.

Martine F.W.,Junk W., (1987). Lost crops of Incas: *Amaranth grain production Guide*. Rodale Research Center. 24p.

Martrosyan D.M., Mirosnichenko L.A., Kulakova S.N., Pogojeva A.V., Zoloedov V.L. (2007). Amaranth oil application for heart diseases and hypertention. *Lipids in Health and Disease* 6:1.

McDermott AY, Shevitz A, Must A, Harris S, Roubenoff R, Gorbach S., (2003.) Nutrition treatment for HIV wasting: a prescription for food as medicine. *Nutr Clin Pract*; 18: 86-94.

Meilgaard M,Civille G.V and Carr B.T., (1999). Sensory Evaluation Techniques. Bola Raton, Fla: CRC press, Third edition.

Menon P, Ruel M.T, Loechl C.U. (2007). Micronutrient sprinkles reduce anaemia 9- 24 months old children when delivered through an intergrated health and nutrition program in rural Haiti. *J Nutr* ; 137: 1023-30.

Mwangi D., (2006). Introduction to Grain Amaranth. Nairobi: Joypet Services and Printers Ltd.

NACC/NASCOP (2009). The Kenya 2007 HIV and AIDS estimates and interim projected HIV prevalence and incidence trends for 2008 to 2015 Nairobi, Kenya.

NASCOP (2006). Kenya National Guidelines on Nutrition and HIV/AIDS.

Ndekha M.J., Van Oosteerhout J.J., Zijilstra E.E., Manary M., Saloojee H., Manary, M.J. (2009). Supplementary feeding with either ready-to-use fortified spread or corn-soy blend in wasted adults starting antiretroviral therapy in Malawi. *BMJ.*338:b1867.

Okoth, J.K., Mathooko F.M. and Makokha A.O., (2005). Impact of Fermentation on Bioavailability of Zinc in some selected foods commonly consumed in Kenya. Inaugural National Nutrition Congress, Nairobi, Kenya.

Okuno, K. and Sakaguchi S., (1981). Glutanious and non-glutanious starches in perisperm in grain amaranths, *Cereal Research Communication* Vol. 9, 305.

Oldewage- Theron W, Dicks E, Napier C., (2006). Poverty, household food insecurity and nutrition: coping strategies in an informal settlement in the Vaal Triangle, South Africa. *Public Health 120:795-804.*

Panagides D, Graciano R, Atekyereza P, Gerberg L, Chopra M. (2007). Discussion paper 48: A review of nutrition and food security approaches in HIV and AIDS programmes in eastern southern Africa. Regional Network for Equity in Health in East and Southern Africa.

Paredez-Lopez, O. (Ed), (1994). Amaranth biology, chemistry and technology. London: CRC Press.

Paton NI, Sangeetha S, Earnest A, Bellamy R.(2006). The Impact of malnutrition on survival and the CD4 count response in HIV-infected patients starting antiretroviral therapy. *HIV Med.*7: 323-330.

Rahul R, Suneetha K, and Paul E McNamara, (2010). The impact of food assistance on weight gain and disease progression among HIV-infected individuals accessing AIDS care and treatment services in Uganda. *BMC Public Health.* 2010:10:316.

Read J.S., Diagnosis of HIV infection in children younger than eighteen months in the United States. *Pediatrics* 2007; 120: e1547

Richardson B. A., Nduati R., Mbori- Ngacha D., Overbaugh J., John-Stewart G. C., (2008). Acute morbidity among Kenyan HIV infected infants. *Clincal Infect Dis*. 15; 46 (2): 289-95.

Robert H, Kate T, Sarah P, Ryan S. (2006). Putting it Together, AIDS and Millenium Dev Goals: HIV/AIDS Worsens the Nutrition Status of children. *Medscape*; 3:11

Rodale (1986). *Amaranth Today Vol. (1).* Rodale Press Inc.

Rodale (1990). *Amaranth Grain ProductionGuide*. Inc. Emmaus,PA,USA, 180 49. Rodale Press.

Sanchez P, Palm C, Sachs J, et al., (2007). The African Millenium villages. *Proc Natl Acad Sci usa; 104: 16775-80.*

Saunders R.M, Betschart A.A and Wood I. (1987). Morphological Studies on Amaranth cruentus. *Journal of Food Science* Vol. 46 (4): 1170-1174.

Saunders R.M. and & Becker R. (1984). Amaranth: A Potential Food and Feed Resource. Advances in *Cereal Science and Technology* Vol. 6 (357-369).

Science and Development Network (Sci Dev Net), (2009). HIV/AIDS undernutrition and food insecurity. *Clinical Infectious Disease*; 50:300

Scrimshaw, NS. and SanGiovan JP, (1997). Synergism of nutrition, infection and immunity, *American Journal of Clinical Nutrition* Vol. 66, 464S-477S.

Shevitz AH, Knox TA, Spiegelman D, Roubenoff R, Gorbach SL, Skolnik PR.1999. Elevated resting energy expenditure among HIV- sero-positive persons receiving highly active antiretroviral therapy. *AID* 1999; 13: 1351-7.

Singhal R.S. and Kulkani P.R. (1988). Composition of seeds of amaranthus species, *J.Sci. Food Agriculture*.42, 325.

Stambullian M, Feliu S, Slobodianik NH. (2007). Nutrition status in patients with HIV infection and AIDS. *Br J Nutr*. 98: s140 143.

Sustainable Rural Livelihoods Program (SRLP) (2005). Annual Report 2004- 2005.

Suzanne P. Murphy, Constance Gewa, Monika Grilleberger, Nimrod O.Bwibo and Charlotte G. Neumann (2007). Designing snacks to address micronutrient deficiencies in rural Kenyan school children. (2007). American Society for Nutrition. *J. Nutr, 137:1093- 1096.*

Swindle, Baker and Auld, (2005). Retrospective versus prospective cohort study designs for evaluating treatment. *Pubmed PMID*: 1639 3033.

Tacio H.D. (2009). Amaranths versatility, nutritional value for humans and ducks. Gaic Discovery ECO Solutions. Sep,2009.

Tagwira M., Tagwira F. Dugger R. Okum B. (2006). Using grain amaranth to fight malnutrition. RUFORUM working document No. 1, pp.201-206.

Teutonico R. A. and Knorr D, (1985). Amaranth: composition, properties and applications of a rediscovered food crop, *Food Technology* Vol.39 (4).

Timothy Wilkin (2010). HIV/AIDS Clinical Care. *Journal Watch* April 2010.

UNAIDS (2004), XV Report on International AIDS conference. Bangkok.

UNAIDS (2007). Global Summary Report of the AIDS epidemic. www.unaids.org.

UNAIDS (2008). 2008 Report on the Global AIDS Epidemics. www.unaids.org.

UNAIDS (2009). World AIDS Day Report. www.unaids.org.

UNGASS(2010).United Nations General Assembly Special Session on HIV and AIDS. Country Report Kenya.

Victora CG, Habicht JP, Bryce J. (2004). Evidence-based public health: moving beyond randomized trials. *Am J Public Health.* 94:400-405.

Villamor E, Misegades L, Fatiki MR, Mbise RL, Fawzi WW. (2005). Child mortality in relation to HIV infection, nutrition status and socio-economic background. *Inter J of Epid.* 34: 61-68.

Walenda C, Alan K, Francis R, Louise W, Marie-Fance A and Philippe M. (2009). *J Trop Peadiatr* 55(3): 170-176.

Walingo M., (2009). Indigeneous Food Processing Methods that Improve Zinc Absorption and Bioavailability of Plant Diets Consumed by the Kenyan Population. *African J Food Agr Nutr and Dev.* Vol.9, 1: 523-535.

Wig N, Bhatt SP, Sakhuja A, Srivastava S, Agarwal S. (2008). Dietary adequacy in Asian Indians with HIV. *AIDS Care*; 20: 370-5.

World Bank (2007). HIV/AIDS, *nutrition and food security: A synthesis of international guidance.* Washington, DC: World Bank.

World Food Programme, World Health Organization, UNAIDS. Policy brief: HIV, food security and nutrition. Geneva: United Nations, 2008.

World Health Organization (WHO) (2003). Nutrient requirement for People with Hiv and AIDS. Report ofa technical consultation. Geneva: 2003.

World Health Organization (WHO) (2005). *Consultation on nutrition and HIV/AIDS in Africa: evidence, lessons, and recommendations for action.* Geneva; 2005 report.

World Health Organization (WHO) (2008). WHO Nutrition: Nurturing Health. Regional consultation on nutrition and HIV/AIDS in French speaking countries in Africa region: evidence, lessons and recommendations for action. Geneva: WHO, 2008.

World Health Organization (WHO) (2009). Guidelines for an integrated approach to nutrition care of HIV-infected children (6 months – 14 years). Switzerland: WHO. Geneva.

World Health Organization. (2006). WHO HIV and infant feeding technical consultation on prevention of HIV infections in pregnant women, mother and their infants. Consensus Statements. WHO, Geneva.

World Health Organization (WHO) (2010). Guidelines on HIV and infant feeding. Statements. WHO. Geneva.

Yarger L, Kelly G. O'Brien, and Martin L. P., (2008). Amaranth Grain and Vegetable types: ECHO Technical Note. http:/ www.echotech.org

Young H, Borret A, Holland D, Salan P. (2005). Public nutrition in complex emergencies. *PMD:* 1555 5671.

APPEDIX 1

MINISTRY OF SCIENCE & TECHNOLOGY

Telegrams: "SCIENCE TEC", Nairobi

Fax No.
Telephone No: 318581
When replying please quote
MOS&T 13/001/36C 447/2

REPUBLIC OF KENYA

JOGOO HOUSE "B"
HARAMBEE AVENUE
P.O. Box 60209-00200
NAIROBI
KENYA

7th July 2006

Winfreda Monyenche Maoga
Kenyatta University
P.O. Box 43844
NAIROBI

Dear Madam

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***'Nutrient Content of Amaranth Grain and its effects on Nutrition Status of Children infected with HIV/AIDS attending the comprehensive care clinic of Thika District Hospital'***

I am pleased to inform you that you have been authorized to carry out research in Thika District for a period ending 30th August 2006.

You are advised to report to the District Commissioner, the District Education Officer and the Medical Officer of Health, Thika District before commencing your research project.

On completion of your research, you are expected to submit two copies of your research report to this office.

Yours faithfully

M. O. ONDIEKI
FOR: PERMANENT SECRETARY

Copy to:
The District Commissioner – **Thika District**
The District Education Officer – **Thika District**
The Medical Officer of Health – **Thika District**

APPENDIX 2

MINISTRY OF HEALTH

Telephone: Thika, (0151) 21621/2 FAX: 21778

All correspondence should be addressed

To the MOH
When replying please quote
MOH/TKA/
Ref. No. .....

THIKA DISTRICT HOSPITAL
P.O. BOX 227
THIKA

17TH JULY 2006

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION

Winfreda Monyenche Maoga is authorized to conduct her PhD research on "Nutrient Composition of Amaranth Grain and its effects on the nutrition and health status of children infected with HIV/AIDs" at Thika District Hospital.

Kindly offer any assistance required.

DR. KARIUKI M. W.
DISTRICT MEDICAL OFFICER OF HEALTH
THIKA DISTRICT

APPENDIX 3: Interview Schedule

IMPACT OF CONSUMPTION OF AMARANTH GRAIN ON THE NUTRITION STATUS OF CHILDREN INFECTED WITH HIV/AIDS ATTENDING THE COMPREHENSIVE CARE CLINIC AT THIKA DISTRICT HOSPITAL

Interviews administered through the questionnaire was intended to provide the researcher with the information that assisted in determining the impact of consuming amaranth grain on the nutrition and health status of the children infected with HIV/AIDS attending the comprehensive care clinic at Thika District Hospital.

Questionnaire No _____

Section 1: Demographic Characteristics of the Child

Please tell me the following about yourself and the child

Name of respondent (care giver) _____

Relationship to the child _____Age of respondent _____

Name of child _____Clinic card number _____

Sex _____Age (Date of birth) _____Childbirth order _____

Number of siblings' _____Age(s) of siblings' _____

School _____ Class _____

Location _____Division _____ Ethnicity _____

Section 2: Diet and Nutrition History

Please tell me the following about the child

Was the child breastfed (YES /NO)

If yes was it exclusive breastfeeding (YES/NO)

At what age did the child stop breastfeeding? _____

What kind(s) of food was the child first introduced to?

_____

Does the child take porridge? (YES/NO)

If yes, what kind of flour(s) do you use?

_____

Have you ever used amaranth grain flour for any of the child's food? (YES/NO)

Section 3: Anthropometrical Measurements of the child

MONTH/DATE	Baseline	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
WEIGHT							
HEIGHT							
AGE							

Section 4: General health information

4.1 Is the child on ARVs? (YES/NO) (Confirm from the clinic card)

4.2 CD4 trend (Laboratory technical assistance)

Baseline CD4 counts	After intervention CD4 counts

4.3 Please tell me if the child has suffered from any of the following in the last two weeks (confirm diagnosis from the clinic card)

Disease/symptom	Baseline	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Cough							
Skin rush							
Poor appetite							
Fever							
Cold/flu							
Nausea & vomiting							
Diarrhoea							
Oral thrush							
Acute respiratory disease							
Pneumonia							
ENT							
Convulsions							
Boils							
Tuberculosis							
Headache							

Section 5: Dietary assessment

5.1 Child food consumption using 24 hour dietary recall (twice at baseline and twice in the sixth month)

a) Starting from yesterday morning to evening, please name all the foods and drinks that the child consumed

b) Indicate the ingredients, quantities and methods of preparation

Meal/time	Name of dish/food	Name of ingredients	Household measure	Amount served	Amount left over	Amount consumed	Metric conversion of household measures
Breakfast							
Snack							
Lunch							
Snack							
Supper							
Others							

Meal	Name of dish/food	Name of ingredients	Household measure	Amount served	Amount left over	Amount consumed	Metric conversion of household measures
Breakfast							
Snack							
Lunch							
Snack							
Supper							
Others							

Meal/time	Name of dish/food	Name of ingredients	Household measure	Amount served	Amount left over	Amount consumed	Metric conversion of household measures
Breakfast							
Snack							
Lunch							
Snack							
Supper							
Others							

APPENDIX 4: Sensory Evaluation Questionnaire

Name _____

Age _____

Gender (M/F) _____

You are given four samples of porridge simultaneously. Please rate the organoleptic attributes as per the hedonic scale provided after each attribute. Taste the samples thoroughly and rinse your mouth after each sample.

ATTRIBUTES	SAMPLES			
	Porridge 1	Porridge 2	Porridge 3	Porridge 4
Appearance				
Texture				
Flavour				
Consistency				
Overall acceptability				

1 = dislike extremely, 2 =dislike much, 3 =dislike moderately, 4 = neither like nor dislike, 5 = like slightly 6 =like, 7 = like moderately, 8 =like much and like extremely.

APPENDIX 4: Mean amounts of selected foods consumed per day by the children

Foods	Amounts (g)
Cereals	125.03g
Pulses	41.24g
Milk	63.15g
Meats	32.30g
Eggs	40.04g
Fruits	30.16g
Vegetables	60.44g
Nuts	5.02g
Fats and oils	5.04g
Sugars	5.53g