EFFECT OF *Moringa oleifera* LEAF POWDER SUPPLEMENT TO IMPROVE NUTRITIONAL STATUS OF SEVERELY MALNOURISHED CHILDREN AGED 6-24 MONTHS IN ARUSHA REGION.

BY

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ABSTRACT

Malnutrition remains one of the most common causes of morbidity and mortality among children throughout the world.The study aimed at evaluating the effect of *Moringa oleifera* leaf powder in improving the nutritional status of children 6 to24 months of age in Arusha Municipality. A total of 140 children were enrolled and randomly allocated to two treatments where by 64 children received moringa leaf powder porridge and 76 children received maize porridge and a randomized control design was used. Anthropometry and morbidity data were collected during monthly household visits for three consecutive months. LSD was used for the comparison of means; unpaired t-test was used for the comparison of two groups. Mean weight-for-age Z-scores (WAZ) for infants in treatment and control group increased from -4.1 and -3.6 at baseline to -2.2 and -3.3 at the end. Likewise, the mean weight-for-length z-scores (WLZ) for infants in treatment and control group increased from -3.4 and -3.4 at baseline to -1.1 and 3.2 at the end respectively. Mean length-for-age z-scores (LAZ) for infants in treatment group increased from -3.2 at baseline to -2.6 end of intervention in contrast to infants in control group which declined from -2.0 at baseline to -2.4 at the end. At baseline 13% and 21% of children in the treatment group had diarrhoea and malaria, respectively but the prevalence decreased significantly to 1.4% and 0.7%, respectively at the end of the intervention. Mean haemoglobin concentration of the children increased from 7.4 to 11.5 for the treatment group while in the control group it increased from 7.1 to 7.3. In this regard, it may be concluded that *M.oleifera* leaf powder had significant positive effect on child nutritional status and morbidity. The use of *M.oleifera* leaf powder is recommended for addressing the problem of undernutrition in Tanzania.

DECLARATION

I, ANNA ANDREW, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has neither been submitted nor being concurrently submitted for degree award in any other Institution.

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The above declaration is confirmed

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(Supervisor)

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DEDICATION

This dissertation is dedicated to my loving parents Mr and Mrs. Andrew Shayo for their love, encouragement and support.

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LIST OF ABBREVIATIONS AND SYMBOLS

ACC/SCN	Administrative Committee on Coordination/Sub-Committee on Nutrition
PEU	Protein Energy Undernutrition
PEM	Protein Energy Malnutrition
MDG	Millenium Development Goals
ENA	Emergency Nutrition Assessment
MUAC	Mid upper Arm Circumference
NIMR	National Institute for Medical Research
PLHA	People Living with HIV and AIDS
RCH	Reproductive Child Health
SAS	Statistical Analysis System
SMART	Standardized Monitoring and Assessments of Relief and Transitions
SUA	Sokoine University of Agriculture
TDHS	Tanzania Demographic and Health Survey
UN	United Nations
UNICEF	United Nations Children's Fund
WFP	World Food Programme
WHO	World Health Organization
W/A	Weight -for -Age

W/H	Weight -for -Height
SD	Standard Deviation
MOH	Ministry of Health
HIV	Human Immune Virus
H/A	Height -for -Age
Hb	Haemoglobin
µg	Microgram
mg	Milligram

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Child malnutrition can be defined as a situation resulting from inadequate nutrition, (protein energy malnutrition due to insufficient intake of energy and nutrients or overnutrition (overweight and obesity) which is due to excessive consumption of energy and nutrients. Nutritional deficiency diseases are due to insufficient intake of one or more specific nutrients such as vitamins or minerals **(**Donna**, 2006).** An increased recognition of nutrition as a basic pillar for social and economic development has recently placed childhood undernutrition among the targets of the first Millennium Development Goal (MDG) that is to eradicate extreme poverty and hunger. The specific target goal is to reduce by 50% the prevalence of undernutrition among children younger than five years between 1990 and 2015 (UN, 2002). Malnutrition commonly affects all groups in a community, but infants and young children are the most vulnerable because of their high nutritional requirements for growth and development (Collins, 2002).

Severe malnutrition is defined as weight-for-height (wasting) z-score <-3SD, bilateral oedema of kwashiorkor, or mid-upper arm circumference (MUAC) <11.0 cm (if less than 65 cm in length) (Berkley, 2002)**.** The two cases of undernutrition are kwashiokor and marasmus. Kwashiorkor occurs in infancy but maximally in the second year following abrupt weaning. Marasmus involves inadequate intake of protein and calories, representing the end result of starvation. It occurs in the first year of life due to lack of breast-feeding and use of dilute animal milk. Poverty and famine, ignorance and poor maternal nutrition are among the major contributing factors (Cederholm, 2002). Developing countries are the most affected, where vitamin A, iron and iodine deficiencies are the most prevailing forms of micronutrients malnutrition. In the case of Tanzania it is estimated that 45% of children under the age of five are affected by iron deficiency anaemia and 37% are estimated with sub-clinical vitamin A deficiency (Behrman, 2004). Considerable investments have been made by governments and aid agencies in the programs designed to prevent malnutrition. Approaches have included school lunch programs, nutrition education and even campaigns to periodically give children massive doses of vitamin A. A major drawback to the approaches is the dependence on imported solutions and outside personnel and progress can quickly dissipate once the program funding dries up (MOH, 2000).

A major advantage of *Moringa oleifera* is the fact that it is a local resource. This contrasts with many of the ongoing programs designed to fight malnutrition which depends on imported products and outside donor support.

M.oleifera tree holds a very unique potential to significantly improve the quality of life. Nutritional analyses show that the leaves have nutritional and medicinal values; it is rich in protein and contains all the essential amino acids, including two which are arginine and histidine that are especially important for children's health. *M.oleifera* leaves are well rewarded with essential vitamins and minerals (Anwar and Banger, 2003). In Senegal, small quantities of moringa leaf powder (10-15gd^{-1}) produced amazing results within only 10 days in children who had been classified as wasted because of micronutrient deficiency (Makkar and Becker, 1999).

1.2 Problem Statement.

Undernutrition is considered to be the underlying cause of more than 50% of all childhood deaths in the world (WHO, 2000). Malnutrition has been associated with over half of all child deaths in developing countries (Stephenson *et al.*, 2000). Infants and young children in their first two years of life have particularly high energy and nutrient requirements per kilogram body weight, while at the same time they have limited gastric capacity and motor skills. Thus, they require special foods of adequate nutrient density, consistency, and texture, and they need to be fed more often than adults. In resource-constrained populations, diets consist mainly of cereal-based staple foods, and access to nutrient-rich foods such as animal products, fruits, and vegetables is limited (Ruel *et al.,* 2004). Globally, malnutrition contributes to about 60% of the 11 million deaths that occur each year among children below 4 years of age (Berkley, 2002)**.** Protein Energy Malnutrition (PEM) is more common in developing countries among children below 5 years of age, the severe form of PEM is between 1-10% and underweight between 20-40%. In Tanzania, the rates of child undernutrition are high; about 40% of children under five years of age are stunted. About 3% are wasted, and 22% of children are underweight (UNICEF, 2008).

Arusha region produces enough carbohydrates and protein food from agriculture as well as from livestock. Despite this considerable production, the prevalence of stunting is 25.4%, 3% wasting, and 3.4% underweight. For each district cases of severe malnutrition is associated with high infant and child mortality rate (NBS and ORC Macro, 2007). Furthermore, there is poor infant and young child feeding practices and inadequate maternal nutrition status in Arusha (UNICEF/UNAIDS/WHO/UNFPA, 2003).

1.3 Justification of the Study

Severe malnutrition is a common condition among children admitted to hospitals in East Africa. Most of the severely malnourished children are in 1-2 years old age group. During this period, adequate nutrition is important for intellectual and physical growth (Dewey and Adu-Afarwuah, 2008). About 25 % of the children in Urban areas are stunted, 3.0% are wasted, 14% are undernutrition (NBS and ORS Macro, 2007).

Children in Arusha as in other places in Tanzania typically suffer simultaneously from multiple micronutrient deficiencies, *M.oleifera* contains high amount of Vitamin A and significant quantities of Vitamin C, protein, calcium, iron, potassium, magnesium, selenium and zinc. Therefore, supplementation with *M.oleifera* can offer an immediate opportunity for providing multiple micronutrients, thus combating widespread child undernutrition in Arusha and other places in the country. The study sought to generate information on the effect of *M.oleifera* leaf powder in improving nutritional status of infants aged 6-24 months. The findings will help to sensitize community on the efficacy of *M.oleifera* on the improvement of nutrition status. Therefore the community will be aware and start to use it. Results from this study will provide evidence of the role of *M.oleifera* in improving the nutrition status of malnourished children.

1.4 Objectives

1.4.1 General objective

The general objective of this study is to assess the effect of *M.oleifera* leaf powder as a supplement to improve health and nutritional status of malnourished children aged 6-24months.

1.4.2 Specific objectives

(i) To determine nutritional status of the study children (6-24month) measured by anthropometric and biochemical measurement.

(ii) To assess the effect of supplementing *M.oleifera* leaf powder on nutritional status measured by anthropometric and biochemical measurement.

(iii) To assess the effect of supplementing *M.oleifera* leaf powder on child morbidity pattern.

1.5 Hypotheses

H_o *M.oleifera* leaf powder as a nutritional supplement does not improve nutritional status of 6-24 months malnourished children.

H_i *M.oleifera* leaf powder as a nutritional supplement improves nutritional status of underfive malnourished children.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Malnutrition.

About 10 million children worldwide are estimated to suffer from severe undernutrition (defined by the presence of severe wasting, stunting and underweight), which greatly increases the risk of mortality). In developing countries children fail to grow in length and weight in a remarkable similar age specific pattern. Faltering in length extends through the first 40 months of life, though is most pronounced during the first 18 months (Lutter and Dewey, 2003). The prevalence of stunting, underweight and wasting varies by region and sub-region throughout low income countries. The Africa region has the highest estimated prevalence of stunting (20.2-48.1%) and has the lowest rate of improvement. In East Africa sub-region, rates of stunting are increasing (WHO, 2000).

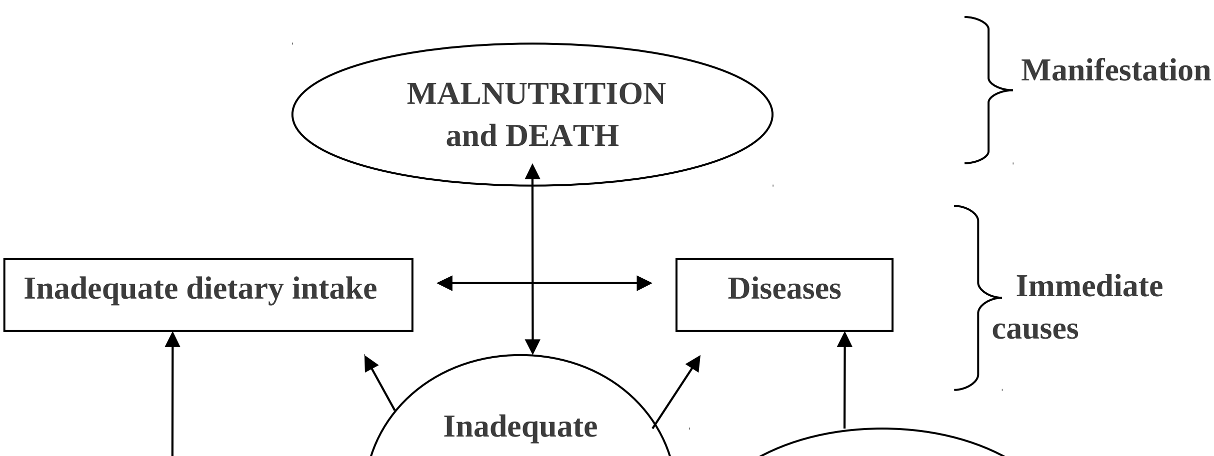
Undernutrition is a state of nutritional inadequacy, whether of protein, energy or micronutrients and is a common public health problem in Tanzania. Nutritional inadequacy exits when the lack of a particular nutrient or nutrients prevents normal growth, development, and biological function. There are two main categories of undernutrition: Protein energy malnutrition (PEM) and micronutrients deficiencies. (Kimati and Scrimashaw,1995). Furthermore, severe PEM by Welcome Trust Classifications comprises of marasmus, marasmic-kwashiorkor and kwashiorkor; often associated with deficiencies of micronutrients particularly zinc, vitamin A, iron, magnesium and selenium (WHO, 2000). Several studies done in children with severe PEM have shown low levels of zinc, vitamin A and selenium respectively (Doulla, 1995). Community surveys done in Tanzania on child malnutrition indicate that 40-60% of children under-five years of age are malnourished and 4 to 9% of them are severely malnourished (WHO, 2000).

2.1.1 Causes of malnutrition

The primary cause of malnutrition in developing country is economic deprivation, or the inability to afford necessary foods. Poor eating habits also play a major role (TDHS, 2000). The conceptual frame work (Fig. 1) shows both biological and socioeconomic causes, and encompasses causes at both micro and macro levels. It breaks the determinants of child nutritional status into three levels of causality: immediate determinants (the most proximate level), underlying determinants, and basic determinants (Isaac, 1992).

The immediate determinants of child nutritional status manifest themselves at the level of the individual human being. They are dietary intake (energy, protein, fat, and micronutrients) and health status. These factors themselves are interdependent. A child with inadequate dietary intake is more susceptible to disease. In turn, disease depresses appetite, inhibits the absorption of nutrients in food, and competes for a child's energy. Dietary intake must be adequate in quantity and in quality, and nutrients must be consumed in appropriate combinations for the human body to be able to absorb them (Hoddinott, 2007).

A key factor affecting all underlying determinants is poverty. A person is considered to be in absolute poverty when he or she is unable to satisfy basic needs for example, to obtain adequate food, health care, water, shelter, primary education, and community participation (Frankenberger, 1996). Finally, the underlying determinants of child nutrition (and poverty) are, in turn, influenced by basic determinants, which include the potential resources available to a country or community, limited by the natural environment, access to technology, and the quality of human resources. Political, economic, cultural, and social factors affect the utilization of these potential resources and how they are translated into resources for food security, care, and health environments and services (Pelletier *et al.*, 2005).


MALNUTRITION
and DEATH
Manifestation
Inadequate dietary intake
Diseases
Immediate
causes
Inadequate

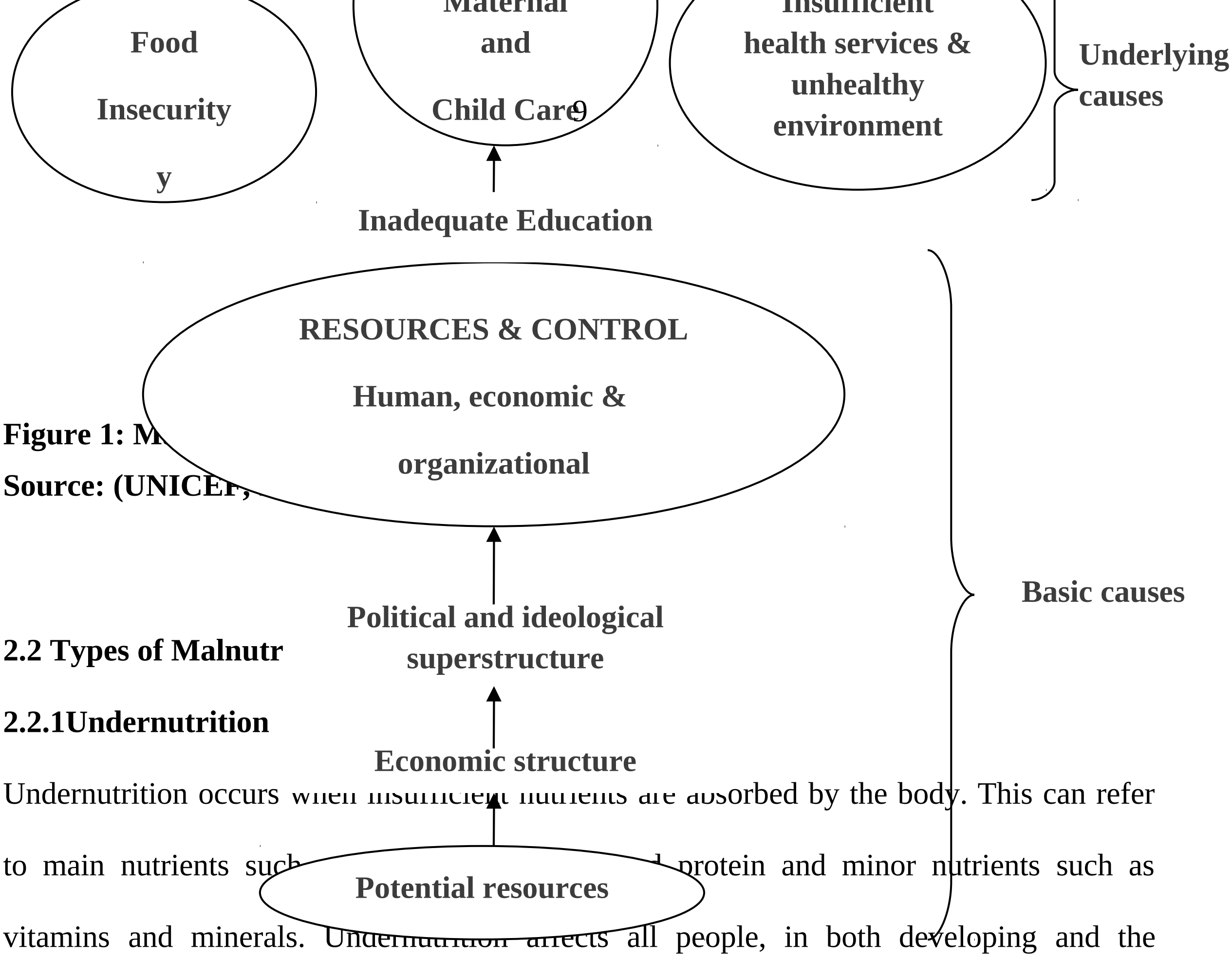


Figure 1: M

Source: (UNICEF,

2.2 Types of Malnutr

2.2.1Undernutrition

Undernutrition occurs when insufficient nutrients are absorbed by the body. This can refer to main nutrients such … protein and minor nutrients such as vitamins and minerals. Undernutrition affects all people, in both developing and the developed world. Undernutrition is often a direct result of starvation as seen in the developing world. Those who are affected worst by malnutrition in developing countries are children under the age of five. This is because children of this age require a lot of nutrients not only to grow but to build up immunity against diseases (Buccini, 2007).

2.2.2 Marasmus

Marasmus is one of the types of protein-energy malnutrition that affects children under the age of one. One of the leading causes of marasmus is the weaning of a child. Mother's milk helps protect a child from harmful bacteria, both in that it is sanitary and in that it contains 'good' bacteria which inhabit the intestinal tract, preventing 'bad' bacteria from gaining a hold.Sometimes, marasmus is also caused by metabolic and genetic problems which hinder the body’s ability to absorb nutrients (Douglas, 2006). As a result the child is no longer absorbing the required intake of nutrients, the body will automatically break down and consume its own tissue, fat and muscle. This process releases carbohydrates and protein which the body needs to survive. Marasmus will at first lead to wasting (the breakdown of muscle and fat) and if sustained to stunting (stunted growth). These will cause serious impediments to a child's growth. This often leaves the child weak and vulnerable to injury and disease. If a child is hurt or contracts a viral or bacterial infection it is likely to die (Eckholm, 2001).

2.2.3 Kwashiorkor

The word Kwashiorkor comes from West African word meaning " first child – second child." Kwashiorkor is a type of malnutrition that affects mainly younger children aged between 1 and 5 years, but can affect all ages. The main difference between kwashiorkor and marasmus is caloric intake. Marasmus is characterised by a minimal protein and energy intake, whereas kwashiorkor on the other hand is characterised as having minimal protein but with an average caloric intake. In other words, kwashiorkor is a protein deficiency disorder (Brown, 2000).

Kwashiorkor is also referred to as the "wet type" of malnutrition because of edema. Edema is an increase in fluids within the body. One of the main causes behind kwashiorkor is weaning. The mother's milk usually consists of many vital nutrients such as amino acids which are the building blocks of protein. Unfortunately in poorer countries, protein sources such as meat, are simply very expensive. The result is a diet of starch which is moderate in caloric intake but lacks vital nutrients that the mother's milk provides (Haggerty, 2006).

2.2.4 Marasmic kwashiokor

Marasmic kwashiorkor is a form of malnutrition that lies in between kwashiorkor and marasmus as implied by its name. Persons affected by this type of malnutrition are characterised by having some fluid but also more body fat than those affected by marasmus (Denning and Sachs, 2007).

2.3 The Advantages of Using *M.oleifera* in Malnutrition Prevention

In the African context, *M.oleifera* is a very simple and readily available tool to help prevent malnutrition. It is a drought-resistant and fast growing tree which is present in nearly all tropical and sub-tropical countries. Its edible leaves are already an occasional food source and appear at the end of the dry season: a time when other greens are in short supply. As a source of good nutrition, its leaves are considered the best of tropical legumes with its high quantities of vitamin A and significant quantities of vitamin C, calcium, iron, protein, potassium, magnesium, selenium, zinc and a good balance of all the essential amino acids. Also, the leaves can be easily dried and ground into powder form for use as a nutritional supplement for sauces or as an addition to infant weaning foods. Generally, vitamins and most minerals are best absorbed and used by the body when they come from natural sources (plants, animals) and are present in natural, complex combinations (Lowell, 2000). Moringa contains specific plant pigments with demonstrated potent antioxidant properties such as the carotenoids – lutein, alpha-carotene and beta-carotene, xanthins, chlorophyll and others. Moringa contains powerful antioxidant vitamins such as vitamin C, E and A (pro-vitamin A as beta-carotene). Moringa has essential micronutrients with antioxidant activity or directly linked to this process: selenium and zinc. Moringa (leaves, seeds, pods) contains other phytochemicals with known powerful antioxidant ability such as kaempferol, quercetin, rutin and caffeoylquinic acids." Among other medical benefits of beta-sitosterol: it boosts the immune defense. It has anti-inflammatory properties. It helps normalize the blood sugar and supports the pancreas (which produces insulin – the hormone controlling blood sugar). It helps to heal ulcers. It can alleviate cramps" (Marcu, 2005).

2.4 The Uses of *M. oleifera* Tree

2.4.1 In health and nutrition

All parts of this scruffy looking tree are edible; the leaves can be eaten raw, cooked like spinach or made into a powder that can be added to sauces, soups or chowders. The new leaves have a tendency to appear towards the end of the dry season when few other sources of green leafy vegetables are available. The young, green pods can be eaten whole and are comparable in taste to asparagus (Marcu, 2005).

2.4.2 *M.oleifera* in health and water treatment.

M.oleifera seeds work on two levels, acting as both a coagulant and an antimicrobial agent. *M.oleifera* seeds have large quantities of low molecular weight, water soluble proteins that carry a positive charge. When added to raw water, these proteins bind with the negatively charged particles that make water turbid (clay, silt, silk, bacteria, etc.). After agitation (stirring), these bound particulates grow in size, and the resulting “flocs” settle to the bottom of a container and/or can be filtered out (Pratt *et al*., 2002).

Antimicrobial aspects of *M.oleifera* continue to be researched, but findings support recombinant proteins both removing micro-organisms (by coagulation) and acting directly as growth inhibitors. It is accepted that *M.oleifera* treatment will remove 90-99.9 percent of impurities in water. Solutions of *M.oleifera* seeds can be made either from the seed kernels or from press cake (the solid residue left over after oil extraction) (Foidl *et al*., 2001).

2.4.3 *M. oleifera* in environment/agriculture

Because of the multiple uses of *M. oleifera*, it can be a highly appropriate tree to include in agro forestry systems or tree nursery projects. The tree grows at a rapid rate it can reach 9 to 15 feet (three to five meters) in a single growing season it has little need for extra fertilizer, and is pest and drought resistant. Some environmental and agricultural uses of *M. oleifera* are windbreaks and live fencing –a live border can be created by planting trees in a row approximately one meter apart. Cuttings from the tree can be planted as live fence posts (Duke, 1983).

M.oleifera trees can provide light shade for other plants as well as support for vines. *Moringa's* rapid growth, long taproots, few lateral roots, minimal shade and large production of high-protein biomass makes it well-suited for use in alley cropping systems (Makkar and Becker, 1997).

M.oleifera seed can be used as fertilizer where cakes can be ploughed into the soil as protein-rich plant fertilizer and leaves can be used in the same way as green manure. Leaves for animal forage – The leaves are good for cattle, goats, pigs and sheep. Leaves can also be used as food for carp and other fish (Rajangam, 2000).

2.5 Childcare Practices.

2.5.1 Feeding practices

Feeding practice is an important determinant of the children's nutritional status. It includes both breastfeeding practice as well as complementary feeding practices. It encompasses use of appropriate food (quality, quantity and frequency) at the right time taking into account the stages of development (WHO, 2003).

2.5.2 Breastfeeding practices

It is well known that breastfeeding improves child survival by providing protection against infectious disease and malnutrition for the baby (Butz *et al.,* 2000). Exclusive breast feeding can save many lives by preventing malnutrition and reducing the risk of infections and hypotheria. Exclusive breast feeding should be practiced for at least 4 months and preferably 6 months in poor countries since they have a high risk of infection through contaminated water and food and to continue breastfeeding, supplemented by other appropriate foods up to 2 years of life. Breast milk has been considered as the most suited food for the child world over (Dualch and Henry, 1999).

2.5.3 Complementary feeding

When breastmilk is no longer enough to meet the nutritional needs of the infant, complementary foods should be added to the diet of the child. The transition from exclusive breastfeeding to family foods, referred to as complementary feeding, typically covers the period from 6 to 24 months of age, and is a very vulnerable period. It is the time when malnutrition starts in many infants, contributing significantly to the high prevalence of malnutrition in children underfive years of age world-wide (WHO/ UNICEF, 2003). Complementary feeding should be *timely*, meaning that all infants should start receiving foods in addition to breastmilk from 6 months onwards. It should be *adequate*, meaning that the nutritional value of complementary foods should parallel at least that of breastmilk. Foods should be prepared and given in a safe manner, meaning that measures are taken to minimize the risk of contamination with pathogens. Food should be given in a way that is *appropriate*, meaning that foods are of appropriate texture and given in sufficient quantity (WHO, 1999).

Infants should start receiving complementary foods at 6 months of age in addition to breastmilk, initially 2-3 times a day between 6-8 months, increasing to 3-4 times daily between 9-11 months and 12-24 months with additional nutritious snacks offered 1-2 times per day, as desired (WHO/ UNICEF, 2003).

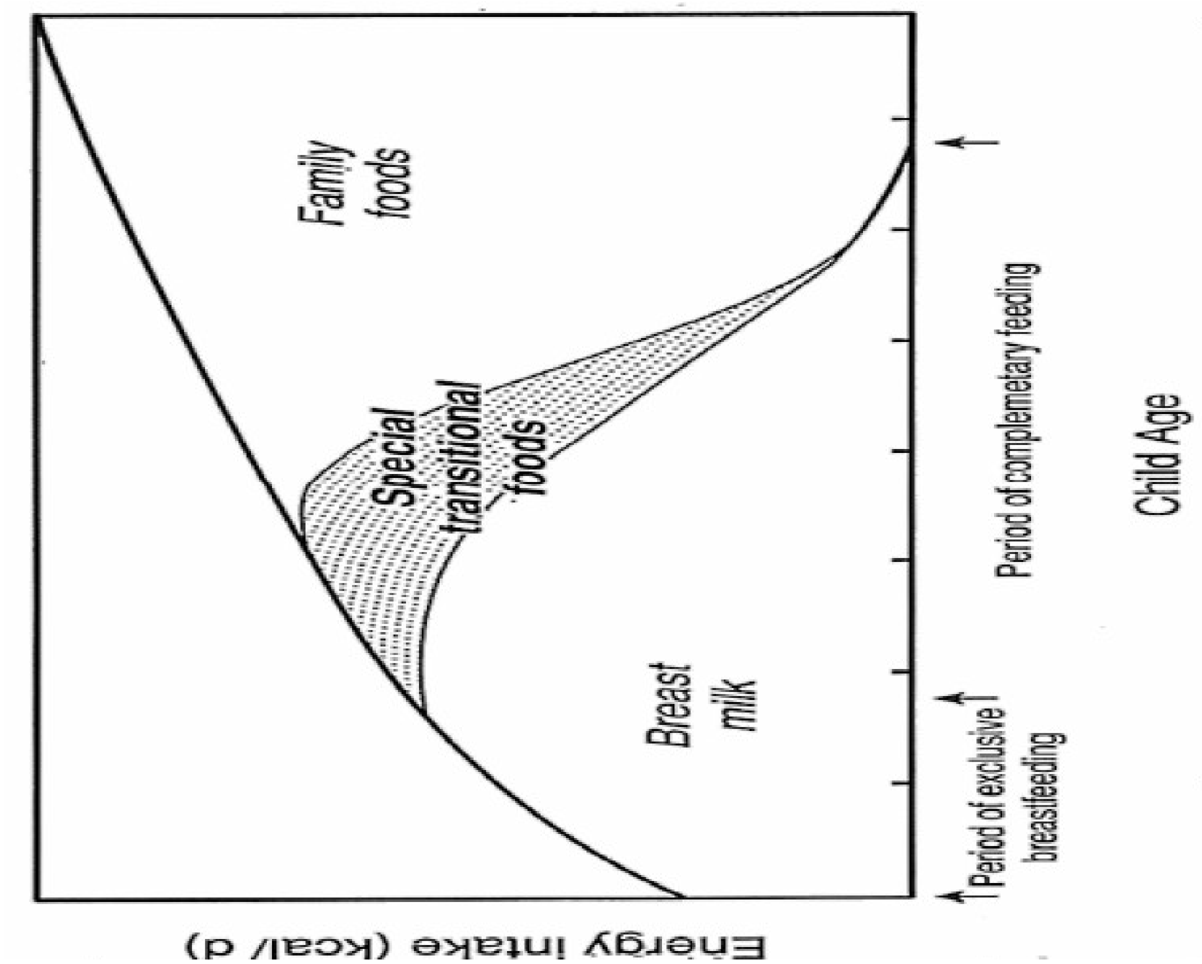


Figure 2: Time of complementary feeding in months

Source : (WHO/ UNICEF, 2003).

The traditional complementary foods in Tanzania are based on starchy staples, usually cereals such as maize, sorghum, rice and finger millet and non-cereals such as cassava, sweet potatoes, yams, bananas and plantains (Mosha *et al.*, 2000). Complementary foods are often of low nutritional quality. Nutritional problems associated with the use of these starchy staples in complementary foods have been widely reported (WHO, 2003).

2.6 Malnutrition and Infection

Nutrition's importance as a foundation for healthy development is often underestimated. Poor nutrition leads to ill-health and ill-health contributes to further deterioration in nutritional status. These effects are most dramatically observed in infants and young children, who bear the brunt of the onset of malnutrition and suffer the highest risk of disability and death associated with it. In 2001, 50−70% of the burden of diarrhoeal diseases, measles, malaria and lower respiratory infections was attributable to malnutrition. The children who die represent only a small part of the total health burden due to nutritional deficiencies. Maternal malnutrition and inappropriate breastfeeding and complementary feeding represent major risks to the health and development of those children who survive (Dewey and Brown, 2003).

Deficiencies in the diet of vitamin A, iodine, iron and zinc are still widespread and are a common cause of excess morbidity and mortality. Over 50 million children under the age of five years are wasted, and in low-income countries one in every three children suffers from stunted growth. Indeed, many children never reach this age. The effects of poor nutrition and stunting continue throughout life, contributing to poor school performance, reduced productivity, and impaired intellectual and social development (Santos *et al*., 2001).

Inappropriate feeding practices are a major cause of the onset of malnutrition in young children. Children who are not breastfed appropriately have repeated infections, grow less well, and are almost six times more likely to die by the age of one month than children who receive at least some breast milk (WHO/ UNICEF, 2003).

2.6.1 Water and sanitation

Water and sanitation improvements, in association with hygiene behaviour change, can have significant effects on health by reducing a variety of disease conditions such as diarrhoea, intestinal helminths, guinea worm, and skin diseases. These improvements in health can, in turn, lead to reduced morbidity and mortality and improved nutritional status.

Water and sanitation improvements affect health primarily by interrupting or reducing the transmission of disease agents, as illustrated in (Figure 3). This occurs through a variety of mechanisms. Of primary importance is the safe disposal of human faeces, thereby reducing the pathogen load in the ambient environment. Increasing the quantity of water allows for better hygiene practices. Raising the quality of drinking water reduces the ingestion of pathogens. With less disease, children can eat and absorb more food, thereby improving their nutritional status (Berkley, 2002).

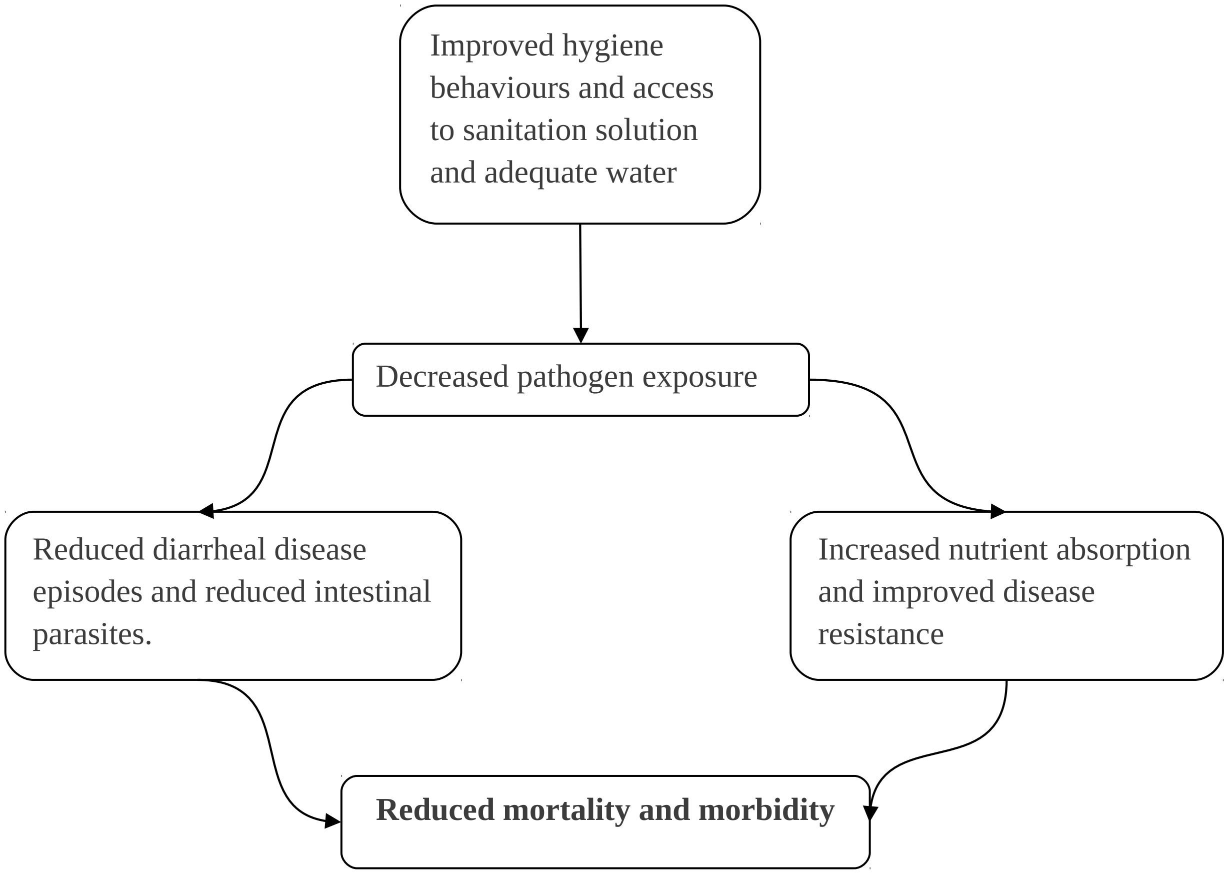


Figure 3: Water and sanitation improvement
Source: Huttly *et al.* (1997)

2.7 Nutrition Interventions

Some nutrition intervention trials to improve the nutrition status of children through improving complementary foods attempted to modify the traditional foods by fortification. Several intervention programs which aimed at solving nutrition problem such as anemia and micronutrient deficiencies using a food approaches have either been fortifying the foods or supplementing them with micronutrient compounds. The scientific intervention studies that have been conducted according to a prospective randomized design, whereby one group was provided with certain types of foods that were aimed at solving a nutritional problem while another group acted as a control was allocated conventional foods utilized in the area. Provided that the two groups were similar at the baseline then the change in nutritional status as a result of the intervention could be attributed to the dietary intervention. A longitudinal study conducted by The Institute of Nutrition of Central America and Panama (INCAP) in Guatemala is one of the richest sources of information about the importance of nutrition for growth and development in developing countries (Martorell *et al.*, 1995).

In three sites (Indonesia, Peru, and Vietnam), where a randomized placebo control trial was carried out using foodlets based multiple micronutrient in preventing growth faltering, anaemia and micronutrient deficiency during infancy, Infants were randomized to 4 treatment groups, daily placebo (P), weekly multiple micronutrients (WMM), daily multiple micronutrient (DMM) and daily iron (DI) supplement. The results showed that DMM group had a significantly greater weight gain, growing at an average of 207g/mo with 192g/mo for the WMM group and 186g/mo for DI and P groups, and there were no differences in height gain. The DMM showed greatest increment in mean haemoglobin concentration (Smuts *et al.,* 2005). Other studies found another benefit that the daily multiple micronutrient supplements improved other circulating micronutrient concentrations, such as riboflavin, retinol, and tocopherol, whereas the weekly multiple micronutrient and the daily iron had no such effect (Domellof *et al.,* 2002).

2.7.1 Efficacy trials

Integrated nutrition programs are widely used to prevent and/or reverse childhood malnutrition, but are rarely rigorously evaluated. Malnutrition, as measured by poor anthropometric growth, has been widespread in developing countries. Table 1 summarizes the studies on impact of nutritional interventions on growth outcome of children in the developing countries (Dewey and Adu-Afarwuah, 2008).

Table 1: Impact of growth outcome of efficacy trials

Author	Site	Target group	Study groups	n	Weight	Height/ length
Adu-Afarwuah *et al*. (2007)	Ghana	6 months	SP or NB	200	-0.71±1.10	-0.42±1.1
			Control	96	-0.74±1.10	-40±1.00
Adu-Afarwuah *et al*. (2007)	Ghana	6 months	Fortified spread	98	-0.40±1.10	-0.14±1.1*
			Control	96	-0.74±1.10	-40±1.00
Kuusipalo *et al.* (2007)	Malawi	6-17 months	Fortified spread	94	-0.18±0.40	2.5±1.1*
			Control		0±0.30	1.7±1.3
				18		
Smuts *et al*. (2005)	South Africa	6-12 months	Daily Multiple micronutrient	49	-0.25±0.84	-1.11±0.98
					-0.5±0.91	-1.16±0.94
			Placebo	50		
Mamiro *et al.* (2004)	Tanzania	6 months	Processed food	133		-2.08±1.02
			Unprocessed food	125		-2.04±1.043

Nutrition intervention as the third step following assessment and diagnosis, can be defined as purposefully planned actions intended to positively change a nutrition-related behavior, environmental condition, or aspect of health status for an individual or the community at large.Table 2 summarizes intervention approaches used and outcomes measured by studies in the developing countries (Dewey *et al.*, 2008).

Table 2: Summary of intervention approaches

Author	Type of study	Site	Nature of intervention	Outcome
Adu-Afarwuah *et al.* (2007)	Efficacy	Ghana	Children received added micronutrients through fortification: one group received extra energy through fortified fat based spread. Duration: 6months	Growth, motor development, morbidity and Fe status
Dhingra *et al.* (2004)	Efficacy	India	Children received added micronutrient in a milk supplement. Duration:12 months	Growth, morbidity, Fe status
Kuusipalo *et al.* (2007)	Efficacy	Malawi	Malnourished children received fortified food in the form of milk or soy based spread. Duration 3 months	Growth. Fe status
Faber *et al.* (2005)	Efficacy	South Africa	Children received added micronutrient through centrally processed food. Duration:6 months	Growth,: Fe/vitamin A/Zn status
Mamiro *et al.* (2004)	Efficacy	Tanzania	Cereal &legume in CF were processed (soak/germinate/roast) to increase energy density & Fe solubility and reduce phytate. Duration 6months	Growth, Fe status intake
Smuts *et al.* (2005)	Efficacy	South Africa	Children received added micronutrient through home fortification with foodlets. Duration:6 months	Growth, Fe/Zn vitamin A status, morbidity
Sharieff *et al.* (2006)	Efficacy	Pakistan	Infant received sprinkles added to CF daily. Duration 2 months	Fe status, morbidity
Villalpando *et al*. (2006)	Efficacy	Mexico	Children received added micronutrient in a milk product. Duration:6 months	Fe intake/Zn status
Giovannini *et al.* (2006)	Efficacy	Cambodia	Children received added micronutrient through home fortification with sprinkles TM. Duration:12 months	Growth, Fe status
Lartely *et al*. (1999)	Efficacy	Ghana	Children received various blends of cereal, legume and/or fish with/without added micronutrient. Duration 6months	Growth, Fe/Zn vitamin A status, morbidity
Bhandari *et al.* (2001)	Efficacy	India	Subjects received nutrition education or education plus fortified milk/cereal food. Duration:8months	Growth, morbidity

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

The following materials were used in this study: Food items; moringa leaf powder and maize flour. Equipment; Salter scale for measuring weight (Vogel and Haike, Hamburg, Germany).Wooden child length measuring boards (Perspective Enterprises, portage, MI, USA) for length measurement. MUAC tape, HemoCue, (AB, Box1204, SE-26223 Angelholm, Sweden), for Haemoglobin (Hb) determination.

3.2 Methods

3.2.1 Description of the study area.

3.2.1.1 Geographical location

The study was conducted in Arusha urban, Tanzania. Arusha region is divided into five districts: Ngorongoro, Arusha, Karatu, Monduli and Arumeru. Arusha region covers a total of 86,999 km^2 of which 3,571 km^2 (4.1%) is water. Despite its proximity to the equator, Arusha's elevation of 1400 m on the southern slopes of Mount Meru keeps temperatures down and alleviates humidity. Cool dry air is prevalent throughout the year. Arusha urban is located between Latitude 03^0 16 ' S and 03^0 20 ' S and Longitude 36^0 37 ' E and 36^0 50 ' E; in Arusha region. The temperatures range between 13 and 30^{0}C with an average around 25 degrees. It has distinct wet and dry seasons, and experiences eastern prevailing wind from the Indian Ocean, a couple of hundred miles east (URT, 2002).

3.2.1.2 Population and ethnic group

Arusha is the capital of the Arusha Region. According to 2002 census, Arusha urban has a population of about 282, 712 people out of whom 49% are males and 51% are female. Arusha urban has a population density of 3040 people per km^2, family size of 4 and dependent ratio of 59%. The current population projection is estimated at 359,044 people. The dominant ethnic group is Maasai and their main activity is livestock keeping and to a very small extent they grow crops, mainly maize as their staple food. The district has migrants whose main activities are crop production, fishing, business, mining and to some extent livestock keeping. Maize is the major staple food crop. Other crops in the district are sweet potatoes, beans, cassava, millet, groundnuts, banana and to a small extent fruits and vegetables (URT, 2002).

3.2.1.3: Economic activities

The primary industry of the region is agriculture, with large vegetable and flower producers exporting to Europe. Arusha region has several factories including a brewery, and fibreboard plant, and a large pharmaceutical industry. The region is the sole source of a gem-quality mineral called Tanzanite, currently produced in large quantities by corporate mining concerns. Tourism is also a major contributor to the economy in Arusha, being the second largest contributor of income in Tanzania. Arusha is home to the offices of the East African Community, and plays host to the International Criminal Tribunal for Rwanda and the African Court on Human and Peoples' Rights, all of which contributes to the local economy.

3.2.1.4. Social services

3.2.1.4.1. Health

Mount Meru hospital is the regional hospital in Arusha. The most common cause of morbidity and illness are malaria, diarrhea, upper respiratory tract infection, airborne disease like tuberculosis, skin disease, malnutrition, anaemia, eye and ear diseases, pregnancy complications and surgical complications (URT, 2002).

3.2.1.4.2. Water and sanitation

Arusha is served with water from Ruvu river, deep and shallow wells, natural and manmade dams, piped water, rain water harvesting and saline bore holes. The population covered with adequate supply of water is 33.9% both in rural and urban.

3.2.2 Research design

Randomized control trial design was used. Children attending at the nutrition unit were randomly assigned to *M.oleifera* leaf powder porridge or maize flour porridge feeding regime.

3.3 Feeding Regime

Maize porridge was provided to children who were eligible in a control group during the study. Children allocated to the treatment group were supplied with *moringa* leaf powder porridge. The intervention involved feeding for 3 months, whereby data was collected at baseline and thereafter monthly for 3 months. Infants (n=140) were randomly assigned to two groups; Treatment group; *moringa* leaf powder porridge (25g) (n=64), Control group; maize porridge (100g) (n=76). Anthropometric and morbidity information were collected monthly. Children were dewormed, treated against any infections e.g. Malaria, before supplementing with *moringa* leaf powder porridge or maize flour porridge.

3.3.1 Preparation of *M.oleifera* porridge.

Leaves were harvested, washed and dried in an airy place out of direct sunlight as seen in Fig.4 (direct sunlight will destroy vitamin A). Dried leaves were crushed with a local motor and pestle, sifted using a local screen sifter as shown in Fig. 5. Maize flour was mixed with cold water until a uniform paste was achieved. A paste was put into boiling water, pot was covered and boiled for 15-20 min, *M.oleifera* leaf powder was added to the porridge before drinking.

3.3.2 Preparation of maize flour porridge.

Maize flour was mixed with water until a uniform paste was achieved. The pot was covered and boiled for 15-20 minutes, then the pot was removed from the fire and allowed to cool then a small amount of sugar was added.

Figure 4: **Fresh *moringa* leaves in airy place**

Figure 5: *moringa* powder sifted using a local screen sifter

3.3.2 Administration of the porridge.

Porridge supplemented with *M.oleifera* leaf powder was provided to children for three month. In the first two months supplementation was done at a rehabilitation unit and in the third month supplementation was done by their mothers at home. In the treatment group a cup of 250 mls of maize porridge, 25 g of *M.oleifera* leaf powder was added and a mother was given to feed the child. And for control group 250 mls of maize porridge was given to the child. After being discharged from the rehabilitation unit mothers were trained on how to prepare the porridge whereby in 250ml of maize porridge they had to add three table spoonful of *M.oleifera* leaf powder which is equivalent to 25 g. Mothers with children in treatment group were given 800 g of *M.oleifera* leaf powder where by those with children in control group were asked to prepare a maize porridge and give their children.

3.3.3 Inclusion criteria

- Children with age 6-24 months
- Weight-for-Length WLZ (Z- score <-3SD)
- Length-for-age LAZ (Z- score <-3SD)
- Weight-for-age WAZ (Z-score<-3SD)

Exclusion criteria

Children who had received blood transfusions or presented with serious health conditions as assessed by a medical doctor at the time of enrolment were excluded.

3.4 Sample Size

The sample size required was computed using the equation in Appendix 1 to obtain 140 children.

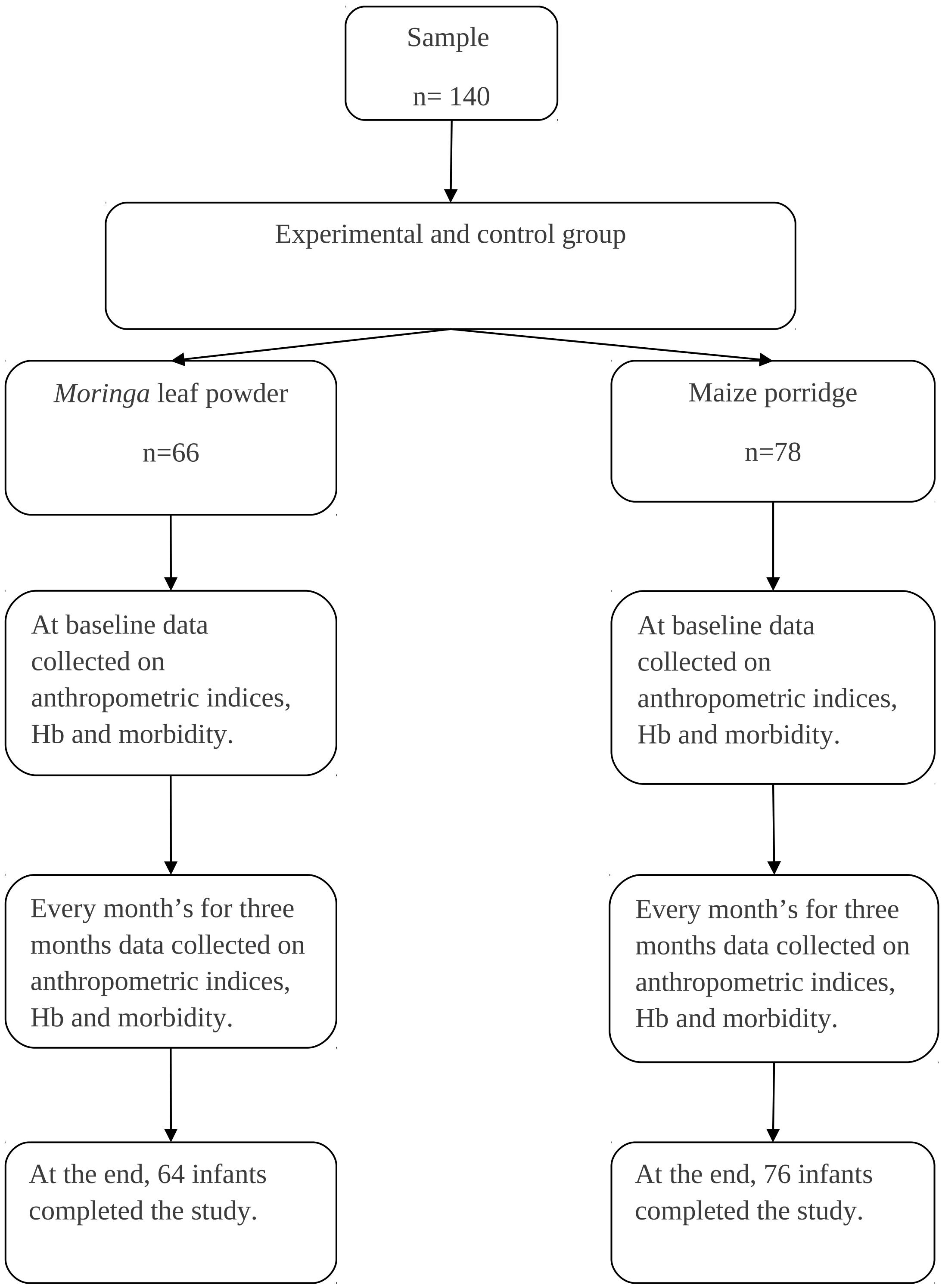


Figure 6: **Trial profile; Participation of infant in *M.oleifera* leaf powder supplementation trial.**

3.5 The Intervention

The intervention involved 3 months of feeding.

3.5.1 Composition of maize meal

In 100 g of maize meal contained 343 Kcal, protein 9.4 g, fat 4.2, calcium 12 mg, and iron 2.5 mg (Appendix 4).

3.5.2 Composition of *M.oleifera* leaf powder

In 25g of moringa leaf powder contained 51.2 Kcal, protein 6.7g, calcium 500mg (Appendix 4).

3.5.3 Sampling procedure

Malnourished children aged 6-24 months who were at the unit, were randomly assigned numbers. Allocation to the treatment and the control group was determined by randomization technique using random number tables.

3.6 Method for Data Collection

3.6.1 Study questionnaire

A structured pre-tested questionnaire (Appendix 6) was constructed and administered at the household to mothers/care givers of children. It was written in English and then translated into Kiswahili and pre-tested on a group of non-participating mothers and adjustments to the questions were incorporated accordingly. It was designed to provide information on: i) household characteristics (demographic and socio-economic i.e. education, occupation and monthly morbidity recording information to know the effect of moringa leaf powder on recovery. These data were collected monthly.

3.6.2 Anthropometric measurements

Standard techniques and equipment (weighing scale for weight, height board for height and MUAC tape for MUAC) were used for collecting anthropometric measurements. All of these were compared to reference values recommended by National Centre for Health Statistics as shown in Table 3.

Table 3 : Classification of malnutrition

Level of malnutrition	**Weight-for-height (z-score)**	**Height-for-age (z-score)**	**Weight-for-age (z-score)**
Moderate	- 2 and -3	- 2 and -3	- 2 and -3
Severe	≤ -3	≤ -3	≤ -3
Global Malnutrition	≤ –2	≤ –2	≤ –2

Source: WHO (1995)

3.6.2.1 Length

Length was measured using a wooden measuring board. The child was placed facing upward with the head towards the fixed end and the body parallel to the long axis of the board. Child's knees were pressed onto the board so that the legs were straight and the toes pointing directly upwards, the movable footboard was then brought to rest firmly against the heels and the measurement taken to the nearest 0.1 cm.

3.6.2.2 Weight

Child's weights were measured using a salter scale and the measurements were taken in the morning. The scales were adjusted to zero before starting the measurements. The child was put in a weighing pant, the strap of the pant was attached to the hook of the scale, and gently the child was lowered and allowed to hang freely. When the scale needle was stationary, the reading was taken, two measurement were taken (to nearest 0.1cm) for each child and recorded after each reading. The average weight was computed during data processing and this made the actual weight of the child.

3.6.2.3 Age and sex

Age to the nearest month and sex of the children was determined from the growth monitoring cards or relying on mother's recall.

3.6.2.4 Arm circumference

MUAC is the circumference of the left upper arm and is measured at the mid-point between the tip of the shoulder and elbow. Left arm was bent, marked with a pen for the olecranon process and acromium. Mid-point between these two marks was marked. With the arm hanging straight down, MUAC tape was wraped around the arm at the midpoint mark. Measurement was taken to the nearest 0.1 cm. MUAC classification was done according to Gibson (1990) as shown in Table 4.

Table 4: MUAC classification

Classification	Remark
>13.5cm	Normal
12.5-13.5cm	Mildly malnourished
<12.5cm	Malnourished

Source: (Gibson, 1990)

3.6.3 Biochemical assessments

3.6.3.1 Haemoglobin concentration.

Haemoglobin concentration in blood was determined by the hemocue technique. All blood collection and preparation was done by an experienced laboratory technician. Blood sample was drawn from a finger prick.The middle finger of the left hand was used to collect blood sample. The site was punctured by using disposable sterile lancets. Whole blood was drawn up into microcuvettes by capillary action and inserted into the HemoCue photometer. Haemoglobin concentration (Hb) determination was carried out using HemoCue technique which uses disposable microcuvettes contain reagents in dried form of sodium deoxycholate which haemolyses the red cells, sodium nitrate converts haemoglobin to methaemoglobin, and sodium azide converts methaemoglobin to methaemoglobinazide. The absorbance at a wavelength of (565nm) methaemoglobinazide was measured in g/dl on an LCD display. Haemoglobin status was classified as shown in Table 5.

Table 5: Anaemia Classification

Classification	Remark
$\geq$11g/dl	Normal
10.0-10.9g/dl	Mild anaemia
7.0-9.9g/dl	Moderate anaemia
4.0-6.9g/dl	Severe anaemia
Less than 4.0g/dl	Very severe anaemia

Source: (CDC and WFP, 2005)

3.6.4 Morbidity information

Information on morbidity was collected from mother/care taker at baseline and monthly during the 3 months intervention period by using a monthly morbidity form (Appendix 6). Data was recorded on whether the child suffered from diarrhoea (more than 3 loose or watery stools per day), acute respiratory infection (cough, runny nose, fever, earache, or sore throat), and malaria during the month of visit, and if the child had fever three days prior to the visit.

3.6.5 Data analysis

Statistical analysis of data was carried out using SPSS (Statistical Package for Social Sciences) software version 12 for Windows and NutriSurvey for SMART. Anthropometric measurements were entered into Emergency Nutrition Assessment (ENA) for SMART, (Erhard and Golden, 2007) software to generate anthropometric indices. Student t-test was used to compare the two groups.

3.6.6 Ethical consideration

Ethical clearance was sought from the Ethics Committee of the National Institute for Medical Research (NIMR) and the Sokoine University of Agriculture for approval to carry out the study. In addition, permission to conduct the study was sought from Mount Meru hospital Administration. Written informed consent was obtained from the mother or the guardian of all participating infants, after a detailed explanation of the purpose of the study. Consent forms explaining the purpose of the study, potential risks or discomfort, the rights of subjects and the benefits to the subjects were available both in English and Kiswahili. For illiterate mothers, the form was read and explained to them. To indicate their consent, mothers were asked to thumb-print it. It was explained that they were free to withdraw from the study and all the information was made confidential.

CHAPTER FOUR

4.0 Results

Results of this study are grouped into two categories which include baseline information and monthly follow up information for the three months of supplementation. Results obtained during baseline included; socio-demographic, nutritional status, and morbidity. During supplementation results obtained were; dietary intake, morbidity and nutritional status.

4.1 Sample Size, Sex, Age and Birth Weight of Infants

A total of 145 children were enrolled in this study. However, 3 children dropped out and 2 died, resulting into 140 children (47.9% males and 52.1% females) who completed the study.

4.1.1 Age and birth weight

Mean age of children in treatment group was 13.9±5.2 months while that of control group was 13±4.90 months. Mean birth weight of infants in the treatment group and control group was 2.90±0.51 kg and 2.93±0.53 kg respectively. Birth weights ranged from 1.9 to 3.5 kg in both groups.

4.1.2 Socio-demographic characteristics of mothers

Headship of the household was observed to be dominated by males 70% and 67.1% in treatment and in control group respectively. There was no significant difference ($P>0.05$) in headship of the house hold. About 47% and 47.4% of the women reported that, they started bearing children when they were between 18 and 25 years of age. Women who delivered when they were younger than 18 years of age were 20.3% and 23.7% in the treatment and control group respectively (Table 6).

The results in Table 6 show that 48.5% in treatment group and 48.7% in control group had attained one to seven years of education for mothers. There was no significant difference ($P>0.05$) in education between the two groups The results also show that 45.3% and 44.7% of the respondents were married and reported receiving social and financial support from their spouses in treatment and in control group respectively. There was a significant difference ($P<0.05$) in marital status between the two groups. The mean house hold size for this study was 13 people. Animal keeping was the main source of income where by 48.4% of mothers were animal keepers in the treatment group and 44.7% of mothers were animal keepers in control group.

Table 6: Socio-demographic characteristics

Variables	Treatment Frequency	Treatment Percent	Control Frequency	Control Percent	χ2	P-value
Age of mother						
<18years	13	20.3	18	23.7	**11.633**	**0.821**
18-25years	30	46.9	36	47.4		
26-35years	15	23.4	15	19.7		
36-45	6	9.4	7	9.2		
Total	**64**	**100**	**76**	**100**		
Sex					**35.08**	**0.000**
Male	32	50.0	41	53.9		
Female	32	50.0	35	46.1		
Total	**64**	**100**	**76**	**100**		
Type of household						
Female headed	19	29.7	25	32.9	**9.26**	**0.23**
Male headed	45	70.3	51	67.1		
Total	**64**	**100**	**76**	**100**		
Mother's education level						
1-7years	31	48.5	37	48.7	**4.94**	**0.877**
8-12years	2	3.1	3	3.9		
none	31	48.4	36	47.4		
Total	**64**	**100**	**76**	**100**		
Marital status						
Married	29	45.3	34	44.7	**10.775**	**0.021**
Single	12	18.8	15	19.7		
Divorced	9	14.1	12	15.8		
Cohabit	14	21.9	15	19.7		
Total	**64**	**100**	**76**	**100**		
Household size						
3 - 5	21	33	22	29	**34.51**	**0.03**
6 - 9	22	34	25	33		
10 - 17	10	15.6	14	18.4		
18 - 25	11	17.4	15	19.6		
Total	**64**	**100**	**76**	**100**		
Occupation						
Farmer	10	15.6	12	15.8	**33.680**	**0.159**
Animal keeper	31	48.4	34	44.7		
Small business	23	35.9	30	39.5		
Total	**64**	**100.0**	**76**	**100.0**		

4.2 Feeding Practices

4.2.1 Breastfeeding

It was observed that 32.8% of children in treatment group and 33.0% for control group were still breastfeeding during the study. There was no significant difference in between the two groups ($p<0.05$). The mean breastfeeding frequency for 24h was 5.68±2.40 times (ranging between 0 and 12 times) in the treatment group, and 6.07±2.17 times (ranging from 0 to 10 times) in control group per day. Breastfeeding was initiated immediately after birth by 62.5 and 63.2% of mothers in treatment and control groups respectively. Only 72.0 and 75% children in treatment and control groups respectively were exclusively breastfed during the first six months of the life (Table 7). There was a significant difference in the breastfeeding initiation between the two groups ($p<0.05$).

4.2.2 Complementary feeding

The study shows that complementary feeding was started at various times. It was observed that 31.3 and 31.6% of infants below 2 months of age received pre-lacteal feeds in treatment and control groups respectively. At 3 month of age prelacteal feed was practised in 28.1 and 31.6% of treatment and control group respectively. The study further revealed about 68.7 and 72.4% of children below the age of six months had received complementary food (CF) in both treatment and control groups respectively. At baseline there was no significant difference in the complementary feeding between the two groups ($p<0.05$).

The most commonly consumed complementary foods were maize porridges and family meals. About 64% of the mother in the treatment group and 67% in control group were feeding their children with plain maize porridge.

Table 7: Feeding practices

Variables	Intervention group					
	Treatment		Control			
	Frequency	Percent	Frequency	Percent	χ2	P-value
Breastfeeding initiation						
Immediately after birth	40	62.5	48	63.2	**16.016**	**0.067**
Within 1hour	6	9.4	7	9.2		
Less than 24hours	8	12.5	12	15.8		
More than 24hours	8	12.5	7	9.2		
Total	**64**	**100**	**76**	**100**		
Continue breastfeeding						
Yes	21	32.8	25	32.9	**33.806**	**0.159**
No	43	67.2	51	67.1		
Total	**64**	**100**	**76**	**100**		
Complementary foods						
Ugali,maize porridge	6	9.4	8	10.5	**52.973**	**0.000**
Maize porridge	41	64.1	51	67.1		
Mtori	4	6.3	4	5.3		
Ugali	2	3.1	2	2.6		
Porridge and *makande*	2	3.1	3	3.9		
Total	**64**	**100**	**76**	**100**		
Time to introduce complementary food						
<2months	20	31.3	24	31.6	**29.047**	**0.024**
3months	18	28.1	24	31.6		
4months	2	3.1	3	3.9		
5months	4	6.3	4	53		
6months	20	31.3	21	27.6		
Total	**64**	**100**	**76**	**100**		
Exclussive breastfeeding						
Yes	46	71.9	57	75.0	**6.130**	**0.01**
No	18	28.1	19	25.0		
Total	**64**	**100.0**	**76**	**100.0**		

4.3 Morbidity

4.3.1 Prevalence of diseases

As shown in Table 8, all of children in the treatment and control groups, were sick 7-days prior to the study during baseline. During the intervention prevalence of morbidity was reduced at a higher rate in treatment than control group. In the first visit 56.5% of children were sick in the treatment group compared to 69.9% in the control group. The percentage of sick children was reduced, where during the second visit 32.5% and 42.7% children were sick in treatment and control groups respectively. During the last visit there were only 7.2% of sick children in the treatment group compared to 53.8% in the control group. This shows there was a significant difference ($P<0.05$) between the two groups at the last visit.

Table 8: Prevalence of diseases

Duration	Children	Treatment		Control		χ^2	p-value
		n	%	n	%		
Baseline	Sick	64	100	76	100	**35.66**	**0.224**
	Well	00	00	00	00		
	Total	**64**	**100**	**76**	**100**		
1st visit	Sick	52	56.5	61	69.9	**11.34**	**0.014**
	Well	10	43.5	13	30.1		
	Total	**62**	**100**	**74**	**100**		
2nd visit	Sick	31	32.5	43	42.7	**36.02**	**0.000**
	Well	33	67.5	31	57.3		
	Total	**64**	**100**	**74**	**100**		
3rd visit	Sick	14	10.0	39	33.57	**36.04**	**0.000**

Well	50	90.0	37	66.4 3
Total	**64**	**100**	**76**	**100**

4.3.2 Impact of supplementation on morbidity

Malaria, acute respiratory infections (ARI) and diarrhoea were found to be the most common childhood diseases in the unit. Generally, more than one disease was responsible for sickness in most children. The results in Figure 9 show that at baseline 13% of the sick children in the treatment group had diarrhoea. However, the figure dropped considerably to 1.4% at the end of the intervention while in control group a small change was observed from 8% at baseline to 1.3% at the end of intervation. About 21% of the sick children in the treatment group also had malaria during the baseline survey but the percentage was reduced significantly to merely 0.7% at the end of the intervention. Similar trend was also noted for the rest of the diseases in the treatment group as opposed to the control group.

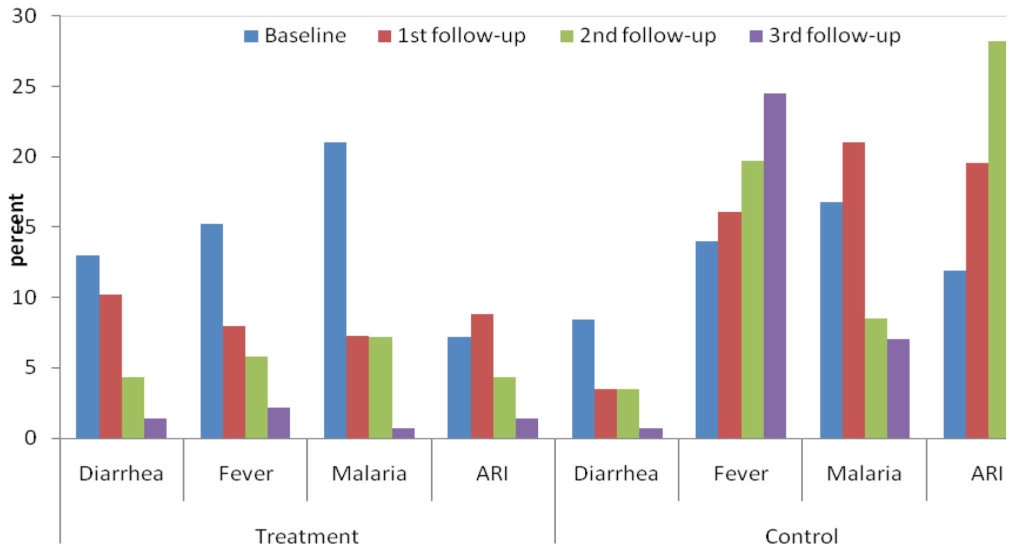


Figure 7: Impact of supplementation on morbidity

4.4 Child Care Practices During Illness

As shown in Table 9, 68.8% and 69.7% of the sick children in the treatment and control groups, respectively were fed on plain maize porridge during sickness, while 6.3% and 6.6% were fed on cow's milk in both treatment and control groups. Other feeds included breastmilk which was fed to 15.6% and 14.5% of the sick children in both groups, respectively. There was no significant different in the type of food fed in the treatment and control group ($p>0.05$). It was also observed that majority of sick children in treatment and control group were fed 4-6 times per day. When asked whether special foods are given to sick children, 14.4% of mothers of children in treatment group reported to usually feeding mashed potato while 30.1% of those in control group mentioned plain maize porridge. Other special foods for recuperating children included porridge and natural juice or milk.

Table 9: Feeding practices during illness

	Treatment		Control			
Feeding practice	**Frequency**	**Percent**	**Frequency**	**Percent**	**χ^2**	**P-value**
Breastmilk only	10	15.6	11	14.5	**25.68**	**0.425**
Porridge plain	44	68.8	53	69.7		
Milk	4	6.3	5	6.6		
Milk and vegetables	2	3.1	3	3.9		
Plain porridge,and fruits	2	3.1	3	3.9		
Breastmilk,mtori	2	3.1	1	1.3		
Total	**64**	**100**	**76**	**100**		
Feeding frequency						
2 times	2	3.1	3	3.9	**81.22**	**0.000**
3 times	6	9.4	3	3.9		
4 times	20	31.3	21	27.6		
5 times	13	20.3	16	21.1		
6 times	21	32.8	30	39.5		
8 times	2	3.1	3	3.9		
Total	**64**	**100**	**76**	**100**		
Special food for sick children						
Mashed potato	20	14.4	14	13.3	**46.50**	**0.862**
Plain maize porridge	9	6.5	33	30.1		
Porridge and milk	16	11.6	6	4.2		
Porridge and juice	19	12.3	23	16.1		
Total	**64**	**100.0**	**76**	**100.0**		

4.5 Effect of *moringa* Leaf Powder on Nutritional Status of Children.

4.5.1 **Weight**

Table 10 shows the mean weight increase of children aged 6-24 months from baseline, to first visit, second visit and at the end of intervention. There was a significant difference in weight increase ($p< 0.05$) between the two groups (treatment and control).

4.5.2 **Length**

Mean length at baseline was 68.7±4.4, 68.8±4.3 during the first visit,69.0±3.5 in the second visit and 70.1±3.7 at the end of intervention in treatment group and in the control group mean length of children which was 68.8±3.4,68.9±3.4 during the first visit,69.1±3.4 in the second visit and 70.2±3.4 at the end of intervention. There was no significant difference ($p>0.05$) in length increase between the two groups (treatment and control).

4.5.3 Haemoglobin concentration

The mean haemoglobin concentration in the treatment group was 7.4±1.8 at baseline, 8.7 ± 1.8 during the first visit, second visit was 9.9 ± 1.2 and 11.5±1.1 at the end of intervention and for the control group it was 7.1±0.8 at baseline, 7.1 ± 0.5 during the first visit, second visit was 7.2 ± 0.6 and 7.3±0.7at the end of intervention. There was no significant difference ($p>0.05$) in haemoglobin concentration at the baseline observed in treatment group and control group, but there was significant difference ($p<0.05$) between the two groups in haemoglobin concentration at the end of intervention.

4.5.4 Mid upper arm circumference (MUAC)

The mean mid upper arm circumference in the treatment group was 10.5±1.7 at baseline, 10.9 ± 1.9 during the first visit, second visit was 11.0 ± 0.8 and 11.3±0.9 at the end of intervention and for the control group it was 10.0±1.7 at the baseline, 10.2 ± 1.6 during the first visit, second visit was 10.3 ± 1.6 and10.4±1.5 at the end of intervention. There was no significant difference ($p>0.05$) in MUAC at the baseline between treatment and control group.

Table 10: Effect of *moringa* leaf powder on nutritional status of children.

	Study Groups		
	Treatment	Control	P-value
Weight (kg)			
Baseline	6.0±1.6	6.1±1.4	0.330
1st visit	6.2±1.3	6.2±1.3	0.290
2nd visit	6.8±1.4	6.3±1.3	0.020
Final	7.6±1.5	6.4±1.4	0.010
Length (cm)			
Baseline	68.7±4.4	68.8±3.4	0.411
1st visit	68.8±4.3	68.9±3.4	0.561
2nd visit	69.0±3.5	69.1±3.4	0.650
Final	70.1±3.7	70.2±3.4	0.089
Haemoglobin (Hg)			
Baseline	7.4±1.8	7.1±0.8	0.960
1st visit	8.7±1.5	7.1±0.5	0.777
2nd visit	9.9±1.2	7.2±0.6	0.003
Final	11.5±1.1	7.3±0.7	0.001
MUAC (cm)			
Baseline	10.5±1.7	10.0±1.7	0.194
1st visit	10.9±1.9	10.2±1.6	0.092
2nd visit	11.0±0.8	10.3±1.6	0.052
Final	11.3±0.9	10.4±1.5	0.023

4.6 Treatment Comparison Within a Group

Table 11 shows mean difference within a treatment group whereby there was a significant ($p < 0.05$) in weight increase. In haemoglobin, the mean difference within a treatment group shows that there was a significant ($p < 0.05$) in haemoglobin increase.

Table 11: Treatment comparison within a group.

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	P-value.
Weight	baseline			
	final	baseline	1.59062(*)	.000
		first	1.26436(*)	.000
		second	0.61315(*)	.017
	first	baseline	0.32627	.206
	second	baseline	0.97748(*)	.000
		first	0.65121(*)	.007
Length	baseline			
	final	baseline	1.46094(*)	.050
		first	1.34616	.057
		second	1.07378	.126
	first	baseline	0.11478	.871
	second	baseline	0.38716	.580
		first	0.27238	.680
Haemoglobin	baseline			
	final	baseline	4.05781(*)	.000
		first	2.74285(*)	.000
		second	1.29257(*)	.000
	first	baseline	1.31496(*)	.000
	second	baseline	2.76524(*)	.000
		first	1.45028(*)	.000
MUAC	baseline			
	final	baseline	0.82187(*)	0.001
		first	0.66239(*)	0.003
		second	0.31105	0.160
	first	baseline	0.15948	0.474
	second	baseline	0.51082(*)	0.021
		first	0.35134	0.093

* The mean difference is significant ($p < 0.05$)

Table 12: Control comparison within a group.

Mean difference within a control group whereby there was no significant difference (p> 0.05) in MUAC.at baseline and at follow up measurements.

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	p-value
Weight	baseline			
	final	baseline	0.50556(*)	0.039
		first	0.26877	0.252
		second	0.01470	0.950
	first	baseline	0.23679	0.313
	second	baseline	0.49086(*)	0.037
		first	0.25407	0.256
Length	baseline			
	final	baseline	1.33056(*)	0.024
		first	1.30061(*)	0.022
		second	1.13608(*)	0.044
	first	baseline	0.02994	0.958
	second	baseline	0.19448	0.730
		first	0.16453	0.760
Haemoglobin	baseline			
	final	baseline	0.64861(*)	0.000
		first	0.48246(*)	0.000
		second	0.30746(*)	0.023
	first	baseline	0.16615	0.217
	second	baseline	0.34115(*)	0.011
		first	0.17500	0.173

Table 12. continued.

MUAC	baseline			
	final	baseline	0.33333	0.210
		first	0.18960	0.457
		second	0.04948	0.846
	first	baseline	0.14373	0.572
	second	baseline	0.28385	0.265
		first	0.14012	0.564

* The mean difference is significant (p> 0.05).

4.7 Nutritional Status of children 6 to 24 months.

4.7.1 Underweight (weight-for-age)

Table 13 presents the mean Z-Scores of weight-for-age at baseline, first visit, second visit and end of intervention. The mean Z-Score of weight-for-age at baseline was -4.1±1.4 in treatment group, and -3.6±1.6 in control group (Figure 10). At baseline and first visit there was no significant different (p>0.05) between the two groups. Mean Z-score was -2.2±1.2 in treatment group and -3.3±1.7 in control group at the end of intervention. There was a significant difference in weight-for-age (WAZ) (p<0.05) between control and treatment groups at the end of intervention.

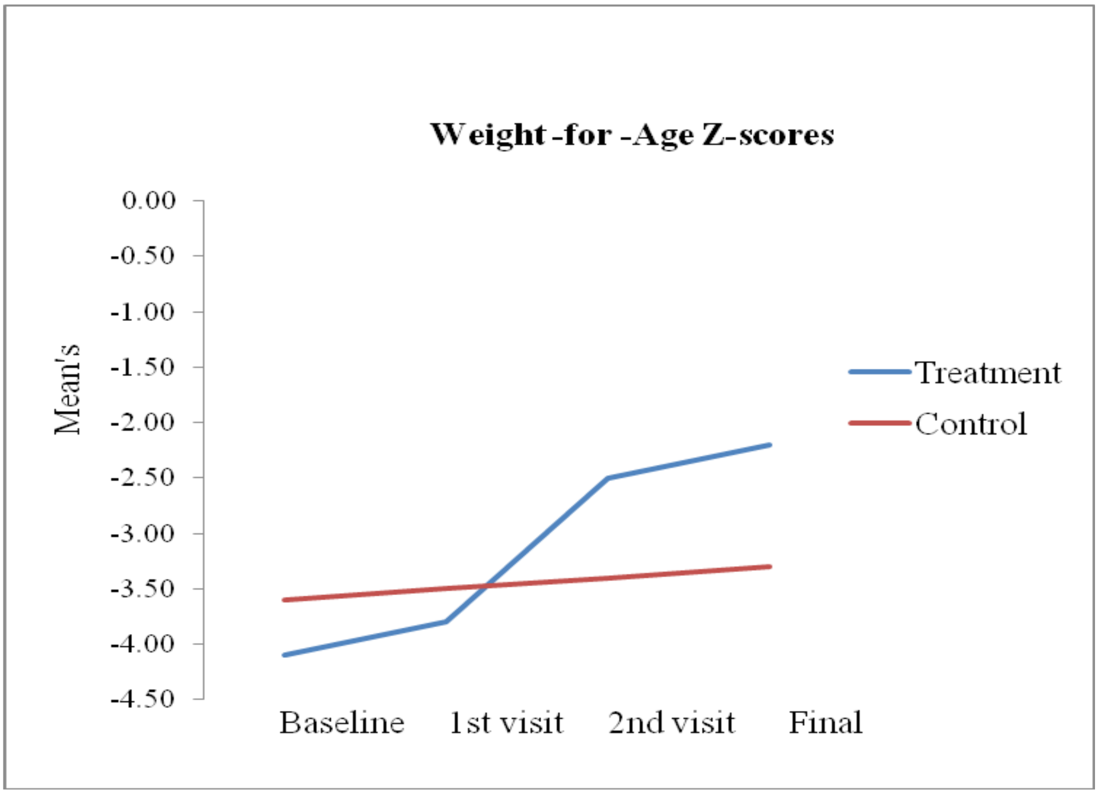


Figure 8: **Prevalence of underweight during intervention**

4.7.2 Prevalence of Wasting (weight-for-length) in children

The mean Z-Score of weight for length at baseline was -3.4±2.2 in treatment group, and -3.4±2.0 in control group (Fig. 11) Children showed no significant different in ($p > 0.05$) WLZ between the treatment and control group at baseline however, there was a significant difference ($p > 0.05$) at the end.

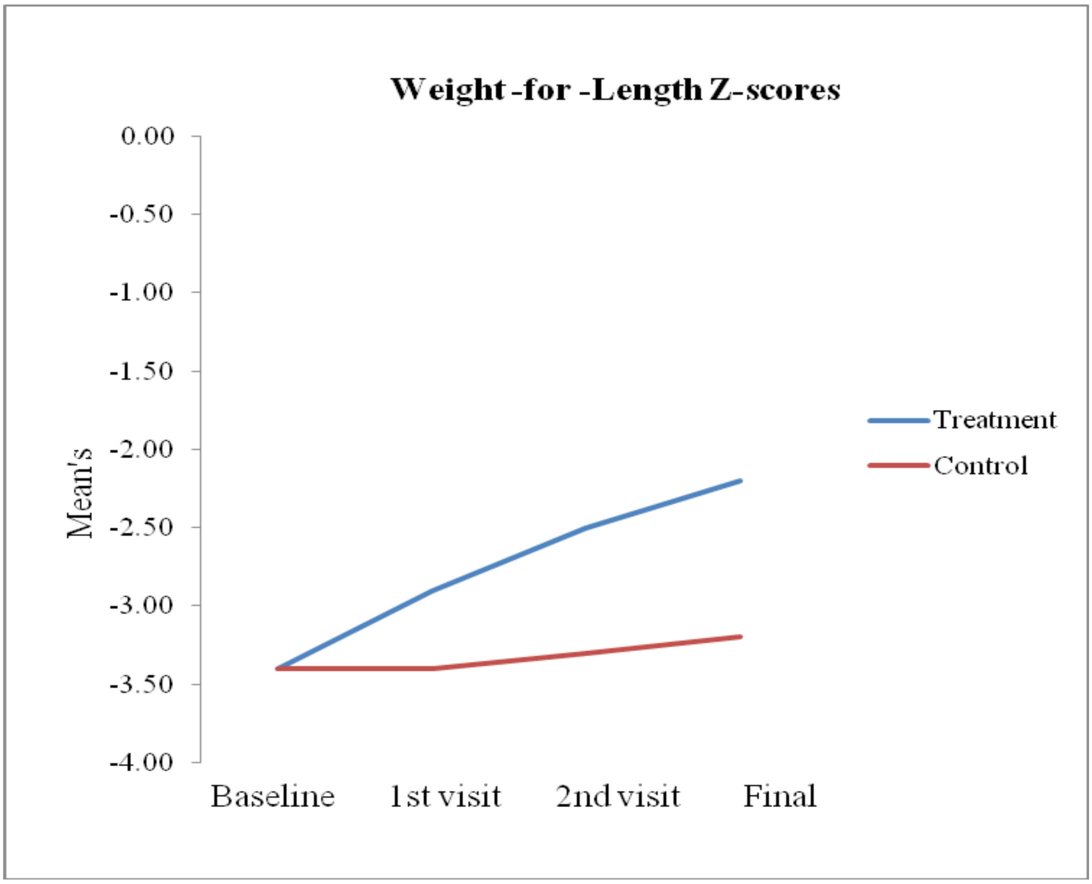


Figure 9: Prevalence of wasting during intervention

4.7.3 Prevalence of Stunting (length-for-age) in children

Low height for age is an indication of chronic under nutrition (shortness or stunting), which is frequently associated with poor overall economic conditions and or repeated exposure to adverse conditions. The mean Z-Score of length for age at baseline was -2.6±1.8 in treatment group, and -2.4±1.6 in control group (Fig. 12). At baseline, first and second visit there was no significant difference ($p>0.05$) between the two groups. Furthermore, there was no significant difference ($p>0.05$) in LAZ between the treatment and the control group at the end of intervention (Table 11).

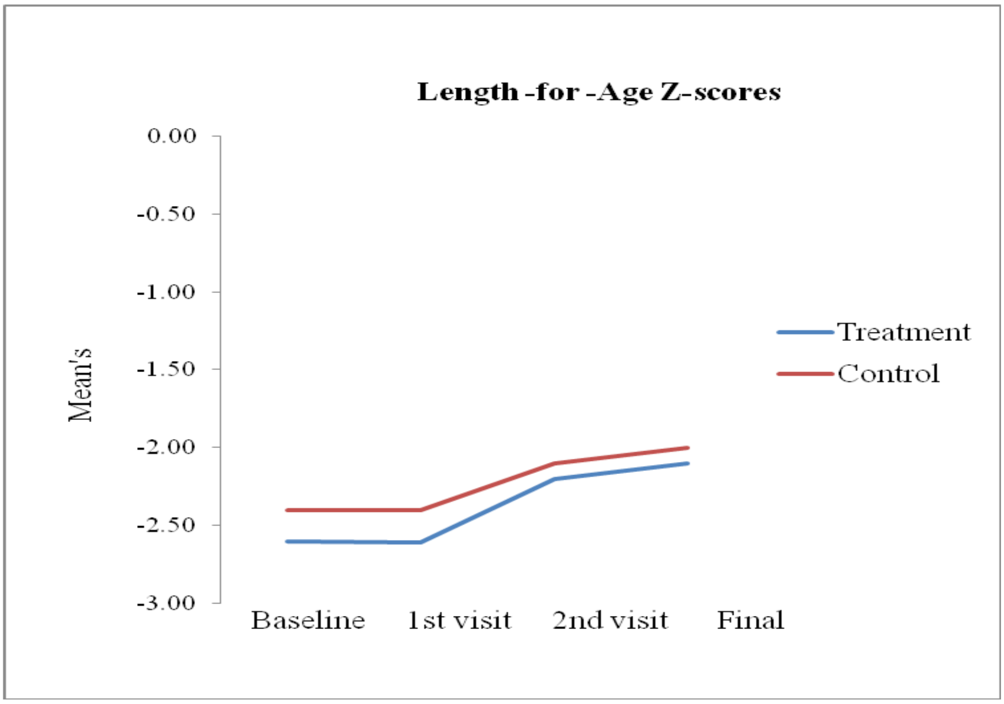


Figure 10: Prevalence of stunting during intervention

Table 13: Changes during intervention

Index	Treatment	Control	P-value
Change in WAZ			
WAZ baseline	-4.1±1.4	-3.6±1.6	0.054
1st visit	-3.8±1.3	-3.5±1.6	0.301
2nd visit	-2.5±1.2	-3.4±1.6	0.200
WAZ final	-2.2±1.2	-3.3±1.7	0.001
Change in LAZ			
LAZ baseline	-2.6±1.8	-2.4±1.6	0.940
1st visit	-2.5±1.8	-2.4±1.6	0.720
2nd visit	-2.2±1.9	-2.1±1.6	0.830
LAZ final	-2.1±2.0	-2.0±1.7	0.641
Change in WLZ			
WLZ baseline	-3.4±2.2	-3.4±2.0	0.886
1st visit	-2.9±2.3	-3.4±2.1	0.640
2nd visit	-2.5±2.3	-3.3±2.2	0.130
WLZ final	-2.2±2.4	-3.2±2.3	0.002

CHAPTER FIVE

5.0 Discussion

This chapter presents an interpretation on the findings of the effect of moringa leaf powder in improving nutritional status of infants aged between 6 and 24 months. The discussion is mainly based on research objectives, Child feeding practices, effect of *moringa* leaf powder supplementation on child's morbidity pattern and nutritional status.

5.1 Socio-demographic Characteristics of Subjects.

The results show that majorities (46.9%) of mothers of children treatment group were aged 18-25years while in the control group majority (47.4%) of mothers were aged 18-25 years which shows that the mothers were in their reproductive ages. On the type of household, male headed was dominating in both groups. This suggest that majority of households in Arusha urban are headed by men. During the survey, the information on education attain was collected on whether or not the respondent had been to school. In the treatment group 48.5% had attained one to seven years of education and 48.7% in control group. The findings show that a high proportion of respondents had been to school. This can be attributed to high enrolment rate due to the implementation of Universal Primary Education (UPE) since 1975 that gave every child the right to free primary education (TDHS, 2004). The mean house hold size for this study was 13 people. Large family sizes tend to strain food budget especially in household with low income resulting inadequacy of food needed to meet daily requirement. Generally the household size in the study area was higher than the national average which stands at 5 people (URT,1989).

5.2 Feeding Practice

Feeding practice is an important determinant of the children's nutritional status (WHO, 2003). It includes both breastfeeding practice as well as complementary feeding practices. It encompasses use of appropriate food in terms of quality, quantity and frequency at the right time taking into account the stages of development of a child.

5.2.1 Exclusive breastfeeding

Human milk is specifically composed to meet the nutritional requirements of the human infant and is considered the optimal nutrition source for the healthy newborns. In addition to the nutritional superiority of human milk, breast milk provides components necessary for the development of both active and passive immunity. It facilitates establishment of a strong bond between the mother and the child. Therefore exclusive breastfeeding is strongly recommended in the first four to six months of age of the infants to ensure that the infant gets all the benefits of breast milk (WHO, 2003). However, in many communities in developing countries and in the study area exclusive breastfeeding is not practiced effectively. In this study the mothers introduced food other than breastmilk to their children as early as below one to two months of age. The main foods given to these children included maize porridge, *mtori* and cow's milk.

In this regard, it is possible for children to be exposed to pathogens quite early in life due to poor handling of the complementary food. Early introduction of complementary foods and fluids tends to displace breastfeeding and thus lead to inadequate nutrient intake, lowering the immunity and causing frequent infections, and subsequent impaired growth (Kulwa *et al*., 2006).

5.2.2 Complementary feeding

After six months of exclusive breastfeeding, breast milk alone is no longer able to satisfy the child's increased nutritional and physiological requirements for energy and specific macro and micronutrients, therefore other foods should be introduced into the infant's diet (WHO, 2003). It was observed that at least 32% of infants below 2 months of age received pre-lacteal feeds. Some mothers gave complementary foods to their children as early as one month of age. The reason behind was that, mothers themselves did not get enough as well as balanced meals this means that, children got little breastmilk and as a result they cried frequently. To avoid the trouble caused by a child, mothers would supplement the child with other foods so that they can work comfortably and the babies can relax and stop crying. The most common complementary food fed to infants in the study area included those based on cereals such as maize, rice, and non-cereals foods such as yams, sweet potatoes and round potatoes. These starch based complementary foods (CFs) are characterized by a high water content, bulkiness and have low energy density and also contain small amounts of micronutrients, particulary iron and zinc which are required by children. The introduction of complementary feeding in addition to breast milk has an important implication for the health as well as nutritional status of the children. (Lartey *et al*., 1999). In the present study it was observed that cereal foods were the main foods fed to infants and children. Other foods which are fed, but in small quantities are, fruits, animal protein and fatty foods.

5.2.3 Feeding during sickness

During sickness usually nutrient requirements increase. Sickness involves loss of appetite and body weakness and therefore if feeding and caring practices for the sick are not optimal the effect of sickness and medication on the sick person becomes worse. This study results indicate that special foods are given to sick children these include mashed potato, plain maize porridge and juice which have less nutrients.

5.3 Morbidity

Malaria has been rated as number one killer disease in Tanzania (NBS and ORC Macro, 2005). As shown in this study the prevalence of malaria in infants was in more than 30% of infants. Most of the deaths occurring in children below five years and pregnant women are caused by malaria. As a preventive measure the mosquito nets are given free of charge to all pregnant women in Reproductive and Child health service (RCHS). Diarrhoea has been sighted as a serious disease to children's health. Each infant in this study had an episode of diarrhoea from birth to six months, which explains its high prevalence. Diarrhoea has a great impact on nutrient utilization by the body. In most cases this is due to unhygienic environments in the rural localities and unclean water. This problem requires more emphasis on awareness and nutritional education such as use of boiled water, clean utensils and better disposal of waste.

The results showed that at baseline 13% of the sick children in the treatment group had diarrhoea, figure dropped considerably to 1.4% at the end of the intervention This decrease in diarrhoea incidence could partly be attributed to the consumption of *moringa* leaf powder which contains multiple micronutrients such as iron, zinc, iodine and Vitamin A. Vitamin A and related retinoids are immune enhancers in development and differentiation of neutrophils, monocytes, lymphocytes and other immunological cells. Cells in immune systems require a large number of enzymes that need zinc to function (Allen and Shrimpton, 2005).

The incidence of diarrhoea, malaria, acute respiratory infection (ARI) was observed to be high in the study area. The disease frequency was reduced in both groups during intervention period. During the last visit there were only 7.2% of sick children in the treatment group compared to 53.8% in the control group. Supplementation with *moringa* leaf powder reduced the frequency of illness. This could be contributed to the presence of vitamin A, zinc and other micronutrient in *moringa* which have been shown to reduce both the frequency and the severity of diarrhoea and acute respiratory infection (Allen and Shrimpton, 2005). These micronutrients (zinc, iron and/or vitamin A nutrient) are likely to enhance absorption and utilization of energy and accelerated protein metabolism. Adequate intake of iron, zinc, vitamin A, iodine and other micronutrient is essential for prevention of diseases. Supplementation of children with *moringa* have been shown in study elsewhere a positive impact on reducing the prevalence and incidence of diseases like ARI and diarrhoea. (Smuts *et al.*, 2005).

5.4 Nutritional Status

5.4.1 Prevalence of anaemia

Result in the current study showed a significant difference ($p<0.05$) on increasing of haemoglobin level among treatment group and control group. The increase of haemoglobin concentration among the experimental group could be due to *moringa* leaf powder has high iron content of about 68.27g per 100g in *moringa* based on analysis done by Sokoine University of Agriculture. Iron content in *moringa* leaf powder can supplement daily requirement of an individual. Iron from breastmilk is not enough to meet child iron requirement after the age of 6months (Latham, 1997). Iron in *moringa* is in nonheme form where by its absorption is strongly influenced by its solubility in the upper part of the small intestine and solubility there depends in turn on the content of the meal as whole. Nonheme iron absorption is influenced by the solubility enhancer which is vitamin C (Bowman and Russel, 2001). *Moringa oleifera* has iron and at the same time it contains vitamin C. The presence of vitamin C and iron in *moringa* could be one factor which facilitated increase of haemoglobin concentration in the treatment group.

The majority (>60%) of the children consumed cereal based diets, which are known to have less iron and vitamin C but with substantial amounts of phytates and other antinutritional factors that bind iron and hence reducing its bioavailability. The vitamin C content of most cereal based meals is less than 1mg/100g. The low haemoglobin concentration among children might be caused by frequent illnesses including malaria and diarrhoea. Malaria parasites invade, multiply and destroy the red blood cells hence reducing the number of red blood cells (TFNC,1996). Diarrhoea often leads to rapid loss of nutrients through the gastrointestinal system therefore reduces absorption rate of nutrients (Mendoza *et al*., 2001).

5.4.2 Weight

Weight gain in the treatment group could be due to supplementation with *moringa* leaf powder which is known to boost the immunity of malnourished children and improve their health status. (Latham, 1997). Good health status promotes good bioavailabity of nutrient from various foods which lead to weight gain. A study done by Lowell (2000), malnourished child gained substantial weight in just two months. With *Moringa* as a supplement it saves money on buying other costly, high-protein foods because Moringa has the vitamins and nutrients children needs for staying healthy. Its leaves are an excellent source of vitamins A, C, iron, calcium, potassium, protein, magnesium, selenium, and zinc.

5.5 Change in nutrition status during intervention

5.5.1 Underweight

Undeweight denotes insufficient intake of energy and nutrients to meet an individual's needs to maintain good health Supplementation of children's diet with *M.oleifera* showed significant change ($p<0.05$) in WAZ between the treatment and the control group. This improvement could be attributed to the multiple micronutrients supplementation fed to children.

5.5.2 Stunting

Stunting of children at early age could have been caused by harmful cultural practices that contribute to inadequate dietary intake during pregnancy. Stunting is a very complex multi-causal problem caused by other limiting nutrients, it also reflects the cumulative effects of numerous insults experienced by children during pregnancy, infancy and early childhood beginning at birth and continuing through the initial 18 months after which is irreversible (Martorell *et al.*, 1995). Faltering in length extends through the first 40 months of life where in weight is concentrated between 3 and 12 months (Kulwa *et al*. 2006). Increase of stunting could be attributed to growth retardation during pregnancy. However, in another study by Lutter *et al.* (2006) there was a positive response whereby the prevalence of stunting decreased by -0.9 after supplementation. However the results showed that there is no significant change (p>0.05) in LAZ between the treatment and the control group infants in the control group. This could be due to the low level of energy intake from the traditional complementary foods, which provided only 55% of the energy requirements.

5.5.3 Wasting

Low weight for height is an indicator of acute undernutrition. It represents failure to receive adequate nutrition in the period immediately preceding the survey and may be the result of recent episodes of illness. Severe wasting is closely linked to mortality and morbidity risk and may reflect acute shortage of food. *M.oleifera* leaf powder porridge improved weight-for-length (WLZ) z-score of children in the treatment group and there was a significant difference (p<0.05) between the WLZ scores of children in the treatment and control groups at the end of the study. This trend was also observed by Kuusipalo *et al*. (2006) and Lutter *et al.* (2006).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In studying the effects of *moringa* leaf powder on improving nutritional and health status of malnourished children by comparing two groups it can therefore be concluded that there is a significant difference between subjects who use *moringa* leaf powder in complementary food compared with those who use maize flour. *Moringa* was found to have effects on increase weight and haemoglobin concentration among the study subjects who used *moringa* leaf powder. *Moringa* leaf powder contains high amount of vitamin A and significant qualities of vitamin C, calcium, iron, potassium, magnesium, selenium and Zinc. *Moringa* leaf powder promotes easy supplementation or as an addition supplement in food.

Findings from this study have showed that, *moringa* added on a daily basis to a child's food has the ability to bring about rapid recovery from malnutrition. Results suggest that, the prevalence of stunting is still high among children in this age group and this could be due to maternal undernutrition during pregnancy, which influences the growth in offsprings beyond the intrauterine period.

6.2 Recommendations

(i) Undernutrition is still irrefutably a serious problem in developing countries. The use of *moringa* is strongly recommended for addressing the problem of undernutrition among children in Tanzania. *Moringa* is a simple and readily available solution to the problem of malnutrition.

(ii) People should be trained in a way of preparing the leaf sauce so that the maximum of their vitamin and mineral content is retained, and encouraging families to use the leaf powder as a multi-vitamin and mineral food supplement would go a long way towards eliminating micronutrient deficiencies.

(iii) Long-term investment, which is deemed cost effective, should be directed to nutrition of infant and or pregnant mothers so as to have healthy pregnancy outcome.

(iv) The usefulness of indigenous knowledge on local foods can not be ignored in designing rural nutrition interventions. This approach provides a more sustainable way of improving the nutritional status of the malnourished children by using moringa leaf powder since *moringa* is affordable by most of the people and is found in our areas.

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APPENDICES

Appendix 1 Sample size determination

The sample size was obtained by using an assumed rate of growth faltering of 40% since the chronic malnutrition rate is 25.4% (NBS, 2007). The equation will be used to determine the sample size. (CDC and WFP, 2005)

The assumptions you need to make before calculating the sample size include:

p_1 The estimated proportion derived from survey 1

p_2 The estimated proportion derived from survey 2

α Level of significance (“alpha”), usually 0.05 or 5% (corresponds with 95% confidence interval); therefore, $Z_{\alpha/2}$ usually equals 1.96.

1- β Power, usually 0.8 (80%); therefore, $Z_{1-\beta}$ usually equals –0.842.

DEFF Design effect resulting from cluster sampling which is 1

The formula is:

$$n = DEFF \times \frac{\left[Z_{\alpha/2}\sqrt{2\bar{p}(1-\bar{p})} - Z_{1-\beta}\sqrt{p_1(1-p_1)+p_2(1-p_2)}\right]^2}{(p_1-p_2)^2}$$

Where,

$$\bar{p} = \frac{p_1 + p_2}{2}$$

p1 – p2 = the smallest difference between the prevalence rates derived from each survey which should be statistically significant.

$Z_{\alpha/2}$ the *z* value for the level of significance (usually 1.96)

$Z_{1-\beta}$ the *z* value for the power (usually = –0.842)

Appendix 1a:

Explanation given to mothers/caregivers concerning the study

1. **Purpose of the study:** This research is going to determine the effect of moringa leaf porridge on improving nutritional status of children aged 6-24months. The main objective of the study is to improve nutritional status of infants. Specific objectives are; Assessment of feeding practices for 6-24month children, to assess the effect of supplementing Moringa leaf powder on nutritional status. and to assess the effect of supplementing moringa leaf powder on haemoglobin concentration.This study is done in collaboration with Sokoine University of Agriculture department of food science,and Mt.Meru hospital.

2. **Study procedure**: If you agree your child to participate in this study, please respond to my questionnaire and provide the required information. I will ask your permission to take your child's body measurements including weight, length, mid upper arm circumference and the blood will be drawn to measure the hemoglobin level at the beginning and at the end of the study. Then follow up will be done monthly to measure the weight, length and Muac for four months .

3. **Risk and discomfort:** Hardly any risk is expected but the child will fill pain during finger pricking to take blood sample. If the child is happen to be allergic to moringa leaf powder will need medical attention and can withdrawn from the study.
4. **Benefits:** It is expected that there will be direct benefit to a child where by the nutritional status will be improved and enhance motor development.
5. **Compensation:** You will not be given any allowances for your child participating in the study.
6. Confidentiality: confidentiality will be maintained.

Statement of consent

I have read the above information or it has been read to me. I have had the opportunity to discuss this research study with researcher, and I have had my questions answered by her in a language I understand .I let my child to take part in this study of my own free will.

Agreement to take part in the study:

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Name of caregiver of child Signature/thumb print Date

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Name of researcher Signature Date

1.b Translated Consent Form

Kichwa cha tafiti: Kutathimini umuhimu wa majani ya moringa katika afya na ukuwaji wa watoto wenye umri kati ya miezi 6- 24.

1. **Dhumuni la tafiti:** Tafiti hii italinganisha umuhimu wa majani ya moringa katika kuboresha lishe na afya ya watoto. Dhumuni kuu la tafiti hii ni kuangalia ukuaji wa mtoto kwa kutumia uji wa majani ya moringa. Madhumuni mengine ni kuchunguza njia mbalimbali za kulisha watoto; kuangalia upokeaji na kukubali matumizi ya juisi kwa wakina mama wenye watoto,kutathimini uwezo wa juisi katika kuongeza lishe bora ya watoto. Tafiti hii inafanyika kwa ushirikiano baina ya Kitengo cha Sayansi ya Chakula kilichopo Chuo cha Kilimo cha Sokoine, kwenye kituo cha afya cha Mt.Meru.
2. **Njia za kufanya tafiti**: Kama mzazi atakubali mtoto wake ashiriki katika tafiti hii, atalazima kutoa ushirikiano katika kujibu dodoso na kutoa taarifa nyingine muhimu zitakazohitajika. Vile vile mzazi ataombwa kutoa ruhusa ili mtoto wake aweze kufanyiwa vipimo mbalimbali kama vile kupimwa uzito,urefu, na damu kwa ajili ya

kuangalia kiasi cha damu mwanzo na mwisho wa tafiti. Ufuatiliaji utafanyika kila mwezi kwa kupima uzito,urefu kwa muda wa miezi mitatu.

3. **Hatari na maumivu:** Hakuna hatari yoyote itakayo tokea isipokuwa mtoto anaweza kusikia maumivu wakati wa kuchukuliwa damu.

4. **Faida za tafiti:** Inategemewa kuwepo kwa faida ya kiafya moja kwa moja kwa mtoto ambapo mtoto ataongezeka ukuaji kwa kupata uji huu.

5. **Fidia:** hakutakuwepo kwa fidia au malipo yoyote kwa mtoto kushiriki katika tafiti hii.

6. **Usiri :**utazingatiwa na matokeo ya tafiti hii yatatumiwa na wote walioshiriki na jamii yote pia.

Maelezo ya kuridhia:

Nimesoma maelezo yaliyotolewa hapo juu,nimepata nafasi ya kujadili na mtafiti na nimepatiwa majibu na ufafanuzi ya kila swali nililouliza juu ya tafiti hii.Nakubali na naridhia kwa utashi wangu mtoto wangu ashiriki katika tafiti hii.

Nakubali kushiriki katika tafiti hii:

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Jina la Mshiriki	**Sahihi/ Dole gumba**	**Tarehe**
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Jina la Mchunguzi/Mtafiti	**Sahihi**	**Tarehe**

Appendix 2) Study questionnaire

SECTION A: PARENT'S AND HOUSE HOLD INFORMATION

1. Age of mother……………..(yrs)Age of father…………..(yrs)
2. Type of the household? 1. Female headed…………….2. Male headed…………..
3. Marital status? 1. Married 2.Single 3. Divorced 4.Cohabit
4. Education level (number of years gone to school).Mother…………..Father…………
5. Occupation of the head of the household? 1. Farmer 2.self employed 3.Paid employed 4.Casual labour 5.Others (Specify)……….
6. What is the main type of staple food for the household 1.Own production? 2. Buying
7. Total number of people in the household (including yourself)……………
8. Total number of children under the age of 5years.

SECTION B: CHILD'S INFORMATION

1. Child' s name…………….
2. Sex; 1.Male 2.Female
3. Date of birth …………..
4. Birth weight (kg)……….
5. How long after giving birth did you stay before putting your child to the breast? 1. Immediately 2. Less than 1hour 3.less than 24hrs 4.More than 24hrs
6. Are you still breastfeeding your child. 1. Yes 2. No
7. If yes, how many times do you usually breast feed your child during the day…..night….

SECTION C: FEEDING PRACTISES

1. What are you currently feeding your child? 1. Breastmilk only 2. Breastmilk and water, or juice 3. Breastmilk and plain porridge. 4. Other(specify)…………..
2. At what age (month) did you start to give your child to fluids and foods other than breast milk?.......

3. What type of foods/fluids did you use to start complementing breastfeeding your child? (mention type of food and fluids and their ingredients……
4. Did you continue to breastfeed the child as you introduced other foods and fluids?1. Yes 2. No
5. How many times did your child eat yesterday including breastfeeding,meals and snacks.Brefeeding………….(times) Meals …………….(times).Snacks……..(times)
6. What do you think is the best number of times to feed young children per day apart from breastfeeding?
7. What types of foods are normally given to a child when the child is sick? 1. Breastmilk only 2. Water 3. Porridge 4. Others (specify)……………..
8. Are there foods you don't give when child is sick? 1. Yes 2. No
9. When your child falls sick how many times you feed your child…….

SECTION C: MORBIDITY INFORMATION

1. Has this child been sick in the past seven days? 1. Yes 2. No
2. If yes what is the illness?.............................
3. Is the baby using the formular?................
4. If yes,what disease did the child suffering from……………..
5. If no,what disease did the child suffering from………………

SECTION D: CHILD'S NUTRITIONAL STATUS

Weight (kg)……………length(cm)……………MUAC (cm)…………….Hb(hg)………….

(Appendix 3) Composition of *M.oleifera* leaf powder and 4whole Maize meal

Nutrient	**Moringa leaf powder (25g)**	**Whole maize meal (100g)**
Energy	51.2kcal	345
Proteins	6.7g	9.40
Lipids	0.5g	4.20
Carbohydrate	9.55g	
Fiber	4.8g	
Calcium	500mg	16mg
Phosphorous	51mg	220mg
Potassium	331mg	250mg
Magnesium	84.6mg	
Zinc	12.9mg	
Copper	0.15mg	
Iron	7.05mg	36mg
Iodine	92mcg	
Selenium	27.9mcg	
Sodium	<267mg	5mg
Vitamin A	4.07mcg	
Vitamin D	0.6mcg	
Vitamin E	28.25mg	
Vitamin C	4.3mg	
Vitamin B1	0.6mg	0.33mg
Vitamin B2	5.1mg	0.10mg
Vitamin B3	0.55mg	0.20mg
Arginine	331.25mg	
Histidine	153.25mg	
Lysine	331.25mg	
Tryptophan	106.25mg	

Phenylanaline	347mg	
Methionine	87.5mg	2.2mg
Threonine	297mg	
Leucine	206mg	
Valine	265.75mg	
Total		

Source; FAO, (1998).Food composition table for energy;*Moringa oleifera: Natural Nutrition for the Tropics* by Lowell F. (2000)