EFFICACY OF HOME-MADE FOODS FORTIFIED WITH MICRO-NUTRIENT POWDER IN REDUCING IRON DEFICIENCY ANAEMIA AMONG CHILDREN AGED 6 - 59 MONTHS IN KILOSA DISTRICT, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF THE MASTER OF SCIENCE IN HUMAN NUTRITION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

Iron deficiency anaemia among under-five children is still a public health problem in developing countries. A longitudinal, randomized, controlled study involving 382 children was conducted in two wards of Kilosa District, Tanzania to determine the effectiveness of a daily home fortification of complementary foods with MNP in reducing IDA among children six to 59 months. The intervention group (n = 191) received 90 sachets of micronutrient powder (10 mg of iron) taken as one sachet daily for three months. The control group (n = 191) did not receive the MNP until after the intervention period. Blood HB concentration and anthropometric measurements were taken at the baseline and monthly thereafter, for a period of three months. Data were analysed using ENA for SMART program, Excel for Windows and SPSS programs. Results showed that, from baseline to the end of the intervention, the mean HB concentration in the intervention group increased by 1.1g/dl, and decreased by 0.2g/dl in the control group ($P < 0.00$). Prevalence of IDA in the treatment group decreased from 100 to 28.6% whereas for the control group, IDA decreased from 100 to 96.4% ($P < 0.01$). No significant effect ($P > 0.05$) was found on the prevalence of wasting (WHZ), stunting (HAZ), and underweight (WAZ). Compliance in the use of the MNP for the intervention group was high in children who consumed more than 80 sachets in the whole study period. It was concluded from the study that, with high compliance and good control of malaria and hookworm as confounders of IDA, use of MNP taken daily for three months is effective in improving the HB status of children and can reduce the prevalence of IDA in under-five children. Mothers/caregivers noted that, supplementing children with MNP resulted in weight gain, children became more active and increased children appetite, reduced the episodes of illness, decreased the demand for breastfeeding and enhanced day and night sleeping. It is recommended based on this study that, in populations where prevalence of anaemia in children under the age of five years is 20% or higher, home food fortification of

complementary foods with MNP should be introduced. Introduction of MNP can be a very effective intervention for IDA among infant and young children.

DECLARATION

I Mcharo, Rehema do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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DEDICATION

To my supporting father and mother, who in their love, understanding and subtle ways initiated, drove and inspired me to pursue my education.

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LIST OF ABBREVIATIONS AND SYMBOLS

ACC	Administrative Committee on Coordination
CCHP	Comprehensive Council Health Plan
CI	Confidence Interval
ENA	Emergency Nutrition Assessment
FAO	Food and Agriculture Organization
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GIT	Gastro-intestinal Tract
HAZ	Height- for-Age-Z- score
Hb	Haemoglobin
HC	Head Circumference
IDDS	Individual Dietary Diversity Scores
Kg	Kilogram
M	Metre
MNP	Micronutrients Powder
MoHCDGEC	Ministry of Health, Community Development, Gender, Elderly and Children
NBS	National Bureau of Statistics
SCN	Sub-Committee on Nutrition
SMART	Standardized Monitoring and Assessment of Relief and Transitions
SPSS	Statistical Package for Social Sciences
TAS	Tanzanian shillings
TDHS	Tanzania Demographic and Health Survey
TFNC	Tanzania Food and Nutrition Centre

UN	United Nations
UNICEF	United Nations Children's Education Fund
UNU	United Nations University
USA	United States of America
WAZ	Weight-for-Age Z-score
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization
WHZ	Weight-for-Height/length Z-score

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Iron deficiency, the most prevalent nutritional deficiency in the world, has a significant negative impact on the health and development of young children. In a study assessing the global and national burden of diseases in children, iron deficiency anaemia was identified as a leading cause of disability in children and adolescents, affecting > 600 million children globally in 2013 (Global Burden of Disease Pediatrics Collaboration *et al.*, 2016). Iron requirements are actually higher for infants and young children. It is recommended that, children from 6 to 23 months of age should receive 9.3 mg of iron per kg body weight per day and children from 24 to 59 months of age should receive the same dose, up to a maximum of 30 mg per day, for 3 years. However, there is a discrepancy between the infants' nutritional requirements at this younger age and the nutrients that they are actually receiving (Scott, 2001). Infant and young children in the developing countries are particularly at risk for iron-deficiency anaemia, as their diets typically consist of foods low in animal sources. Animal foods are the best sources of iron, zinc and vitamins. Iron deficiency anaemia during early childhood is associated with increased risk of death, reduced immune function and impaired cognitive, motor and social development (Gleason and Scrimshaw, 2007).

Anaemia in children is a major public health problem in both developed and developing countries. In Tanzania Overall, 58% of children ages 6 - 59 months are anemic with hemoglobin less than 10.98 g/dl. The most common form of anaemia in Tanzania is moderate anaemia (30%). Anaemia is highest in children age 9 - 11 months and those whose mothers have no formal education. Prevalence of anaemia among children in

Tanzania has decreased in the past decade, from 72% in 2004-05 to 58% in 2015-16 (NBS, 2015). Other causes of anaemia, such as hookworm infestation and malaria infection, are not highly prevalent in Tanzania. It has therefore been assumed that, anaemia is predominantly caused by deficiency of dietary iron. Iron deficiency is likely to be widespread among women and children, as deteriorating socio-economic conditions force a large proportion of families to consume diets low in meat. A recent study by Roba *et al.* (2016) found out that, only 16.2% (n = 31) of children were fed with foods containing meat in the previous 24 hours prior to their survey.

UNICEF/ WHO /UNU (2001) suggested that, when prevalence of anaemia is greater than 40% in a population of a certain gender and age range, virtually the entire population for this age and gender group is likely to have some degree of iron deficiency. As the prevalence of anaemia among children below five years of age in Tanzania is estimated to be 58% (NBS, 2015), it is reasonable to conclude that nearly all children in this age group have some degree of iron deficiency. Current strategies to improve micronutrient status include increasing dietary diversification, nutrient supplementation, bio-fortification of crops, and fortification of staple foods (Allen *et al.,* 2006; Bhutta *et al.,* 2008; Olney *et al.,* 2009; Rebhan *et al.,* 2009). None of these strategies specifically target iron-deficiency anaemia in young children aged 6 - 59 months, which is the age group most susceptible to anaemia.

In recent years, an alternative method of delivering iron has been developed by the Sprinkles Global Health Initiative at the Hospital for Sick Children in Toronto, Canada. This innovative method involves the use of micronutrient sprinkles, a mixture of iron and other micronutrients (zinc, vitamins A and C, and folic acid) in powder form, to fortify home-made complementary foods. The powdered micronutrients, packaged in single-serving sachets, are sprinkled over semisolid foods just before it is consumed. This enables families to improve the nutrient content of complementary foods prepared at home (Lundeen *et al.*, 2014).

The efficacy, safety and acceptability of MNP for infants and young children have been demonstrated through several community-based studies in multiple countries around the world. MNP have proven to be as efficacious as the standard iron syrup/drop in treating and preventing anaemia in young children, with cure rates ranging from 55 to 90% (Zlotkin *et al.,* 2005). Additionally, MNP can have considerable advantages over iron drops and syrups in terms of compliance, convenience, acceptability, cost, incorporation of other micronutrients, and reduced side effects (Zloktin and Schauer, 2003; Zloktin *et al.*, 2004). Based on international evidence for the efficacy of micronutrient powder, this study was conducted to determine the effectiveness of micronutrient powder in reducing iron deficiency anaemia among children aged 6 - 59 months in Kilosa District, Tanzania with the eventual goal of providing policy and programmatic recommendations to guide future decision making on scaling up MNP supplementation intervention in nutritionally vulnerable districts.

1.2 Problem Statement and Study Justification

Iron deficiency anaemia during early childhood is associated with increased risk of death, reduced immune function and impaired cognitive, motor and psycho-social development (Gleason and Scrimshaw, 2007). Iron is essential for cognitive development in children and low iron intake can contribute to anaemia. Millions of children fail to reach their growth/ development potential because they have been deprived of essential nutrients for healthy growth and brain development (UNICEF, 2001). Iron deficit child often misses class and do less well at school and can lose an average of 13.5 IQ points and is less productive in later life, since he/she become short and weak adults who cannot work hard. This makes it very difficult for poor households to escape from the poverty cycle (Melse-Boonstra and Mwangi, 2016). About 58% of Tanzanian children aged 6-59 month have anaemia mainly due to iron deficiency anaemia (NBS, 2015).

Complementary foods are often carbohydrate-based and lack sufficient protein, minerals and vitamins. Dietary diversity is low, the main dish is usually plain porridge meal made from maize, sorghum or cassava flour. Consequently, intake of several vitamins and minerals is insufficient to meet the child's nutrient requirements, thus increasing the risk of developing iron-deficiency anaemia. Only 21% of children aged 6 - 23 months in Kilosa received nutritionally adequately complementary feeding as recommended (NBS, 2010). Three quarters (74%) of children in Tanzania live in multi-dimensional poverty (UNICEF/NBS, 2015). Iron rich foods are expensive as deteriorating socio-economic conditions force a large proportion of families to consume a diet low in meat. According to MoHCDGEC (2015) over one-third of children age 6 - 23 months ate foods rich in iron the day before the survey and only 2% of children age 6 - 59 months received an iron supplement in the week before the survey. Home food fortification with micronutrients powder is cost effective intervention that can provide more than 15 vitamins and minerals per single serving, which is difficult to obtain in locally homemade foods.

Traditional practices, which include giving black tea to young children starting at early infancy increases the risk of iron-deficiency. Tannic acid in black tea is a known inhibitor of non-heme iron absorption that can inhibit absorption of non-heme iron by 79 - 94% (Hurrell *et al.*, 1999). Most of Tanzanian households obtain dietary iron from plant based diets. Non-heme iron accounts for about 90% of total dietary intake, while heme iron constitutes only 10% of iron intake. Majority of families in rural areas of the country use locally milled maize flour and second-grade wheat flour for making bread and noodles. This wheat flour is high in phytate (also a known inhibitor of iron absorption). Fortification of staple flours with iron and other micronutrients is still limited in many areas of Tanzania.

Every year, deficiencies of iron, vitamin A and folic acid alone cost Tanzania over US$ 518 million, which is about 2.65% of the country's GDP (World Bank, 2015). Childhood iron deficiency anaemia alone is associated with a 2.5% drop in adult wages (World Bank, 2015). Recent reports estimated that, every one shilling invested in food fortification in Tanzania can result in an increase in GDP of 0.58%. In addition, almost 6,800 deaths per year would be averted by supplementing young children and infants with foods fortified with micronutrients powder (World Bank, 2015).

Children in Kilosa as in the other parts of Tanzania, suffer from multiple micronutrients deficiencies. Therefore, fortifying their semi-solid foods that are consumed daily in their homes with micronutrients powder can offer inexpensive, immediate way to reduce the severity of the problem. This study was aimed to increase the micronutrients content of the child meal without changing their usual dietary habits.

1.3 Objectives of the Study

1.3.1 Overall objective

To assess the efficacy of homemade foods fortified with micronutrient powder (MNP) in reducing iron deficiency anaemia among children aged 6 - 59 months in Kilosa district, Tanzania.

1.3.2 Specific objectives

(i) To determine anthropometric measurements (weight, length/height and head circumference) of children 6 - 59 months in Kilosa district.

(ii) To determine iron status of children under the age of five years (receiving and not receiving iron supplement) in Kilosa district.

(iii) To access maternal perception of benefits and side-effects of MNP fed to their children for a period of three months.

1.4 Hypothesis

H0: MNP as a nutritional supplement cannot reduce the prevalence of iron deficiency anaemia among children aged 6 - 59 months.

Hi: MNP as a nutritional supplement can reduce the prevalence of iron deficiency anaemia among children aged 6 - 59 months.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Nutrition and Child Growth

Adequate nutrition during infancy and early childhood is fundamental to the development of each child's full human potential (Mekbib, 2014). It is well known that, from birth to two years of age is "critical window" for optimal growth in health, cognition and behaviour. Longitudinal studies have consistently shown that, 0 - 2 years is the peak age for growth faltering. Deficiencies of certain micronutrients and common childhood illnesses such as diarrhea can result in stunting which is very difficult to reverse after the age of 2 years (Mekbib, 2014).

Immediate consequences of poor nutrition during these formative years include morbidity and mortality and delayed mental and motor development. In the long-term, early nutrition deficits are linked to impairments in intellectual performance; reduced adult income, high risk of chronic diseases related to nutrition, reduced off-spring birth weight, shorter than normal adult height and overall poor health during adolescence and adulthood (Dewey, 2001).

2.2 Infant and Young Child Feeding

Feeding is an important determinant of the children's nutritional status. It includes both breastfeeding as well as complementary feeding. It encompasses use of appropriate foods (quality, quantity and frequency) at the right time, taking into account the stage of child development (Black *et al.*, 2006).

2.2.1 Breastfeeding practices

Early and exclusive breastfeeding is the foundation of good nutrition and protects children against diseases (Series, 2012). An exclusively breastfed child is 14 times less likely to die in the first six months of life than a non-breastfed child. Breastfeeding drastically reduces deaths from acute respiratory infections and diarrhea, two major child killer (Scott, 2001). Studies have shown that, breastfed children do better on intelligence and behaviour tests into adulthood than formula-fed babies (Series, 2012). Despite these well documented benefits of breastfeeding, NBS (2016) reported that, the proportion of children who are not exclusively breastfed for up to six month in Tanzania is very high (41%). Among these children, 73% are given complementary foods at age 4 - 5 months, 49% at age 2 - 3 months and 11% at age 0 - 2 months (MoHCDGEC, 2015).

2.2.2 Complementary foods

Around the age of 6 months, infant 'needs for energy and nutrients start to exceed what is provided by breast milk. Complementary feeding becomes necessary to fill the gap of energy and other nutrients (Daelmans *et al.,* 2003). It is recommended that, breastfeeding should continue with adequate complementary feeding up to 2 years or beyond (Daelmans *et al.,* 2003). If complementary foods given do not provide adequate nutrients, the growth of the child may start to falter (Daelmans *et al.,* 2003). Both breastfeeding and complementary feeding can have direct or later consequences on the health of the child (WHO, 2011a). According to NBS (2010), 21% of children aged 6 - 23 months in Tanzania receive nutritionally adequately complementary feeding.

2.2.3 Water and sanitation

Water and sanitation improvements, in association with hygiene behaviour change, can have significant effect on the health of children by reducing a variety of diseases such as diarrhoea, intestinal helminthes, guinea worms and skin diseases. These improvements in health can, in turn, reduce morbidity and mortality and improve nutritional status. Water and sanitation affect health primarily by reducing the transmission of disease agents. Increase in the quantity of water allows for better hygiene practises. Increasing the quality of drinking water reduces the ingestion of pathogens. With fewer diseases, children can eat and absorb more nutrients from foods, thereby improving their nutritional status (Berkley, 2002).

2.3 Dietary Diversity

Dietary diversity is defined as the number of different foods or food groups consumed over a given reference period (Sthapit, 2004). Definition of dietary quality varies widely, but historically, it has been used to refer to nutrient adequacy (Arimond *et al.,* 2010). Nutrient adequacy refers to a diet that meets requirements for energy and all essential nutrients (Torheim *et al.,* 2004). The growing concern in developed countries as well as in countries in nutrition transition regarding over nutrition and excess intake of certain nutrients and foods has led to a global shift in the definition of dietary quality to include both concepts of nutrient deficiency and over nutrition (Sawadogo *et al.*, 2006). Nutrient adequacy refers to the achievement of recommended intake of energy and other essential nutrients. The dietary diversity among children in Tanzania is still low. At national level only 24.5% of children aged 6 - 23 month received foods from 4 or more food groups per day (TFNC, 2014).

2.3.1 Dietary diversity and family income

As income increases people tend to diversify their diets (Torheim *et al.,* 2010). Diversity also significantly improves dietary quality and the likelihood that individuals will meet their daily nutrient requirements, especially micronutrients. Dietary diversity is a good proxy for income/expenditure and food security (Vandevijvere *et al.,* 2010). World Bank (2015) report, 28.2 % of the Tanzanians population (12 million) lives in poverty with 70 % of the people living with less than 2 USD per day income.

2.3.2 Dietary diversity and nutritional status of children

Nutritional status is considered as an outcome of biological processes that involve food utilization while dietary diversity ensures adequate nutrient intakes (Steyn *et al,* 2006; Azadbakht and Esmaillzadah, 2010). Dietary diversity has a direct relationship with favourable nutritional status since it is associated with a number of improved outcomes such as nutrient adequacy, anthropometric indices and improved hemoglobin concentration. Studies in Mali and Kenya showed a strong association between dietary diversity and children's nutritional status (Hatloy *et al.,* 2000; Swindale and Bilinsky, 2006).

2.4 Cooking Practices

Various ways in which cooking affects vegetables should be thoroughly understood by the housewife (Severi *et al.,* 1998). Some cooking methods conserve the food nutrients whereas others lead to loss of the nutrients, thus directly affecting the nutritional status of the child (Severi *et al.,* 1998). Water-soluble vitamins such as vitamins C and B group are the most vulnerable to degradation during processing and cooking (cooking for a long time, discarding the cooking water) (Beck *et al.,* 2014). High bioavailability of dietary iron can be achieved by increasing the content of food components that enhance iron absorption such as ascorbic acid, meat/fish (Beck *et al.,* 2014).

2.5 Food Shortage

Food shortage occurs when the population does not have the ability to sustain its food requirements (Radimer *et al*., 1992). More than 84 and 64% of the Tanzania residing in rural and urban areas, respectively, faced food shortages between September 2016 and

February 2017 (Twaweza, 2017). Prices of maize doubled in the past two years, from TZS 400 per kilogram in early 2015 to TZS 852 in December 2016, to 1 253 per kilogram in early September 2016 and February 2017 (Bank of Tanzania Monthly Economic Reports, 2017). The common staple food for more than 93% of Morogoro residents is stiff porridge made from maize flour (Jane, 2011). Increase in prices of maize adversely affect food intake at the household level.

2.5.1 Effect of food shortage on child nutrition

Household food shortage has been pointed out as a possible underlying determinant of wasting and underweight (Avan *et al.*, 2015). Nepal Nutrition Profile report shows that, children in food-secure households have the lowest rates of stunting (33%), while children in food-insecure households have stunting rates of up to 49% (Khatri-Chhetri and Maharjan, 2006). In a longitudinal study in rural Bangladesh, household food shortage was associated with increase in the prevalence of wasting and underweight among infants and young children aged 6 - 59 month (Ali *et al.*, 2015). Moreover, poor dietary quality or diversity is a significant contributing factor to malnutrition, especially, micronutrient deficiencies (Osei *et al.*, 2010). Another study conducted in South Africa among children, showed that there is a strong association between household food shortage and being underweight and wasted (Naser *et al.*, 2014). Another study conducted in Western Ethiopia on the nutritional status of under five children showed a strong association between food shortage and increase in the prevalence of underweight and iron deficiency anaemia but not with stunting and wasting (African, 2015).

2.5.2 Causes of food shortage

Food shortage in Africa is considered as a challenge across the region, and that its causes are complex, attributed to multiple and often intertwined factors (Pauw and Thurlow, 2011). The main concerns are the impacts of natural disasters such as drought, flood and political disasters such as civil conflicts and misguided economic policies such as price controls (FAO and WFP, 2010). General causes of food shortage in Tanzania include small production due to small size of farms, dependency on rainfall, drought, floods, civil conflicts, low-level of technologies used especially among crop producers and animal keepers. Others include poor storage causing high post-harvest food losses, financial limitation to acquire farm inputs, poor markets for agricultural and livestock products, poor agricultural extension services, poor division of labour at the household level. Also bad farming practices leading to various environmental degradation and poor transportation of input supplies and products transportation to markets (Kayunze *et al.*, 2009). Masalawala *et al.* (2010) points out that, Tanzania can feed herself through domestic production but the food produced in the country cannot be efficiently distributed, making it unavailable in some areas especially during off-season.

2.5.3 Food shortage and coping strategies

Households at risk of food insecurity are known to plan strategically to minimize its impact. Studies have been done worldwide to understand the experiences of households suffering from food insecurity (Radimer *et al.*, 1992). A few studies done in semi-arid and rural India indicated that, in order households to prevent household food shortage, they make changes in the food consumption pattern, diversify income generation activities, sell or mortgage land and household assets, or migrate seasonally (Marditarini, 2005). Some other coping strategies to combat food shortage involve the consumption of less preferred food, limiting the portion size of food, borrowing food or money and missing of meals for whole days (Gupta *et al.,* 2015).

2.6 Under-nutrition

Under-nutrition exists when there is inadequate food intake and repeated infections leading to one or more of the following conditions: low height for age (stunting), low weight for height (wasting) and/or low weight for age (underweight) (African, 2015). Underweight measures acute and chronic malnutrition. Wasting is associated with immediate crisis such as periodic food shortages. Chronic malnutrition is due to inadequate nutrients over a prolonged period of time due to latent poverty, chronic food insecurity, poor feeding practices and repeated episodes of health problems (such as infections) or poor health services in an unhealthy environment (Glover-Amengor *et al.,* 2016).

2.6.1 Indicators of stunting, underweight and wasting

The WHO Global Database on Child Growth and Malnutrition uses a Z-score cut-off point of < -2SD to classify low weight-for-age, low height-for-age and low weight-for-height as moderate and severe under nutrition, and < -3 SD to define severe under nutrition. The cut-off point of > + 2SD classifies high weight-for-height and overweight in children.

2.6.2 Prevalence of stunting, wasting and under-weight

Global data shows that underweight caused 3.1 million deaths in 2011 (Black *et al.,* 2013). In 2013, global data show that the prevalence of stunting, underweight, and wasting was 37, 15 and 8%, respectively (WHO, 2015). Under-nutrition is reported to be higher in Asia and Africa than in Europe. In Africa prevalence of stunting and underweight has increased for the past 23 years (WHO, 2015). Tanzania has developed and implemented a number of programs aiming to reduce child under-nutrition. Some of the programs include infant and young child feeding, sanitation, deworming, vitamin A supplementation and health education (MoHSW/NBS, 2015). Despite these programs, under-nutrition is still a challenge. According to NBS (2015) report, stunting increased from 38% in 2004/2005 to 42% in 2010, and then decreased to 34% in 2015.

2.7 Major Micronutrient Deficiencies

2.7. 1 Iron deficiency

In the first two years of life, children need more iron than adults since their weight and blood volume triples (Chandyo *et al.*, 2015). Children in their first years have the fastest growth rate and their brain reach 80% of the adult size. A lot of iron is needed at this age to carry oxygen in the blood and to help develop brain cells (WHO, 2011b). Lack of iron at this age can impair intellectual development and it is often irreversible. Children who are seriously deficient in iron in their first two years of life do not learn well once they get to school (Iqbal *et al.*, 2015). Despite serious health and social implications, anaemia remains a major public health problem and is one of the leading causes of infant mortality and morbidity in developing countries (Ewusie *et al.*, 2014). More than 58% of children in Tanzania are anemic and out of these, 35% have iron deficiency (MoHSW, 2016).

At six months of age, iron stores are depleted and a child should start receiving iron fortified foods and vitamin C rich foods in addition to breast milk. At seven months of age, a child should consume iron rich foods preferably meat, eggs, chicken and vitamin C rich fruits that will assist in absorption of iron. The common food for most of children in Tanzania is stiff porridge made from maize, sorghum or cassava flour. Dietary diversity in children is low and only 30% of children, aged 6 - 35 months in Tanzania consume foods rich in iron (NBS and ICF, 2011).

2.7.2 Iodine deficiency

Iodine deficiency is the primary cause of preventable brain damage in children leading to preventable mental retardation. Its most devastating impacts occur during the fetal stage and in the first few years of life (Zimmermann *et al*., 2008). Globally, about 30% of the world's population still live in areas with iodine deficiency and suffer from related complications. Globally, 29.8% of the of world's population is estimated to have insufficient iodine intakes (Andersson *et al.*, 2012). In Tanzania, iodine deficiency is prevented through fortification of salt with iodate. More than 71.5% of residents in Morogoro consume adequate amount of iodized salt (TFNC, 2014).

2.7.3 Vitamin A deficiency

Vitamin A deficiency affects about one third of children living in low and middle income settings, mainly in sub-Saharan Africa and South Asia (WHO, 2011b). Vitamin A deficiency weakens the immune system and increases a child's risk for contracting and dying from infections such as measles and diarrheal illnesses (WHO, 2011b). Vitamin A deficiency affects about 33% of children aged 6 – 59 months in Tanzania (NBS, 2010). Tanzania has make progress in reducing Vitamin A deficiency by fortifying cooking oil with vitamin A and supplementing under-five children with mega dose of Vitamin A capsule after every six months. More than 72.2% (range 70.6 - 73.7%) of children under the age of five years received vitamin A capsule twice a year in 2013 (TFNC, 2014).

2.7.4 Zinc deficiency

Zinc is an essential micronutrient for human growth, development, and immune function. Zinc deficiency impairs overall immune function and resistance to infection (Caulfield and Black, 2004). Zinc deficiency is common in low income countries due to the low dietary intake of zinc-rich foods and inadequate absorption in the GIT. Zinc deficiency is also a contributing factor in child deaths due to diarrhea. Diarrhea is a preventable illness. In Tanzania diarrhea is the third leading cause of child death, accounting for 17% of child mortality (MoHSW, 2015). Tanzania government passed a legislation requiring all large scale industries to fortify wheat and maize flour within order to reduce the problem of zinc deficiency in the country (Darnton and Nalubola, 2002; Smarter Futures, 2016). Majority of Tanzanians (80%) consume maize meal made from their own home-grown maize which is usually not fortified (Enzama *et al.*, 2017).

2.8 Strategies for Controlling Micronutrients Deficiency

Current strategies to improve micronutrients status include improved dietary diversification, individual food supplementation, bio-fortification of crops, and large scale staple food fortification (Allen *et al.*, 2008; Bhutta *et al.*, 2008; Olney *et al.*, 2009; Rebhan *et al.*, 2009). None of these strategies specifically target iron-deficiency anaemia in the age group most susceptible, i.e., infants aged 6 - 23 months. A crucial period of rapid growth and development translating into higher iron needs is 6 - 23 months. An alternative strategy to combat childhood micronutrients deficiencies is through ‘in-home fortification,’ which provides vulnerable populations with multiple vitamins and mineral preparations that can be directly added to foods prepared in the home. This study focuses on the effect of home food fortification with micronutrients powder in reducing iron deficiency among children aged 6 - 59 months.

2.8.1 Food fortification

Food fortification is considered as a sustainable public health strategy because it can reach wide at-risk populations through existing food delivery systems without requiring major changes in existing consumption patterns (Serdula, 2010). Compared to other interventions, food fortification is more cost-effective. In addition, if fortified foods are regularly consumed it has the advantage of maintaining steady body stores (Allen *et al.*, 2006).

2.8.2 Types of food fortification recommended by the Tanzania Government

2.8.2.1 Mass fortification

Mass fortification is the process of adding micronutrients to foods or condiments that are consumed regularly by the population, such as flour, sugar, salt and cooking oil.

Mass fortification is generally the best approach when majority of the population have high risk for deficiencies. In August 2011 Tanzania Government passed legislation requiring all large scale food industries to fortify vegetable oil, wheat and maize flour by adding specified amounts of iron, vitamin A and/or zinc (Darnton, 2002; Smarter Futures, 2016). In most African countries except South Africa, it is difficult to get fortified maize flour to rural communities since 80% of population consumes their own home-grown maize flour, milled at local hammer mills (Enzama *et al.,* 2017). Prevalence of micronutrients deficiency in Tanzania is higher in rural areas compared to the urban communities (TFNC, 2014).

2.8.2.2 Targeted fortification

In targeted food fortification programs, foods meant for specific subgroups of the population are fortified, thereby increasing the intake of certain nutrients by the particular social group. Example, complementary foods for infants and young children, foods developed for school feeding programs, special biscuits for children and pregnant women, and blended foods for emergency feeding and displaced persons which provide iron supplements to pregnant women or supply high-dose vitamin A supplement to young children and postpartum mothers

In Tanzania under-five children are supplemented with vitamin A. Under-five children are the most vulnerable social group. Their requirements for micronutrients are higher compared to the other social groups due to their rapid growth. Supplementing under-five children with Vitamin A only will not be enough since vitamin A supplement tends to prevent only vitamin A deficiency while there are other micronutrients such as iron and iodine that are also crucial for the child growth. Micronutrients powder provides all necessary nutrients needed for child growth since it provides a child with 15 vitamins and minerals per serving, which is difficult to obtain in locally prepared, homemade foods.

2.8.2.3 Home food fortification with micronutrients powder

Home fortification refers to provision of vulnerable populations with a multiple vitamin and mineral preparation that can be directly added to foods prepared in the home. This concept enables families to ‘fortify’ food for young children at an appropriate and safe level with the needed micronutrients at home. The preparations used are called micronutrient powders, or MNP, with ‘Sprinkles®’ being; the most widely tested and used worldwide (Zlotkin *et al.,* 2005; Silversides *et al.,* 2009)**.** Home food fortification with MNP is not a ‘stand-alone’ intervention but is implemented in concurrently with an improved infant and young child feeding education protocol for young children beginning at 6 months of age. Caregivers/ mothers are taught on how to add MNP to complementary foods appropriately.

2.9 Micronutrients Powder (MNP)

The nutrients and amounts used in the multi-micronutrient formula are based on the recommendation by UNICEF/WHO/WFP daily dietary allowances for 15 vitamins and minerals. The nutrient content of 1g of MNP sachet is vitamin A (400 μgRE), vitamin D3 (5 μg), vitamin E (5 mg TE), vitamin B1, B2, B6 each (0.5 mg), folic acid (150 μg), niacin (6 mg), vitamin B12 (0.9 μg), vitamin C (30 mg), iron (10 mg), zinc (4.1 mg), selenium (17 μg), copper (0.56 mg), and iodine (90 μg). The MNP is supplied in a single-dose sachet (one dose = one sachet) sold out in packs of 30 × 1 sachets. The doses of micronutrients given to under-five children are calculated based on the WHO recommendation for iron that will prevent Iron deficiency anaemia (UNICEF/ UNU/WHO, 2001).

Micronutrient Powders such as ‘Sprinkles’, are single-serve sachets of mixed vitamins and minerals in powder form, which can be instantly sprinkled onto prepared ready-to-eat complementary foods for young children without changing the color or taste of the food. Single dose sachets are packed to ensure that the correct amounts of micronutrients are given. MNP are designed to prevent and control micronutrient deficiencies among young children aged between 6 - 59 months and pregnant women. The use of MNP is a low cost scalable approach to improve nutritional status of young children. As part of Infant and Young Child Feeding programs, MNP has shown consistent results as well as offering a safe strategy that can reach large numbers of vulnerable children in a relatively short period of time with long lasting results (Ho and McLean, 2011)**.** It is generally recommended that, when the amount of bioavailable iron cannot be immediately improved through the diet, alternative measures, including supplementation, must be considered to control iron deficiency anaemia (WHO, 2011b).

2.9.1 MNP and reduction of iron deficiency anaemia

MNP shown to be as effective in treating and preventing anaemia as iron syrup and are better accepted and cause fewer side effects (Ho and McLean, 2011). MNP has been reported to reduce anaemia in young children between 6 and 24 months by 45% (Young *et al.*, 2017). Another study conducted among children aged 6 - 59 months showed that, MNP was able to reduce iron deficiency by 58% (De-Regil *et al.*, 2011). In two studies (Bangladesh and Haiti), the impact of MNP was found to be maintained even 6 to 7 months after a daily regime of MNP administered for 2 months had ended. A study conducted among young children in Kyrgyz Republic, for 2 months showed that, anaemia decreased from 72% at baseline to 52% at follow-up among the intervention group while in the control it increased from 72 to 75% (Lundeen *et al.*, 2014). In another study focusing on multiple micronutrient supplementation in Sri Lanka reported that, MNP was effective in reducing anaemia and iron deficiency by 31% (six trials) and iron deficiency by 51% (four-trials) among infants and young children (Jayatissa, 2014).

2.9.2 MNP and reduction of stunting underweight and wasting

A study conducted in Sri Lanka reported that, consumption of MNP did not show any significant association between receipt of MNP and any of the anthropometric outcomes like stunting, wasting or underweight (Jayatissa, 2014). Salam *et al*. (2013) reported similar results that, MNP supplementation had no impact on various anthropometric outcomes including stunting and wasting

CHAPTER THREE

3.0 MATERIALS AND METHODS

This study was designed to determine the effectiveness of daily home fortification of complementary foods with micronutrient powder (10 mg of iron in addition to other micronutrients) for three months in reducing the prevalence of iron deficiency anaemia among children aged Six to 59 months in Kilosa district. The primary hypothesis was that a three-month supply of micronutrient powder, provided with information on appropriate use, with the control of malaria and hookworms as confounders of iron deficiency anaemia would increase hemoglobin levels and decrease the prevalence of iron deficiency anaemia among children 6 to 59 months of age. It was hypothesized that micronutrient powder may also improve growth parameters of children.

3.1 Description of the Study Area

This study was conducted in Kilosa district, which is one of six districts in Morogoro region. The district is bordered to the West by Dodoma and Iringa regions, Mvomero district in the East, Kilombero district in the South and to the North by Tanga and Arusha regions. It lies between latitudes 6° S and 8° S and longitude 36°30′E and 38°E. The district has a total surface area of 14 400 km^2 and a population of 489 513 people living in 105 635 households with an average household size of 4.2 persons (Mboera *et al.*, 2013). Agriculture and livestock keeping are the main livelihood activities of most people in the district and are characterized by predominantly smallholder farming of less than one hectare (90%) and large scale farming (10%) (Kahimba *et al.*, 2015).

Administratively, Kilosa district is divided into nine divisions, 37 wards and 164 villages. In terms of health care services, Kilosa district has 71 health facilities and among these, there are three hospitals, seven health centers and 61 dispensaries. The number of villages exceeds the number of health facilities and hence most health facilities serve more than one village. Kilosa district has 56 Government owned primary health care facilities of which six are health centres and 50 are dispensaries. The facilities are evenly distributed across different villages in the district. The Comprehensive Council Health Plan (CCHP) records show that, the required number of health staff in the district is 509 while the actual number available is only 195 staff members. The same situation goes for equipment. On average, the hospital outpatient department attends 100 patients per day (Kilosa District Hospital Annual Report, 2006).

3.2 Study Design

Longitudinal, randomized, controlled study design was employed, with intention to treat anaemic under-five children. Children under the age of five years were screened at the baseline to identify those who were anaemic with haemoglobin levels between 7 - 10.98 g/dl. Identified anaemic children were randomly assigned to receive fortified diet (treatment) or normal diet (control). For the group receiving the supplement the children were given foods fortified with iron for a period of 90 days. At the end of the intervention period, haemoglobin levels of the treatment and control groups were compared and improvement in the iron status was determined. Children in the control group were given one box of MNP that contained 30 sachets at the end of the intervention period. Malaria and hookworm infections which are known to be confounder of iron supplementation were controlled in both groups (treatment and control) during the study period by administering mebendazole and anti-malaria drugs to the children.

3.3 Sampling Frame/ Study Population

All children aged 6 - 59 months living in the study district-Kilosa.

3.3.1 Inclusion criteria

All children 6 - 59 months who lived in the district for at least one year and attending the monthly RCH clinics, with haemoglobin levels ranging from 7 - 10.9 g/dl were included in the study.

3.3.2 Exclusion criteria

All children aged 6 - 59 months with haemoglobin above 10.99 g/dl and with haemoglobin less than 7 g/dl were excluded from the study. Children who had inborn error of metabolism e.g. Phenylketonuria (PKU), chronic illnesses such as sickle cell anaemia, tuberculosis (TB), human immunodeficiency virus (HIV) were excluded from the study. Children whose parents refused to participate in the study were also excluded. Children who were in nutrition management programs e.g. Overweight and obese and were receiving special diets for weight management were excluded from the study. Children who had mental impairments, e.g., insane, children with developments delays were also excluded from the study.

3.3.3 Sampling technique/procedure

A purposive sampling technique was used to identify the district. This was because Kilosa is a district implementing a One Health Pilot Project (OCHEA) which was supporting this study. Two wards were randomly selected namely Chanzulu and Zombo and two villages within the selected wards namely Zombo and Ilonga were selected for the study. Zombo village served as an intervention while Ilonga village served as a control centre. Zombo and Ilonga RCH clinics were centres where mothers of recruited children were attending monthly clinic sessions. Allocation of the treatment to the intervention and control groups was done randomly

3.3.4 Sample size

A formula by Fisher *et al.* (1991) was used to determine the sample size.

$$N = \frac{Z^2P(1 - p)}{d^2}$$

Where

N = the desired sample.

Z= the standard normal deviate (Which is 1.96 corresponding to 95% CI)

P= Proportion in the target population with characteristics of interest (0.35), since prevalence of iron deficiency among children aged 6 - 59 month is 35% (NBS, 2015).

q= 1-p

d= precision level (acceptable error 0.05)

N= 1.96×1.96x 0.35(1-0.35)∕0.05×0.05 = 348

Ten percent attrition was used to compensate for the drop-outs, equivalents to 34 children. A total of 382 children were recruited for the iron deficiency control study, whereby 50% of the children were enrolled in the control group while 50% others were enrolled in the intervention group. Fig 1 shows the intervention plan and study layout.

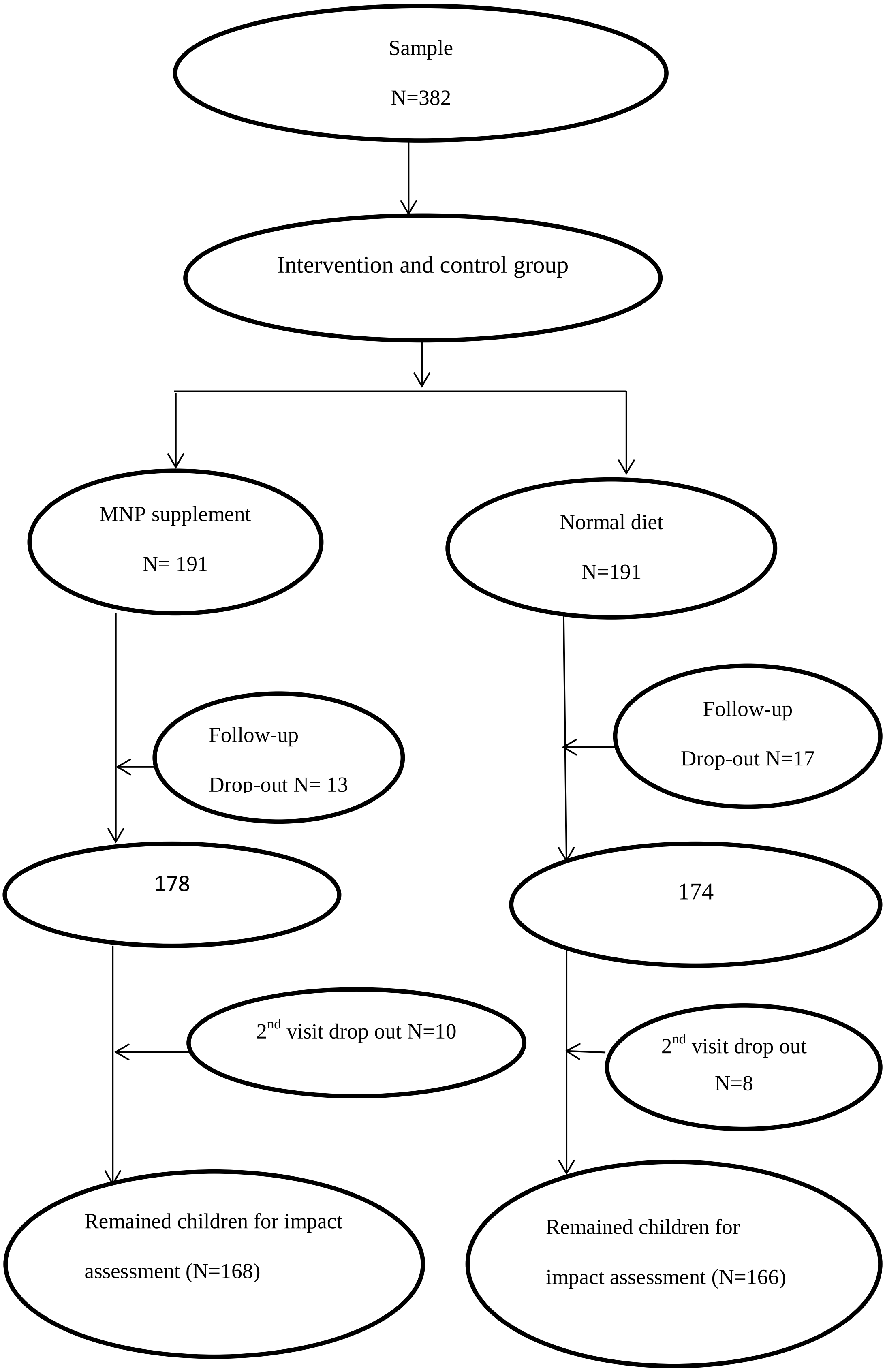

Figure 1: **Intervention plan, participation of children in MNP supplementation study**

3.4 Supplementation and Feeding Regime

3.4.1 Nutritional value

The MNP supplement used in this study was VIRUTUBISHI® manufactured by Hexagon Nutrition Pvt. Ltd. Plot No. B11, MEPZ, Chennai, INDIA. One MNP sachet provides daily intake of 15 vitamins and minerals for one child. The nutrient content of 1 g of MNP were vitamin A (400 μg RE), vitamin D3 (5 μg), vitamin E (5 mg TE), vitamin B1, B2, B6 each (0.5 mg), folic acid (150 μg), niacin (6 mg), vitamin B12 (0.9 μg), vitamin C (30 mg), iron (10 mg), zinc (4.1 mg), selenium (17 μg), copper (0.56 mg) and iodine (90 μg).

3.4.2 Preparation of foods

After the semi-solid foods were prepared, e.g., porridge, paps and were at acceptable temperatures, the mother or caregiver carefully opened one sachet and poured all the powder into a bowl containing the food. The food was mixed thoroughly to ensure uniform distribution of the nutrients in the food. One sachet was used for one child and was not shared with the other household members. The amount of minerals and vitamins in a single sachet was just enough for one child. The food with micronutrients powder was fed to the child within 30 minutes and all the fortified food was taken in a single sitting.

3.4.3 Feeding regime

Children recruited in the intervention and control groups before the start of the feeding study were screened for malaria. Those found with trophozoites or schizons received anti-malaria drugs. All children aged 12 - 59 months enrolled for the study received a dose of deworming drugs (mebendazol). Children below the age of one year are usually not given deworming drugs. One sachet per person was sprinkled onto home prepared semi-solid food, e.g., porridge, meat soup, beans soup, pap or other food that was consumed by the young child. The powder was aimed to increase the micronutrients content of the child's meal without changing their usual dietary habits. The control group did not receive the supplements but ate their normal diets while being monitored for a period of 90 days. At the end of intervention period, children in the control group were also given the supplement just like the intervention group.

3.4.3.1 Supplementation dose

Each child consumed one sachet of MNP per day, equivalent to seven sachets per week and 30 sachets per month.

3.4.3.2 Amount of food mixed with the MN supplement

The supplement was mixed with an amount of food that the child could consume and finish in a single sitting.

3.4.3.3 Administration of the supplement

The fortified food (preferred semi-solid food) was given to the child once per day at any mealtime preferably in the morning.

3.4.3.4 Duration of intervention

The children received the MNP supplement for a period of 90 days.

3.5 Monitoring Compliance and Follow-up Visits

Five health workers (VHW) were recruited to monitor the compliance of consumption of the MNP. The VHW visited the subjects' households on a daily basis to encourage mothers/caregiver to feed the supplements to their children. Compliance was monitored through calendars that were given to mothers and asked to put the sign X in each date that the child received the MNP supplement and also through counting the empty MNP sachets that the parents returned for each child at the end of the month before they could get the MNP supply for the subsequent 30 days.

3.6 Data Collection

3.6.1 Construction of a questionnaire

A questionnaire was constructed to solicit maternal information such as perceived benefits and side-effects of MNP, preparation of foods for children, use of micronutrients powder in children foods, dietary diversity and feeding practises. The questionnaire comprised of six sections A through F. Section A solicited socio-economic and demographic information of the households. Section B collected information on feeding practices and household dietary diversity. Section C solicited information about household food shortage, causes and coping strategies. Section D gathered information about foods preparation and compliance to the use of fortified food for children and section E collected information about mothers' perceived benefits and side effects of using MNP. Section F collected information about anthropometric and biochemical measurements namely weight (cm), height (cm), head circumference (cm) and haemoglobin levels (g/dl). The questionnaire was translated to Kiswahili to facilitate easy communication with respondents during data collection.

3.6.2 Pre-testing of the questionnaire

The questionnaire was pre-tested prior to data collection. Pre-testing involved a sample of 10 mothers selected in Mzumbe ward, Mvomero District. Mvomero district has similar characteristics to those of Kilosa district. Necessary changes were incorporated in the questionnaire before its final administration.

3.6.3 Training of enumerators and administration of the questionnaire

Five enumerators were trained on how to administer the questionnaire and take anthropometric and biochemical measurements. They were also taught about ethics during interviews, proper recording of the responses and confidentiality of the data. For mothers with children aged 6 - 35 months the pre-tested questionnaire was administered to them by face-to-face interview during monthly RCH clinic visits, whereas for those mothers whose children was above age 35 - 59 months, who are no longer attending monthly RCH clinic visits as it is recommended (every monthly) pre-tested questionnaire was administered to them during home visit. Interviews were conducted during the morning hours of the day.

3.6.4 Anthropometric measurements

Standard techniques and equipment (weighing scale for weight, height board for height and non-stretchable tape measure for head circumference) were used for collecting anthropometric measurements. Measurements included weight, height/ recumbent length (for children under 24 months) and head circumference. These measurements were compared to the WHO (2006) reference values.

3.6.4.1 Height/length

In each visit, height measurement was taken for those who had an age above 24 months. Children who were less than two years of age, recumbent lengths were measured with a height board positioned flat on a hard surface. The child was placed on the board while facing upward with the feet touching the immovable fixed end of the board. The movable head board was then carefully fitted at the top of the head, pressing the hair slightly. The height was read on the stadiometer and recorded to the nearest 0.1 cm. For children above 24 months, a audiometer was placed against a wall firmly. Then, subjects were asked to stand straight with the head positioned such that the frankfurt plane was horizontal, feet placed together, knees straight and heels, buttocks and shoulder blades in contact with the vertical surface of the stadiometer. Hands hanged loosely with palms facing the thighs.

The movable headboard was then lowered slowly until it touched the crown of the head. Measurement was read and recorded to the nearest 0.1 cm (Gibson, 1990).

3.6.4.2 Weight

SECA (made in Germany) weighing scale was used for both children and their mothers. The scale was placed on a hard flat surface. The scale was then turned on and adjusted to zero. Children with age above two years were asked to step on the scale bare feet and stand still to allow their weights to be displayed. Then the measurement was read and recorded to the nearest 0.1 kg. For those children with age below two years, their respective mothers/caregivers stood and the scale was zeroed with the mother on it. The mother/caregiver was then given the child to carry him/her while standing on the scale. The weight of a child was then read and recorded to the nearest 0.1 kg.

3.6.4.3 Head circumference

Non-stretchable tape was used to take head circumference. The tape was placed above the eyebrows, above the ears, and around the biggest part on the back of the head. The tape was pulled snugly to compress the hair and circumference was recorded to the nearest 0.1 cm.

3.7 Age and Sex

Age of the child was determined by recording the birth date, month and year. Growth monitoring card was used to obtaining this information.

3.8 Haemoglobin Determination

Haemoglobin concentration was determined from a finger prick capillary blood sample. The middle finger was cleaned with methylated spirit and pricked with a sterile disposable safety lancet. A drop of blood was picked by a micro-cuvette. Immediately, the filled cuvette was cleaned and inserted into the Hemo-Cue photometer and the reading was determined. Haemoglobin value in g/dl was recorded in the nearest 0.1 g/dl.

3.9 Data Analysis

Data were coded, entered into a computer spread-sheet and cleaned to facilitate analysis. Anthropometric measurements namely weight and length were entered in the ENA for SMART software (2010 Version) to generate anthropometric indices of weight for age, weight for height and height for age Z-scores and head circumference-for-age reported using WHO (2006) growth reference values. Individual dietary quality was assessed using diversity scores based on seven food groups recommended by FAO (2011) namely grains, roots and tubers, legumes and nuts, dairy products, flesh foods (meats/fish/poultry), vitamin A rich fruits and vegetables. Diversity score ranged from 0 – 7. Zero mean that none of the food groups mentioned above was consumed in the previous 24 hours while 7 mean that the child consumed foods in all the groups in the previous 24 hours. If the child consumed less than four food groups, he/she was regarded as having low dietary diversity (WHO, 2008). The health indicators compared were the prevalence of stunting, wasting, underweight and iron-deficiency anaemia at the baseline and after every one month of intervention. Comparison of mean HAZ, WHZ, WAZ, and hemoglobin levels was also carried out for the same age groups. Ninety-five percent confidence intervals (95% CI) were calculated for indicator variables using either chi-square test or independent samples t-test. P value of <0.05 was considered to be statistically significant. Frequencies, percentage and means in categorical variables such as sex, marital status was calculated by descriptive analysis.

3.10 Ethical Considerations

This study was initiated after receiving ethical clearance from National Institute for Medical Research (NIMR). Permission was also obtained from the regional and district health authorities and the District Executive Director (Kilosa) to conduct this research in the respective villages in the district.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-economic and Demographic Characteristics of the Respondents

More than half of women from the treatment group (55%, n = 105) and control group (50.8%, n = 97) were in the medium age group (26 - 35 years). However in the control group, the percent of mothers who delivered when they were younger than 18 years of age was higher (5.8%, n = 11) than that in the treatment group (2.6%, n = 5). The number of female children was higher in both treatment (58.1%, n = 111) and control (52.4%, n = 100) groups as compared to their counterpart male children (Table 1). Most (95.4%, n = 183) of children had ages ranging between 6 and 35 months and only few had ages above 36 months (4.2%, n = 8). The age imbalance could be due to the fact that, mothers of older children (above 36 months) no longer attended RCH clinics.

4.1.1 Highest level of education attained by mothers

Table 2 shows that, most of the mothers in both groups attained primary school education however, the proportion of mothers in the treatment group with primary education was higher (54%, n = 103) compared to mothers in the control group (55.4%, n = 106) (Table 2). The level of education for mothers observed in this study was lower than that reported by the Tanzania National Bureau (2013). At national level NBS (2013) reported that, 73.1% of women attained primary education.

Table 1: **Age and sex distribution of the respondents at baseline**

Age and Sex	Treatment		Control			
	Number	**Percent**	**Number (N=382)**	**Percent**	χ^2	**P-Value**
Sex of children						
Female	111	58.1	100	52.4	**3.043**	**0.081**
Male	80	41.8	91	47.6		
Total	**191**	**100.0**	**191**	**100.0**		
Age of children (Months)						
6-8	11	5.8	20	10.5	**3.987**	**0.551**
9-11	28	14.7	18	9.4		
12-17	30	15.7	34	17.8		
18-23	35	18.3	56	29.3		
24-35	75	39.3	55	28.8		
>36	12	6.2	8	4.2		
Total	**191**	**100.0**	**191**	**100.0**		
Age of mothers (years)						
<18	5	2.6	11	5.8	**9.331**	**0.53**
18-25	45	23.6	62	32.4		
26-35	105	55.0	97	50.8		
36-45	32	16.8	18	9.4		
>45	4	2	3	1.6		
Total	**191**	**100.0**	**191**	**100.0**		

Research on the effect of mother's education on child's nutritional status showed that, there was a strong linkage between maternal level of education and the children's health. Children born to educated mothers suffered less from malnutrition, which manifested as underweight, wasting and/or stunting (Abuya *et al.,* 2012). Maternal education has been associated with nutrition outcomes on children in several studies (Handa, 1999; Frost *et al*., 2005; Kabubo *et al.,* 2009). Moreover, formal education of mothers directly transfers health knowledge to future mothers.

Table 2: Socio-economic and demographic characteristics of respondents

Socio- economic attribute	Treatment Number	Treatment Percent	Control Number	Control Percent	χ^2	P-Value
Education						
Informal	35	18.3	39	20.4	**23.54**	**0.001**
Primary	103	53.9	106	55.4		
Secondary	45	23.6	43	22.6		
Higher level	8	4.2	3	1.6		
Total	**191**	100.0	**191**	**100**		
Marital status						
Unmarried	41	21.4	41	21.4	**42.38**	**0.001**
Marriage	101	52.8	140	73.2		
Divorced	8	4.2	5	2.6		
Widow	1	0.6	3	1.6		
Separated	40	21	2	1		
Total	**191**	**100**	**191**	**100**		
Monthly expenditure (USD)						
Below poverty line(<1.9)	78	40.8	90	47	**1.109**	**0.574**
Above poverty line (>1.9)	113	59.2	101	53		
Total	**191**	**100**	**191**	**100**		
Family size (persons)						
Small (1-6)	22	11.6	16	8.4	**6.445**	**0.44**
Medium (7-8)	117	61.2	100	52.4		
Large (>=9)	52	27.2	75	39.2		
Total		**100**		**100**		
Occupation						
Farmers	86	45	106	55.4	**62.3**	**0.001**
Employed for wage	47	24.6	14	7.4		
Petty business	7	3.6	27	14.2		
Self-employed	11	5.8	12	6.2		
Housewives	40	21	32	16.8		
Total	**191**	**100**	**191**	**100**		

4.1.2 Marital status of the mothers

Majority of mothers from both groups (treatments and control) were married (52.8%, n = 101 and 73.2%, n = 140), respectively. The separated/divorce rate was high among mothers in the treatment group (4.2%, n = 8) compared to those in the control group (2.6%, n = 2.6). The proportions of married and separated/divorce mothers obtained in this study were higher than the values 51.1 and 2.5% reported by NBS (2013) at national level (Table 2). A study conducted in rural areas of Ethiopia showed that, women malnutrition was significantly associated with marital status. Women malnutrition was higher among unmarried and divorced/separated women compared to their married peers (Woldemariam and Timotiows, 2002).

4.1.3 Household income and expenditure per month

Global Poverty Line Update September 30, (2015) reported that, a household is classified as living below poverty line if its daily expenditure is less than 1.9 USD. In this study, about 40% of the households from both treatments and control groups lived under poverty line of 1.9 USD (Table 2). This proportion was, however, smaller than the percent reported by NBS/UNICEF (2016) in which three quarters of children in Tanzania (74%) were reported to live in multi-dimensional poverty. Family income influences diet quality and diversity. Dietary diversity has been strongly associated with socioeconomic status of a household. A longitudinal study done by Ponce *et al*. (2006) found that, higher economic status was associated with higher dietary diversity and better micronutrient adequacy. Other studies have shown that, households with greater incomes and resources tend to have more diverse diets since food access is determined by both income and food prices (Arimond and Ruel, 2004; Ponce *et al.,* 2006; Brinkman *et al.,* 2009).

4.1.4 Household size

Household size in this study ranged from one to 13 persons. Participating households were classified into three groups small, medium or large household sizes. Small household sizes were those with one to six persons; medium size household were those with seven to eight persons while a large households were those with nine or more persons. Majority of household from both treatment and control groups had family size ranging from six to seven persons (Table 2). One study conducted in Nigeria showed that, households with large family size were more likely to have malnourished children (Ajao *et al.*, 2010).

4.1.5 Occupation of mothers

Results showed that, half of mothers from treatment (45%, n = 86) and control (55.4%, n = 106) groups depended on farming to earn their livelihoods (Table 2). This proportion was less than the percent (96.5%) reported by Katega amd Lifuliro (2013) in Chamwino. The percent of mothers who were housewives in the treatment group was higher than the percent of mothers who were dependents in the control groups (Table 2). Women's occupation has been known to influence household nutritional status, women's self-esteem and decision-making ability (ACC/SCN, 1990). Evidence shows that, women's earnings are spent preferentially on food which increase dietary diversity and improve the health of children. Own-controlled income empowers mothers to have self-confidence to purchase and to decide how this money should be used in the household (Susan, 2013).

4.2 Feeding Practices

4.2.1 Exclusive breastfeeding

More than half of mothers from both treatment (54%, n = 103) and control (54.4%, n = 104) groups did not exclusively breastfeed their children for six months as recommended. Proportion of children in the treatment group who were given supplementary feeding at 2 mo was 3.9% (n = 4), at 3 mo was 5.8% (n = 6), at 4 mo was 9.7% (n = 10) and at 5 mo was 32% (n = 33). As for the children in the control proportion of children given supplementary foods at 2 mo was 9.6 (n = 10), at 3 mo was 8.7% (n = 9), at 4 mo was 18.1% (n = 20) and at 5 mo was 22.1% (n = 23) (Table 3).

Table 3: **Feeding practices**

Feeding Practices	Treatment		Control			
	Number	**Percent**	**Number**	**Percent**	χ^2	**P-Value**
Exclusive breastfeeding						
Yes	88	46.0	87	45.6	**0.01**	**0.92**
No	103	54.0	104	54.4		
Total	**191**	**100.0**	**191**	**100**		
Age at introduction of complementary feedings (months)						
2	4	3.9	10	9.6	**15.7**	**0.01**
3	6	5.8	9	8.7		
4	10	9.7	20	18.1		
5	33	32	23	22.1		
6	47	45.6	38	36.5		
Total	**103**	**100**	**104**	**100**		

The percentage of mothers in this study who did not do exclusive breastfeeding was higher than that reported by NBS (2015) at national level. NBS (2015) reported that, 41% of mothers in the country did not breastfeed their children exclusively for 6 months. Children who were not exclusively breastfed for up to 6 months had higher risk for diarrhea mortality compared to those who were exclusively breastfeed (Scott, 2001). Scott (2001) found that, an exclusively breastfed child was 14 times less likely to die in the first six months of life from acute respiratory infections and diarrhea which are the two major child killer diseases. A study in Malawi on exclusive breastfeeding and its effect on growth of infants reported that, breastfed infants had significantly fewer episodes of fever and/or diarrhea during the two weeks before their survey (Kuchenbecker *et al.*, 2015).

4.3 Food Shortage

Table 4 shows the distribution of food shortage, causes for the food shortage and coping strategies at the household level. About half of the respondents from the treatment group (58.6%, n = 112) and control groups (64%, n = 123) admitted that they experienced food shortage during certain times of the year. Majority of respondents (38.3%, n = 43) from both groups reported increase in prices of staple food as the major cause of the food shortage (Table 4). Coping strategies adopted by the households in response to food shortage included reduction of the number of meals consumed per day (7.4%, n = 7), consumption of low grades of wheat, rice and meat (46.8%, n = 44) (Table 4). The proportion of households experiencing food shortages in this study was smaller than that reported by Twaweza (2017). According to Twaweza (2017), 84% of people in urban and rural areas experience food shortage at some period of the years. Woldemichael *et al.* (2017) reported that, increase in price of staple foods increases the likelihood of childhood stunting and underweight by up to 0.6%.

Table 4: Food shortage, causes and coping strategies

Household food shortage	Treatment		Control			
	Number	**Percent**	**Number**	**Percent**	χ^2	**P-Value**
Currently experiencing food shortage						
Yes	112	58.6	123	64.0	**1.34**	**0.247**
No	79	41.4	68	36.0		
Total	**191**	**100.0**	**191**	**100.0**		
Causes of food shortage						
Low production	32	28.6	31	25.2	**39.49**	**0.000**
Floods	12	10.7	27	22.0		
High prices of foods	43	38.4	37	30.1		
Climate change	19	16.96	24	19.5		
Drought	6	5.4	4	3.3		
Total	**112**	**100.0**	**123**	**100.0**		
Effect of food shortage on family consumption						
Yes	94	84	106	86	**0.211**	**0.646**
No	18	16	17	14		
Total	**112**	**100**	**123**	**100**		
Coping strategies for food shortage						
Low grades/less preferable foods	44	46.8	26	24.5	**13.21**	**0.054**
Less expensive foods	14	14.9	16	15.1		
Seasonal vegetable and fruits	29	30.9	57	53.8		
Reduce number of meals/day	7	7.4	7	6.6		
Total	**94**	**100.0**	**106**	**100**		

Increase of price of foods on the other hand tends to limit intake of animal products such as meat, chicken; hence increasing the risk of iron-deficiency anaemia among under-five children (Meerman and Aphane, 2012). The price of maize has more than doubled in the past two years from just under TAS 400 per kilogram in early 2015 to TZS 852 in December 2016 and TAS 1 253 per kilogram in early January 2017 (BOT, 2017). The coping strategies reported by the respondents in this study were similar to those reported by Olack *et al.* (2011).

4.4 Minimum Dietary Diversity

Minimum dietary diversity is defined by the proportion of children between 6 - 23 months who received food from four or more food groups in the past 24 hours. The food groups are; grains, roots and tubers, legumes and nuts, dairy products, flesh foods, eggs, vitamin A rich fruits and vegetables and other fruits and vegetables. (UNICEF/AED, 2010). In this study, more than half of children in both treatment (54.4%, n = 104) and control (51.8%, n = 99) groups were reported to have consumed foods from ≤ 4 food groups (Table 5). Those who did not meet the WHO (2011a) recommendation were 44.5% (n = 85) in the treatment group and 47.6% (n = 91) in the control group.

Table 5: Individual dietary diversity score for children aged 6-59 months

	Treatment		Control					
IDDS	**Number**	**Percent**	**Number**	**Percent**	**Mean**	***SD***	χ^2	***P*-Value**
Food groups								
Low (≤4)	85	44.5	91	47.6	**3.19**	**1.020**	**0.661**	**0.719**
Medium(>4-6)	104	54.5	99	51.8				
Highest(>7)	2	1.0	1	0.6				
Total	**191**	**100.0**	**191**	**100.0**				

The average consumption of various food groups in this study was 3.19 ± 1.02 (Mean ± SD) groups/day. Oldewage-Theron and Kruger (2008) reported the mean dietary diversity score (DDS) values for South Africa to be 4.04 groups/day. This mean DDS was higher than the average DDS value of 3.19 groups/day observed in this study. Other studies from developing countries (Kennedy *et al.*, 2009) namely (Filipino, Burkina Faso, Laos and Northen Uganda) have reported mean DDS values of 4.9, 4.6, 5.2 and 3.6 groups/day, respectively. This study was conducted at a time when 64% of the interviewed respondents reported that they were facing food shortages.

4.4.1 Animal products given to young children

Healthy term-infants with normal birth weight are born with a considerable endowment of iron and high hemoglobin levels. The two are usually sufficient to maintain the infants' iron needed for growth during the first 6 months of life (Anderson and MacLaren, 2012).

Table 6: Details consumption of animal products consumed by under-fives

Children consumed animal foods	**Treatment**		**Control**			
	Number	**Percent**	**Number**	**Percent**	χ^2	**P-Value**
Red Meat						
Yes	31	16.2	25	13.1	**0.196**	**0.658**
No	160	83.8	166	86.9		
Total	**191**	**100**	**191**	**100**		
Fish						
Yes	5	2.6	2	1.05	**0.020**	**0.889**
No	186	97.4	189	98.95		
Total	**191**	**100**	**191**	**100**		
White meat						
Yes	0	0	0	0	**2.011**	**0.156**
No	191	100	191	100		
Total	**191**	**100.0**	**191**	**100**		

Consumption of iron-rich or iron fortified foods is therefore recommended globally for infants and young children as a strategy to fight iron deficiency anaemia (WHO, 2014). WHO recommended iron rich foods as flesh foods (WHO/UNICEF, 2010). Only 18.8% (n = 36) of the children aged 6 - 59 months from both groups (treatment and control) had consumed foods rich in iron in the past 24 hours during the survey (Table 6). There was no significant difference in the proportion of children who consumed iron rich foods between the two groups ($p > 0.05$). Low consumption of iron-rich foods therefore put children at an increased risk for IDA.

4.5 Preparation of Foods/Drinks Fortified with MNP

At the first month of intervention, there were only few mothers/caregivers who reported to fortify complementary foods with MNP against what was taught during the beginning of the study. Some mothers/caregivers reported to add the MNP in a cooking pot while the food was hot (0.6%, n = 1), others reported to add the MNP in a cooking pan/pot while the food was still hot (10.5%, n = 19). Some others added the MNP to drinks namely black tea (1.1%, n = 2) and water (1.1%, n = 2). Adding MNP into a very hot food was not recommended since, high temperatures tend to destroy thermo-labile vitamins such as vitamin C. Also, mixing MNP with black tea/water may cause micronutrients powder to float on the top of the liquid and sticks to the cups/glass thus some of the powder is lost in the process. This practice was rectified and there were no cases reported to continue with this practice in the second and third months of intervention (Table 7). Majority of mothers/caregivers (96.7%, n = 174) report to mix MNP with maize porridge and only 9.8% (n = 16) of the mothers mixed MNP with other foods such as vegetable soup (3.5%, n = 6), meat soup (1.2%, n = 2) and mashed banana (4.8%, n = 8) (Table 7). There was no any situation where the MNP was eaten directly without being mixed with food/fluids

Table 7: Food preparation and MNP use

Period of intervention		Number	Percent
Mode of food preparation			
1st month	Directly from the sachet into individual child's food	176	77.2
	Added to individual drinks	4	2.2
	Total	**180**	**100**
2nd month	Directly from the sachet into individual child's food	178	100
	Added to individual drinks	0	0
	Total	**178**	**100**
3rd month	Directly from the sachet into individual child's food	168	100
	Added to individual drinks	0	**0**
	Total	168	**100**
Type of food/drinks mixed with MNP			
1st month	Maize porridge	174	96.7
	Mixed maize and beans dish	2	1.1
	water	2	1.1
	Black tea	2	1.1
	Total	**180**	**100**
2nd month	Maize Porridge	152	85.4
	Beans soup	4	2.2
	Mashed potatoes	2	1.2
	Rice	20	11.2
	Total	**178**	**100**
3rd month	Maize porridge	152	90.5
	Mashed banana	8	4.8
	Vegetable soup	6	3.5
	Meat soup	2	1.2
	Total	**168**	**100**
When do you add the powder to the food			
1st month	When the food has cooled down	**160**	**88.9**
	Just after cooking	19	10.5
	In a cooking pan	1	0.6
	Total	**180**	**100**
2nd month	When the food has cooled down	178	100
	Total	**178**	**100**
3rd month	When the food has cooled down	160	100
	Total	**168**	**100**

4.6 Monitoring Compliance for Intake of Micronutrients Powder

4.6.1 Compliance based on the count of empty MNP sachet

Compliance monitoring showed high adherence to the use of the MNP especially in the second and third months of intervention (84.7%, n = 144 and 92.2%, n = 153; respectively) (Table 8). The increase in adherence in the second and third months of intervention could be due to the follow-up visits to the households that were made on daily by the village health workers to encourage the mothers/caregivers to feed the MNP supplements to their children. The similar proportion of adherence (85.8% and 90%) was reported by Adu-Afarwuah *et al*. (2008).

Table 8: Compliance to the use of the MNP by the participating household

Period of intervention	**Compliance to MNP**	**Number**	**Percent**
1st month	Very low adherence (≤25%)	23	13.5
	Low adherence (26%-49%)	9	5.3
	Adequate adherence (50%-74%)	15	8.8
	High adherence (≥75%)	123	72.4
	Total	**170**	**100**
2nd month	Very low adherence (≤25%)	3	1.8
	Low adherence (26%-49%)	10	5.9
	Adequate adherence (50%-74%)	13	7.6
	High adherence (≥75%)	144	**84.7**
	Total	**170**	**100**
3rd month	Very low adherence (≤25%)	0	0.0
	Low adherence (26%-49%)	3	1.8
	Adequate adherence (50%-74%)	10	6.0
	High adherence (≥75%)	153	92.2
	Total	**166**	**100**

4.6.2 Average consumption of MNP

Consumption of MNP was checked after every 30 days of intervention. Compliance was measured by the number of empty sachets returned. The compliance rate was estimated by dividing the total number of empty sachets returned by the total number of distributed sachets. Result of compliance showed that out of 90 sachets distributed, each child was given 25 sachets on the first month. During the second and third months, the average number of sachets consumed was 26 and 29 per month, respectively (Table 9).

Table 9: Average MNP consumption

Period of intervention	Average MNP sachet consumed/month	Percent
1st month	25	83
2st month	26	86
3rd month	29	97
	Number of participants who consumed all 30 sachets	
1st month	100	58.8
2nd month	121	68.0
3rd month	132	78.6

NB: Mothers/caregivers were given 30 sachets after every 30 days of intervention

The increase in the number of sachets consumed in the second and third months could be due to the fact that, some of the mothers/caregivers noticed positive changes in the health and behavior of their children. One mother by the name Amina said that, *"for sure I was motived to continue feeding the MNP to my child after I saw the big improvement on his health."* Mothers/Caregivers stated that, their children became very active, they were happy and their appetites improved greatly. One mother reported that, "before the introduction of this MNP, *"I have never heard my son asking for food by himself but now you hear him saying mom I 'am hungry".* The approach of counting the returned empty sachet of MNP to assess the compliance of MNP intervention was also used by Sazawal *et al*. (2014). Lundeen *et al*. (2014) also reported that, compliance for the study was assessed by counting the number of empty micronutrient powder sachets that were returned at the end of the intervention.

4.6.3 MNP compliance based on participants who shared sachets

During the interview few, caregivers/mothers (5.5%, n = 10) at first month of intervention reported sharing the MNP with other household members (Table 10). Majority of women who reported sharing the MNP with other people in the household gave one or two sachets to one of the child's sibling. They reported that, some children who were above the eligible age in the households felt jealous on why they were not given the MNP. The mothers/caregivers therefore shared the MNP once in a while to please the elder sibling. The number of respondents who reported sharing MNP at the second month of intervention decreased from 5.5% (n = 10) to 1.2% (n = 4) (Table 10). Nutrition education and information regarding the MNP throughout the intervention period contributed to the reduction in sharing the MNP at the end of the intervention (0.5%, n = 1). Reduction in sharing the MNP sachet resulted to the increase sachet consumption by children in the study (Table 11). Osei *et al*. (2014) reported that, six mothers shared MNP-fortified food among siblings during the study period.

Table 10: Participants who shared MNP sachet during the intervention

Participants who shared MNP sachets during intervention	**Number**	**Percent**
1st month (n = 180)	5	2.8
2nd month (n= 178)	4	2.2
3rd month (n = 168)	1	0.5

4.6.4 MNP compliance based on participants who lost/threw the empty sachets

Some women/caregivers (5.5%, n = 10) at the first month of intervention could not account for half of the sachets given. However, the number of caregiver/mothers who lost the empty sachets decreased to 4.5% (n = 8) at the second month of intervention and to 1.2% (n = 2) at the third month of intervention (Table 11). Failure of mothers/caregivers to account for some of the given sachets was related to their movement to and from the house and hence could not know where they left the empty sachet after use.

Table 11: Participants who lost or threw away the empty MNP sachets

Participants who lost or threw away the empty sachets	**Number**	**Percent**
1st month (N=180)	10	5.5
2nd month (N=178)	8	4.5
3rd month (N=168)	2	1.2

4.7 Challenges of Preparing and Feeding MNP to Children at Home

Mothers/caregivers did not face difficulties in preparing and feeding MNP to the children during the intervention (Table 12). During the first, second and third months of intervention (25%, n = 2), (30%, n = 6) and (36%, n = 10) mothers/caregivers reported slight change in the color of the food, while 30% (n = 3), 60% (n = 60) and 10% (n = 1) reported slight change in the taste of the foods also, 36.7% (n = 10), 53.6 (n = 15) and 10.7% (n = 3) of the mothers/caregivers reported slight change in both color and taste of the foods after MNP was added (Table 12).

Table 12: Potential challenges in preparing and feeding the MNP at home

Period of intervention	Challenge	Number	Percent
1st month	Difficulty in opening MNP sachets	6	100
	Total	**6**	**100**
2nd month	Difficulty in opening MNP sachets	0	0
	Total	**0**	**0**
3rd month	Difficulty in opening MNP sachets	0	0
	Total	**0**	**0**
	Change in food organoleptic attributes after MNP was added		
1st month	Color only	2	25
	Taste/smell only	5	62
	Color, smell and taste	1	13
	Total	**8**	**100**
2nd month	Color only	3	30
	Taste/smell only	6	60
	Color, smell and taste	1	10
	Total	**10**	**100**
3rd month	Color only	10	36.7
	Taste/smell only	15	53.6
	Color, smell and taste	3	10.7
	Total	**28**	**100**

Mothers/caregivers described the changed colour as yellowish while in terms of taste, mothers/caregiver said the foods had a metallic taste similar to MOVIT syrup, which they were given during pregnancy or when a child had anaemia (Table 12). None of these mothers reported to have stopped feeding the MNP to their children due to changes in the organoleptic attributes.

4.8 Acceptability of Micronutrients Powder

4.8.1 Likeability

The mothers/caregivers of the children were asked whether their children liked the MNP and more than (88%, n = 160) of the mothers/caregivers responded as summarized in (Table 13). A slight increase in child's likability towards fortified food ($p > 0.05$) could be observed in the second (88.9% n = 158) and third (95.2%, n = 160) month of intervention (Table 13). Some of the general comments made by the mothers to gauge the likeability included children reminded their mothers/caregivers to add the MNP into their food.

Table 13: Proportion of caregivers of children who liked MNP

Period of intervention	**Likeability**	**Number**	**Percent**
1st month	Like	156	88.7
	Dislike	24	11.3
	Total	**180**	**100**
2nd month	Like	158	88.9
	Dislike	20	11.1
	Total	**178**	**100**
3rd month	Like	160	95.2
	Dislike	8	4.8
	Total	**168**	**100**

"My child always asked; mum you have not added the MNP into my food" and "I had to cheat him/her that I cooked it in the food during preparation, since we have been told to give one sachet per day in one meal of our choice".

4.8.2 Percent of children who finished the whole fortified food portion

Results in Table 14 show that, a large number of the children during the intervention period finished their food either every time (82.2%, n = 148) or almost every time (11.1%, n = 20).

Table 14: Proportion of children who finished the whole fortified food portion

Period of intervention		Number	Percent
	Percent of children finished the fortified food		
1st month	Every time	148	82.2
	Almost every time	20	11.1
	Sometimes	8	4.4
	Never	4	2.3
	Total	**180**	**100**
2nd month	Every time	148	83.1
	Almost every time	17	9.6
	Sometimes	10	5.6
	Never	3	1.7
	Total	**178**	**100**
3rd month	Every time	151	89.3
	Almost every time	10	6.0
	Sometimes	6	3.6
	Never	1	1.5
	Total	**168**	**100**
1st month	**Action taken by mothers/caregiver concerning leftovers**		
	Kept it and fed it to the child later	1	3.1
	Fed it to the child's siblings	3	9.4
	Threw it away	28	87.5
	Total	**32**	**100**
2nd month	Fed it to the child's siblings	1	3.3
	Threw it away	29	96.7
	Total	**30**	**100**
3rd month	Threw it away	17	100
	Total	**17**	**100**

The proportion of children could not finish the portions of the fortified food was very small at the end of the intervention (0.5%, n = 1) compared to the beginning of the intervention (2.3%, n = 4) period. At the first month of intervention, mothers were asked "what they did with the leftover food" responses included; kept it and fed it to the child later (3.1%, n = 1), fed it to the child's siblings (9.4%, n = 3) and threw it away (87.5%, n = 28).

The decrease in percentage of children who could not finish their food in the third month of intervention was caused by the fact that, caregivers/mothers noted that their children cannot finish the fortified foods, mothers/caregivers decided to feed the child during the morning hours by adding the MNP to a small portion of the food of their choice. Night fast made the children hungry and more receptive of the fortified food in the morning.

"I gave it to him in the morning before eating anything else. I mixed the powder with a small portion of porridge only to have 5-7 spoons of fortified porridge then I forced him to eat. It was hard at the begging but as time goes he changed and starts to ask for the fortified food by himself".

4.8.3 Ease of use

Table 15 shows the number of mothers/caregivers who said the MNP was easy to use. All of the caregivers/mothers reported that MNP was easy to use from the first (100%, n = 180) to the third months of intervention (100%, n = 168). Trial *et al*. (2012) on their study titled "Effect of Micronutrient Sprinkles on Reducing Anaemia," reported similar results as reported in this study, i.e. 100% of caregivers/mothers reported that they did not face difficulties in following the instruction on how to use the MNP.

Table 15: Number of respondents reporting on the use of MNP

Period of intervention		Number	Percent
	Instruction for use		
1st month	Easy to follow	180	100
	Difficult to follow	0	0
	Total	**180**	**100**
2nd month	Easy to follow	178	100
	Difficult to follow	0	0
	Total	**178**	**100**
3rd month	Easy to follow	168	100
	Difficult to follow	0	0
	Total	**168**	**100**

4.8.4 Willingness to purchase the MNP

At the end of the intervention, mothers were interviewed on their willingness to purchase the MNP. Majority of the mothers/caregivers (83.9%, n = 31) were willing to buy the MNP. Suggested prices ranged from 50 to 500 TAS. Majority of the mothers (86.5%, n = 122) suggested a price of 100 TAS or less while 6.4% (n = 9) of the mothers suggested the price of 200 TAS or more (Table 16). Mothers who were not willing to purchase the MNP (6%, n = 10) said that they would use as long as it was given out for free. The study on the use of micronutrient powder at home foods used for young children (6 - 18 month) reported higher proportion (85%) of mothers/caregivers who were willing to purchase the powder (Albelbeisi *et al*., 2017).

Table 16: Maternal willingness to purchase the MNP and suggested prices

Maternal willingness to purchase MNP	Number	Percent
Willingness of caregivers/mothers to buy the MNP		
I'm ready to buy	141	83.9
I'm not ready	10	6.0
Maybe	17	10.1
Total	**168**	**100**
Suggested price for one sachet of MNP (TAS)		
50	8	5.7
100	122	86.5
200	9	6.4
500	2	1.4
Total	**141**	**100**

4.9 Perceived Benefits and Side Effect of Micronutrients Powder in Children

4.9.1 Benefits of micronutrients powder

Table 17 shows the benefits of micronutrients powder on child health. Reported positive effects according to the mothers/caregivers included increase in child appetite (89.6%, n = 138), child became more active (76.2%, n = 128), child became more energetic (11.9%, n = 20) and good weight gain (65.5%, n = 110). Other effects included height gain (11.9%, n = 20), less incidences of diseases (4.7%, n = 8), good sleeping (10.7%, n = 18), free from frequent constipation (3.6%, n = 6), became more intelligent and cleaver (10.1%, n = 17), hair turned to black from gray (0.6%, n = 1) and disappearance of paleness of the palm (0.6%, n = 1).

Table 17: Caregiver/maternal perceived benefits of micronutrients powder

Benefits of micronutrients	Number (n = 168)	Percent
Changes observed in child behavior		
Increase appetite	138	82.1
Child became more active	128	76.2
Child become more energetic	20	11.9
Child became energetic and active	16	9.8
Changes in child physical appearance		
Child skin became brighter	40	23.8
Observed changes in child health		
Good weight gain	110	65.5
Height gain	20	11.9
Less diseases	8	4.8
Other changes observed		
Baby stopped eating clay/charcoal	36	21.4
Good sleeping	18	10.7
Free from frequent constipation problem	6	3.6
Child became more intelligent and clever	17	10.1
Child hair turned black from gray	1	0.6
Paleness on palm of hands and eyes disappeared	1	0.6

Jefferds *et al*. (2015) reported similar positive effects as those reported in this study; weight gain, reduced sickness, children become stronger and healed from anaemia. Creed-kanashiro *et al*. (2016) also reported similar findings. A study by Albelbeisi *et al*. (2017) on the use of micronutrints powder in home food fortification for young children (6 - 18 months) resulted in an increase in child apetite by 88%. None of these studies reported the effect of micronutrients powder to children who ate clay/charcoal. It was observed in this study that, children who consumed the micronutrients powder stopped consuming clay/charcoal. About 21.4% (n = 36) of children who were reported to eat clay/ charcoal stopped this practice two weeks after starting to consume the micronutrients powder.

"My child used to eat clay/charcoal. It was hard to stop her, every morning she would wake up taking clay/charcoal as her breakfast. I accepted this situation and hoped that she will stop when she/he grows up, but I wondered after two weeks of using the MNP that practice disappeared. Now, even when I tried to put clay/charcoal on her hands she throws it away"

4.9.2 Perceived negative effect of micronutrients powder in children

Some mothers/caregivers who participated in this study reported negative effects to their children when they consumed the MNP during the first month of intervention. Negative effects reported by mothers included dark stool color (91.1%, n = 5), decreased child appetite (66.7%, n = 2), constipation (3.6%, n = 2) and loose stool (5.4%, n = 3). None of these mothers reported any side effect during the second and third months of intervention (Table 18). The effects were experienced for various durations e.g. loss of appetite (5 - 6 days), dark stool (20 - 30 days), loose stool (2 - 3 days) and constipation (3 - 5 days). Nevertheless, only few (11.6%, n = 5) mothers/caregivers reduced the dose of MNP from 7sachet/week to 4 sachet/week and 25.6% (n = 11) of mothers/caregivers made calls to the researchers to seek for advice about the side effects experienced by their children (Table

18). During the interview, one mother reported to reduced breastfeeding her baby due to micronutrients powder.

Table 18: Reported side effects, duration and action taken by mothers/caregivers

Period of intervention	Side effect of MNP	Number	Percent
	Changes noted by mothers/caregivers when child goes to the bathroom/toilet		
1st month	Dark stool	51	91.1
	Loose stool	3	5.4
	Constipation	2	3.6
	Total	**56**	**100**
2nd month	Dark stool	0	0
	Loose stool	0	0
	Constipation	0	0
	Total	**0**	**0**
3rd month	Dark stool color	0	0
	Loose stool	0	0
	Constipation	0	0
	Total	**0**	**0**
	Other negative effects observed		
1st month	Loss of appetite	2	66.7
	Decreased breastfeeding	1	33.3
	Total	**3**	**100**
2nd month	Decrease appetite	0	0
	Decreased breastfeeding	0	0
	Total	**0**	**0**
3rd month	Decrease appetite	0	0
	Decreased breastfeeding	0	0
	Total	**0**	**0**
1st month	**Duration of the negative effect observed (days)**		
	2-3	3	5.7
	3-5	2	3.4
	5-6	2	3.4
	20-30	51	87.9
	Total	**58**	**100**
1st month	**Action taken by mothers/caregivers after observing the negative effects**		
	Continue using the powder	27	62.8
	Reduce the dose	5	11.6
	Make a call to researcher to seek for advice	11	25.6
	Total	**43**	**100**

"My baby was one and half years but the only food she like was breast milk at this age I used to breastfeed her for more than six times a day, but after one month of using this powder daily, the frequency of breastfeeding decrease to an average of three times per day. She now likes complementary foods more than the breast milk"

The association between increased diarrhea and dark stool with iron supplementation has also been reported by Gera and Sachdev (2002). These reported similar negative effects in a study of effectiveness and safety of home fortification and mechanisms of implementation among 6 - 9 months infants. The most common side effects reported were diarrhea and dark stool. Mirkovic *et al.* (2017) also reported side effects such as constipation, decrease in child appetite, diarrhea and dark stool.

4.10 Impact of Micronutrient Powder Intervention on Iron Status of the Under-five Children

Table 19 shows the impact of the micronutrient powder intervention on the mean hemoglobin concentrations of the children studied. The mean hemoglobin concentrations of the children in the treatment group was 9.9 ± 0.90 g/dl at the baseline, 10.29 ± 0.49 g/dl after the first month, 10.6 ± 0.47 g/dl after the second month and 11.1 ± 0.79 g/dl after the third month of intervention. The mean hemoglobin concentrations for the children in the control group was 10.1 ± 0.7 g/dl at the baseline, 10.0 ± 0.76 g/dl after the first month, 9.98 ± 0.78 g/dl after the second month and 9.94 ± 0.8 g/dl after the third month of intervention.

Hemoglobin determination is the most common method used to screen iron deficiency. With low hemoglobin (7 - 10.99 g/dl) a presumptive diagnosis of iron deficiency anaemia is supported by a good response to iron supplementation. If the children's level of hemoglobin does not improve after taking iron supplements for one month, further assessment is recommended which include serum ferritin test (MMWR, 1998).

Table 19: Comparison of mean hemoglobin concentration between children in the intervention and control groups at baseline and in the subsequent months of intervention

	Treatment group		Control group		
Hemoglobin (g/dl)	**Number**	**$\bar{X}$±SD**	**Number**	**$\bar{X}$±SD**	**P-value**
0 month	191	9.9±0.90	191	10.1±0.70	**0.087**
1st month	180	10.29±0.49	178	10.0±0.76	**0.003**
2nd month	178	10.6±0.47	174	9.95±0.78	**0.000**
3rd month	168	11.1±0.79	166	9.9±0.8	**0.000**

It was observed in this study that, children in the treatment group one month of taking the MNP supplement, the mean hemoglobin concentration increased by 0.3 ± 0.88 g/dl, 0.6 ± 0.88 g/dl after two months of intervention and by 1.1 ± 1.24 g/dl after the third month of intervention. For the children in the control group, the mean haemoglobin concentration after one month of intervention decreased by 0.1 ± 0.24 g/dl, by 0.05 ± 0.42 g/dl after the 2nd month of intervention and by 0.2 ± 0.88 g/dl after the third month of intervention (Table 19). Results showed that, there was no significant difference (*P* > 0.05) in the mean hemoglobin concentrations between treatment and control groups at baseline. However, there was a significant improvement (p < 0.05) in the mean hemoglobin concentrations in the follow-up visits between the treatment and control groups (Table 19).

A study on acceptability and effects of micronutrient powder in improving hemoglobin levels among 6 - 24 months infants and young children revealed that, at the end of two months of intervention, the mean (±SD) hemoglobin levels were significantly higher (P <

0.05) in the intervention group (11.8 ± 1.2 g/dl) than in the control group (11.1 ± 1.3 g/dl) (Kedir, 2016). Another study on the effect of daily use of sprinkle micronutrient powder in reducing anaemia among children 6 - 36 months showed that, the mean hemoglobin concentrations in the intervention group increased by 7 g/dl, whereas it decreased by 0.2 g/dl in the control groups (Lundeen *et al.*, 2014).

A study on the effect of providing multiple micronutrients powder through primary care on anaemia revealed that, there was a significant increase in blood hemoglobin concentration of 6 g/dl in the intervention group Cardoso *et al*. (2016). Furthermore, a study involving evaluation of multiple micronutrients powder supplementation programme in Sri Lanka showed that, there was significant increase in mean concentration of hemoglobin concentration for children in the treatment group. The mean increase in hemoglobin concentration in this study was levels reported in other studies (Jayatissa, 2014; Lundeen *et a.l*, 2014; Cardoso *et al*., 2016; Suchdev *et al*., 2016). This could be due to fact that, in the current study all children from both groups were dewormed with mebendazole (500 mg) at the baseline no competition of iron the intestinal worms unlike the other reported studies (Jayatissa, 2014; Detzel and Wieser, 2015).

4.11 Impact of Micronutrients Powder Intervention on Prevalence of Iron Deficiency Anaemia

According to WHO/UNICEF/UNU (2001), when prevalence of anaemia is greater than 40% in a population of a certain gender and age range, virtually the entire population for this age and gender group is likely to have some degree of iron deficiency. Thus, it was assumed in this study that, every child who was recruited for this study had some degree of iron deficiency anaemia since the prevalence of anaemia among children below five years of age in Morogoro at the national level is more than 66% (NBS, 2016).

Results for this study revealed that, prevalence of iron deficiency anaemia (hemoglobin < 10.9 g/dl) among children in the treatment group decreased from 100% (n = 191) at baseline to 85.0 % (n = 153) at first month, to 61.2% (n = 167) in the second month and to 28.8% (n = 48) at the third month of intervention. Meanwhile, in the control group, prevalence decreased from 100% (n = 191) at baseline to 94.9% (n = 169) at the first month to 95.4% (n = 167) at the second month and 96.4% (n = 160) in the third month of intervention, increase in the prevalence of iron deficiency anaemia among children in the control group on the second 95.4% (n = 167) and third moth 96.4% (n = 160) of intervention was due to drop-outs (Table 20).

Table 20: Comparison of mean hemoglobin among children in the intervention and control groups at baseline and monthly thereafter

Intervention period	Prevalence of IDA	Treatment		Control		
		Number	Percent	Number	Percent	P-value
0 month	**Hemoglobin (g/dl)**					
	<10.99	191	100	191	100	
1st month	**Hemoglobin (g/dl)**					
	<10.99	153	85.0	169	94.9	**0.002**
	Hemoglobin (g/dl)					
2nd month	<10.99	109	61.2	167	95.4	**0.000**
	Hemoglobin (g/dl)					
3rd month	<10.99	48	28.8	160	96.4	**0.000**
	Change in IDA status compared with baseline (%)					
	Recovered children from Iron deficiency anaemia at 1st month	27	15	9	5.1	**0.000**
	Recovered children from Iron deficiency anaemia at 2st month	69	39	7	4.6	**0.000**
	Recovered children from Iron deficiency anaemia at 3st month	120	71	6	3.6	**0.000**

On the second and third months of intervention, there was a 24 and 57% absolute reduction, 57 and 67% relative reduction in the prevalence of iron deficiency anaemia among children in the intervention group, as compared to the control group, with a 0.5% and 1% absolute increase, 2 and 3% relative increase in the prevalence of iron deficiency anaemia. The difference between the treatment and control groups in the prevalence of iron deficiency anaemia at first, second and third months of intervention was statistically significant (*P* = *0*.000) (Table 20).

The cure rate for the children in the treatment group was 15% (n = 27) in the first month, 39% (n = 69) in the second month and 71% (n = 120) in the third month of intervention. These represent the percentages of children who were having iron deficiency anaemia at baseline and were cured from iron deficiency anaemia at follow-up. Only 5.1% (n = 9) of children who were having iron deficiency anaemia in the control group recovered in the first month of intervention, 4.6% (n = 7) recovered in the second month while 3.6% (n = 6) recovered in the third month of intervention. The cure rate was significantly different between two groups (*p* = 0.000) (Table 20). The fact that, the recovery rate in the treatment group was more than twice the recovery found in the control group (*p* = 0.000) it indicates that, the micronutrient powder was in fact effective in curing iron deficiency anaemia among the treated children, and the MNP was effective in curing iron deficiency anaemia more than the recovery rate that could be achieved through normal diet alone.

Reduction in prevalence of iron deficiency anaemia (28.8%, n = 48) and the cure rate (71%, n = 120) achieved through this home fortification study are higher than what has been found in similar micronutrient powder studies in other countries. A study by De-Regil *et al*. (2011) on home fortification of foods with multiple micronutrient powders for health and nutrition in infants and young children reported reduction in prevalence of iron deficiency by 51%. Suchdev *et al*. (2016) reported a decrease in prevalence of iron deficiency anaemia by 19.3%. Also Jayatissa *et al*. (2014) reported that, micronutrients powder significantly reduced the prevalence of iron deficiency anaemia by 57%. Higher response to micronutrient powder among children in this study could be due to fact that, malaria and hookworm infections which are known to be strong confounders of iron intake were controlled in both groups unlike in the other studies. Reduction in the prevalence of iron deficiency anaemia in the control group was insignificant (P > 0.05) may be due to the fact that, there was generally low dietary intake of iron-rich foods for the children in this group.

4.12 Effect of Micronutrients Powder on the Anthropometric Measurements of Children

4.12.1 Length of children

The mean length of the children in the treatment group was 82.50 ± 11.2 cm at baseline, 82.52 ± 11.1 cm after one month, 82. 70 ± 11.3 cm after two months and 83.10 ± 11.2 cm after three months of intervention. For the children in the control group, the mean length was 82.00 ± 9.3 cm at baseline, 82.04 ± 9.2 cm after one month, 82.30 ± 9.2 cm after two months and 82.50 ± 9.7 cm after three months of intervention.

There was a slight increase in length among children in both groups. For the treatment group, the mean length/height increased by 0.02 ± 0.8 cm after one month, 0.3 ± 0.5 cm after two month and 0.42 ± 0.56 cm after three months of intervention. For the control group, the mean length increased by 0.01 ± 0.1 cm after the first month, 0.3 ± 0.5 cm after two months and 0.39 ± 0.57 cm three months of intervention. There was no significant difference in the mean increase in lengths or height at follow-ups between the intervention and control groups (*P* > 0.05) (Table 21). A study on the effect of micronutrient by Juan *et al*. (2003), reported that, the average difference in length between two supplemented groups was 0.09 ± 0.42 cm and this mean difference was not significantly different.

Table 21: Change in anthropometric measurements

Measurements	Treatment group Number	x̄±SD	Control group Number	x̄±SD	*P*-value
Length					
0 month	191	82.5±11.2	191	82.00±9.3	**0.878**
1st month	180	82.52±11.1	178	82.04±9.2	**0.668**
2nd month	178	82.7±11.3	174	82.30±9.2	**0.637**
3rd month	168	83.0±11.2	166	82.5±9.72	**0.672**
Length mean change					
0-1 month		0.02±0.8		0.01±0.1	**0.80**
0-2 month		0.30±0.5		0.3±0.5	**0.65**
0-3 month		0.42±0.6		0.39±0.57	**0.64**
Weight (kg)					
0 month	191	10.8±2.8	191	10.60±2.4	**0.43**
1st month	180	11.0±2.7	178	10.70±2.3	**0.19**
2nd month	178	11.3±2.8	174	10.70±2.4	**0.04**
3rd month	168	11.7±3.1	166	10.80±2.4	**0.03**
Weight mean change					
0-1 month		0.1±0.75		0.1±0.8	**0.738**
0-2 month		0.4±0.75		0.1±0.29	**0.000**
0-3 month		0.8±0.75		0.2±0.29	**0.000**
Head circumference (cm)	191	47.20±2.8	191	46.80±2.3	**0.111**
0 month	180	47.24±2.8	178	46.83±2.0	**0.118**
1st month	178	47.45±2.9	174	47.00±2.2	**0.095**
2nd month	168	47.45±2.8	166	47.00±2.1	**0.067**
3rd month					
Head circumference mean change		0.04±0.21		0.03±0.18	**0.47**
0-1 month		0.25±0.44		0.2±0.44	**0.34**
0-2 month		0.25±0.44		0.2±0.46	**0.34**
0-3 month					

4.12.2 Weight of the children

The mean weight of the children in the treatment group was 10.8 ± 2.8 kg at baseline, 11.0 ± 2.7 kg at first month, 11.3 ± 2.8 kg at second month and 11.7 ± 3.1 kg at the third month of intervention. The mean weight for the children in the control group was 10.6 ± 2.4 kg, 10.7 ± 2.3 kg, 10.7 ± 2.4 kg and 10.8 ± 2.4 kg at the baseline, first month, second month and third month of intervention, respectively. There was no significant difference ($P > 0.05$) in weight gain between the control and the treatment groups (Table 21). The higher mean weight gain attained by the children in the treatment group could be due to the increase in appetite which led to more food intake. A study on the effect of multi-micronutrient supplementation on growth of under-five children in South Africa showed no significant differences in the mean weight gain of children in the treatment and control groups (Mda *et al.*, 2013).

4.12.3 Head circumference of the children

The mean head circumference of the children in the treatment group was 47.20 ± 2.8 cm at the baseline, 47.24 ± 2.9 cm after one month, 47.45 ± 2.9 cm after two months and 47.45 ± 2.0 cm after three months of intervention. For the control group, the mean head circumference was 46.8 ± 2.3 cm at baseline, 46.86 ± 2.0 cm after one month, 47.0 ± 2.2 cm after two months and 47.0 ± 2.1 cm after three months of intervention. Despite the slight increase in mean head circumference among the children in the treatment group during the first month (0.04 ± 2.1 cm), the head circumference remained the same in the second month (0.25 ± 0.4 cm) and third month (0.25 ± 0.4 cm) ($p > 0.05$) (Table 21). A study on effectiveness of micronutrient powders (MNP) in children revealed that, no significant impact was observed in the head circumferences of the study children (Salam *et al.,* 2013).

4.13 Impact of Micronutrient Powder Intervention on Mean Z-scores of Children

4.13.1 Weight-for-length z- score

At the baseline the mean weight-for-length Z-scores was -0.91 ± 1.1 SD and -1.10 ± 0.9 SD for the treatment and control groups, respectively. During the third month of intervention, the mean weight-for-length-z-scores were -0.89 ± 1.0 SD for children in the treatment group and -0.11 ± 0.9 SD for those in the control group. At the second month and third months of intervention, the mean weight-for-length-z-scores decreased to -0.04 ± 0.24 SD and -0.02 ± 1.1 SD for the treatment group and by -0.03 ± 0.2 SD and -0.04 ± 0.1

SD for the children in the control group, respectively (Table 22). The changes in the mean WHZ scores between the treatment and control groups from 1st to 3rd months of intervention were not significantly different (*P* > 0.05) (Table 22). According to Giovannini (2006) and Adu-Afarwuah (2007), children who were given micronutrients supplements for six and twelve months, respectively, did not show significant changes in their WHZ scores. These observations were similar to those observed in this study.

4.13.2 Height -for- age z- score

The mean height-for-age Z-score for the children in the treatment group during the first, second and third months of intervention was -0.92 ± 1.0 SD, -0.9 ± 1.2 SD and -0.8 ± 1.2 SD, respectively. For the children in the control group, the mean height-for-age Z-score at the first month was -1.0 ± 1.1 SD, -0.95 ± 1.3 SD at second month and -0.93 ± 1.4 SD at the third month of intervention. Results revealed that, during the second and third months of the intervention, the mean height-for-age Z score for the treatment group increased by 0.02 ± 0.14 SD and 0.1 ± 0.32 SD, respectively while for the control group, the mean height-for-age Z-scores increased by 0.05 ± 0.23 SD and 0.07 ± 0.27 SD, respectively. There was no significant difference in the mean height-for-age z-scores at follow-up months between the treatment and control groups (*P*> 0.05) (Table 22). A study on the effect of supplementation with two different combinations of micronutrients delivered as sprinkles on growth of children aged 6 - 24 month, did not result in a significant increase in the mean height-for-age Z-scores (Giovannini *et al.,* 2006).

Table 22: Change in mean Z-scores for under-five children during the study period

	Treatment group		Control group		
Indicators	**Number**	**$\bar{x}$±SD**	**Number**	**$\bar{x}$±SD**	**P-Value**
Weight –for- length (WLZ)					
0 month	191	-0.91±1.1	191	-1.10±0.9	**0.07**
1st month	180	-0.91±1.1	178	-1.10±0.9	**0.07**
2nd month	178	-0.95±0.9	174	-1.13±0.9	**0.18**
3rd month	168	-0.89±1.0	166	-1.14±0.8	**0.60**
Changes of WLZ					
From 0 to 2nd month		0.04±0.24		-0.03±0.2	**0.70**
From 0 to 3rd month		0.02±0.9		-0.04±0.1	**0.10**
Length-for-age (LAZ)					
O month	191	-0.92±1.0	191	-1.0±1.0	**0.77**
1st month	180	-0.92±1.0	178	-1.0±1.0	**0.77**
2nd month	178	-0.90±1.2	174	-0.95±1.3	**0.43**
3rd month	168	-0.80±1.2	166	-0.93±1.4	**0.44**
Change of LAZ					
From 0 to 2nd month		0.02±0.14		0.05±0.23	**0.13**
From 0 to 3rd month		0.11±0.32		0.07±0.27	**0.28**
Weight-for-age (WAZ)					
0 month	191	-0.9±1.2	191	-1.10±1.1	**0.47**
1st month	180	-0.9±1.2	178	-1.10±1.1	**0.47**
2nd month	178	-0.92±1.2	174	-1.12±0.9	**0.33**
3rd month	168	-0.82±0.6	166	-1.17±0.9	**0.25**
Changes of WAZ					
From 0 to 2nd month		0.02±0.24		-0.03±0.3	**0.07**
From 0 to 3rd month		0.04±0.43		-0.06±0.3	**0.15**

4.13.3 Weight-for-age

Results in Table 22 show that, the mean weight-for-age Z-scores for the children in the treatment group increased by 0.02 ± 0.24 SD and 0.04 ± 0.43 SD during the second and third months of intervention, respectively while for the control the mean weight-for-age Z-score decreased by -0.03 ± 0.3 SD and -0.06 ± 0.3 SD during the second and third months of intervention, respectively. These changes in mean weight-for-age Z-scores at the 2nd and 3rd months of intervention were not significantly different (P > 0.05). Micronutrients supplements were given to 304 children for six and 12 months, respectively, did not result in a significant improvement in the mean weight-for-age Z-scores (Giovannini, 2006; Adu-Afarwuah, 2007). In addition, a study on effectiveness of micronutrient powders in women and children showed that, MNP had no impact on mean weight-for-age Z-scores for both mothers and children (Salam *et al.,* 2013).

Overall, the Z-scores of height for age (HAZ) increased, the Z-scores of weight for height (WHZ) showed no major improvements, and the weight for age increased, improvements on weight for age was only in the treatment group but decreased in the control group. The changes in height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ) Z-scores between treatment and control groups from the zero month to three months of intervention were not statistically different ($P > 0.05$).

4.14 Impact of Micronutrients Powder on Prevalence of Wasting, Stunting and Underweight

4.14.1 Prevalence of wasting, stunting and underweight at baseline

At baseline survey, prevalence of wasting, stunting and underweight among under-five children in the treatment group was 8.9% (n = 18), 9.9% (n = 19), 11% (n = 21), respectively. For the control group, prevalence of wasting, stunting and underweight among studied children was 9.4% (n = 18), 10.9% (n = 21) and 12% (n = 21), respectively. There was no significant difference ($P > 0.05$) in the prevalence of wasting, stunting and underweight between children in the treatment and control groups at baseline (Table 23). National Bureau of Statistics (2016), reported prevalence of stunting and underweight among under-five children to be 34% and 14%, respectively. These prevalence rates at national level were higher compared to those obtained in the current study. The prevalence of wasting reported by NBS (2016) at national level was less (5%) than that obtained in this study (8.9%) (Table 23).

Table 23: Prevalence of wasting, stunting and underweight

		Treatment		Control			
Intervention	Indicators	Number	Percent	Number	Percent	χ^2	*P*-value
0 month	Wasted children	17	8.9	18	9.4	**2.03**	**0.57**
	Stunted children	19	9.9	21	10.9	**1.24**	**0.54**
	Underweighted children	21	11.0	23	12.0	**1.36**	**0.72**
1st month	Wasted children	16	8.9	17	9.5	**2.03**	**0.57**
	Stunted children	18	10	19	10.8	**1.24**	**0.54**
	Underweighted children	20	11.1	22	12.0	**1.36**	**0.72**
2nd month	Wasted children	16	8.91	17	9.7	**0.43**	**0.81**
	Stunted children	18	10.1	21	11	**2.29**	**0.32**
	Underweighted children	20	11.2	24	12.6	**3.18**	**0.20**
3rd month	Wasted children	15	8.9	17	9.9	**3.01**	**0.22**
	Stunted children	12	7.1	16	9.6	**4.47**	**0.11**
	Underweighted children	18	11.7	25	15.0	**1.36**	**0.50**

4.14.2 Prevalence of wasting, stunting and underweight at 2nd month of intervention

Prevalence of wasting among children in the treatment group increased by 0.01%, from 8.9% (n = 16) to 8.91 (n = 16), whereas for the control children, prevalence of wasting increased by 0.3%, from 9.4 (n = 18) to 9.7% (n = 17). Prevalence of stunting increased by 0.2% for the treatment group and by 0.1% for the children in the control children. For children in the treatment group, the proportion of underweight children increased by 0.2%, from 11.0% (n = 21) at baseline to 11.2% (n = 21) at the second month while in the control group the prevalence increased by 0.6%, from 12% (n = 23) at baseline to 12.6% (n = 24) during 2nd month of intervention (Table 23). Food shortages and rising food prices were reported to increase prevalence of wasting and underweight among children within a period of three months (Olack *et al.*, 2011). Majority of households in this study with children under the age of five years were experiencing food shortage due to low food production at the household and high prices of staple foods.

4.14.3 Prevalence of wasting, stunting and underweight at 3rd month of intervention

In the 3rd month of intervention, the prevalence of wasting in both groups showed no major improvement as related to baseline. The prevalence of stunting among children in the treatment group showed a decrease of 2.8% from 9.9% (n = 19) at baseline to 7.1% (n = 12), whereas for the control children, the prevalence decreased from 10.9% (n = 21) to 9.6% (n = 16). For both groups, there were consecutive increases in the prevalence of underweight children from the baseline period to the 3rd month of intervention. In the treatment group, the prevalence of underweight children increased from 11.0% (n = 21) at baseline to 11.7% (n = 18) at 3rd month of intervention, whereas for the control group underweight increased from 12% (n = 23) at baseline to 15.0% (n = 25) (Table 23).

A study done by Trial *et al.* (2012) on the effect of micronutrient sprinkles in reducing anaemia reported that, there was no significant difference in the prevalence of wasting, stunting and underweight at any time of intervention. Another study evaluating the impact of home fortification of complementary foods on child anaemia and stunting revealed that, overall there was no effect on the prevalence of stunting, underweight or wasting but there was a significant decline of 8.4% in stunting for children aged 12–18 months (Jayatissa, 2014). A study by Salam *et al.* (2013) on the effectiveness of micronutrient powders (MNP) on children indicated no impact of MNPs on various anthropometric outcomes including stunting, wasting and underweight.

The increase in the prevalence of wasted and underweighted children could be a result of food shortage that was experienced by the households where the under-five children were drawn (Table 4). In a longitudinal study in rural Bangladesh, household food shortage was associated with increase in the prevalence of wasting and underweight among infants and young children aged 6 -59 months (Ali *et al.*, 2015). Another study conducted in Sekela

District, Western Ethiopia on the nutritional status of under-five children showed strong association between food shortage and increase in the prevalence of underweight.

Overall, for the three months of intervention, the prevalence of wasting showed no major improvements, whereas stunting decreased and underweight increased slightly (Table 23). The changes in the prevalence of wasting, stunting and underweight between treatment and control groups from the baseline to three months of intervention however, was not significantly different ($P > 0.05$).

Generally, the results of this study demonstrated that, consumption of one micronutrient powder sachet (10 mg of iron per sachet) taken daily for 3 months improved the mean hemoglobin concentration and reduced the prevalence of iron deficiency anaemia among children aged 6 to 59 months in Kilosa District. The 67% relative reduction in the prevalence of iron deficiency anaemia among children who took the micronutrient powder (from 85% to 28.8%) was achieved within the three-months of intervention period, whereas the prevalence of iron deficiency anaemia increased in the control group that did not receive the micronutrient powder.

The rate of recovery from iron deficiency anaemia (cure rate) in the intervention group at the end of the intervention was 71% (n = 120), versus only 3.6% (n = 6) that was observed in the control group. From these cure rates, it is evident that, the control group experienced a certain degree of natural recovery from iron deficiency anaemia. This natural recovery could be a result of aging of the children in the study and thus children were no longer in the period of greatest risk for iron-deficiency anaemia. The fact that the recovery rate in the intervention group was more than twice that in the control group ($P = 0.000$) indicated that, the micronutrient powder was effective in curing iron deficiency anaemia among a large proportion of children in the treatment group and the MNP was more effective in curing iron deficiency anaemia beyond that which is expected from natural recovery.

4.15 Limitations of the Study

Cost and logistic constraints prohibited the measurement of other biochemical markers of iron status (ferritin and transferrin). As a result, iron deficiency anaemia was determined by measuring only hemoglobin concentration.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A three-month supplementation of children aged 6 – 59mo with MNP did not result in significant improvement in the wasting, stunting and under-weight. With high compliance and good control of anaemia confounders (malaria and hookworm), the use of micronutrients powder, taken daily for three months can be a very effective method in improving hemoglobin status and reducing the prevalence of iron deficiency anaemia in children. Mothers/caregivers, attributed supplementing children with MNP with increase in appetite, decrease in episode of illness, weight gain, increased in learning ability, decrease in the demand for breastfeeding and good sleeping during day and night. Mothers/caregivers accepted MNP in terms of willingness to purchase, it was easy to use, highly likable with good organoleptic properties (e.g., colour and taste), and no side effects.

5.2 Recommendations

Based on the results obtained in this study, it is highly recommended that, in populations where the prevalence of anaemia in children under the age of five years is 20% or higher, home food fortification of complementary foods with iron-containing micronutrients powder should be introduced. This would be a good short term intervention against iron deficiency anaemia in children.

REFERENCES

Abuya, B. A., Ciera, J. and Kimani-Murage, E. (2012). Effect of mother's education on child's nutritional status in the slums of Nairobi. *Biomed Central Journal* 12(1): 2431: 12-80.

ACC/SCN (1990). Women and Nutrition: Nutrition Policy Discussion Paper No.6: 14-102.

Adu-Afarwuah, S., Lartey, A., Brown, K. H., Zlotkin, S., Briend, A. and Dewey, K.G. (2008). Home fortification of complementary foods with micronutrient supplements is well accepted and has positive effects on infant iron status in Ghana. *American Journal of Clinical Nutrition* 87: 929–938.

African, E. (2015). Risk factors for child under-nutrition with a human rights edge in rural villages of North Wollo, Ethopia: [https://doi.org/10.4314/eamj. v82i12.9367] site visited on 10/12/2017.

Ajao, K. O., Ojofeitimi, E. O., Adebayo, A. A., Fatusi, A. O. and Afolabi, O. T. (2010) "Influence of family size, household food security status, and child care practices on the nutritional status of under-five children in Ile-Ife, Nigeria," *African Journal of Reproductive Health* 14(4): 123-131.

Albelbeisi, A., Shariff, Z. M., Mun, C. Y., Rahman, H. A. and Abed, Y. (2017). Use of Micronutrient Powder in At-Home Foods for Young Children (6 - 18 Months): A Feasibility Study. [https://doi.org/10.3923/pjn. 372.377] site visited on 30/01/2018.

Ali, D., Saha, K. K., Nguyen, P. H., Diressie, M. T., Ruel, M. T. and Menon, P. (2015). “Household food insecurity is associated with higher child under-nutrition in Bangladesh, Ethiopia, and Vietnam, but the effect is not mediated by child dietary diversity” *Journal of Nutrition* 143: 12-21.

Allen, L., de Benoist, B., Dary, O. and Hurrell, R. (2006). Guidelines on Food Fortification with Micronutrients. World Health Organization and Food and Agricultural Organization of the United Nations.

Allen, L.H. (2008). To what extent can food-based approaches improve micronutrient status? Asia. *Journal of Clinical Nutrition*. 17 (Suppl) 1: 103-5.

Andersson, N., Karumbunathan, M., V. and Zimmermann, M. B. (2012). Global Iodine Status in 2011 and Trends over the Past Decade 1 – 3, 744–751. *Journal of Nutrition*. [mhttps://doi.org/10.3945/jn.111.149393] site visited on 03/07/2018.

Arimond, M. and Ruel, M. T. (2004). Dietary diversity is associated with child nutritional status: Evidence from 11 Demographic and Health Surveys. *The Journal of Nutrition*, 134: 2579-2585.

Arimond, M., Wiesmann, D., Becquey, E., Carriquiry, A., Daniels, M. C., Deitchler, M., Fanou Fogny, N. and Torheim, E. L. (2010). Developing Simple Measures of Women’s Diet Quality in Developing Countries: Methods and Findings. University of North Carolina, U.S.A. *Journal of Nutrition* 140:2059-2069.

Avan, B. I., Raza, S. A. and Kirkwood, B. R. (2015).An Epidemiological Study of Urban and Rural Children in Pakistan: Examining the Relationship between Delayed Psychomotor Development, Low Birth Weight and Postnatal Growth Failure. 109:189–196. [https://doi.org/10. 1093/trstmh/tru162] site visited on 25/10/2017.

Azadbakht, L. and Esmaillzadeh, A. (2010). Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. *Journal of Public Health Nutrition* 14: 62-69.

Beck, K. L., Conlon, C. A., Kruger, R., and Coad, J. (2014). Dietary determinants of and possible solutions to iron deficiency for young women living in industrialized countries: A review. *Nutrients* 6(9): 3747–3776. [https://doi. org/10.3390/nu6093747] site visited on 30/10/2017.

Berkley, J. A. (2002) Invasive Bacterial Infections in Children at a Sub-Saharan District Hospital. University of Newcastle Up on Tyne, UK. 288pp.

Bhutta, Z. A., Ahmed, T., Black, R. E., Cousens, S., Dewey, K. and Giugliani, E. (2008). What works? Interventions for maternal and child under nutrition and survival. *Lancet* 371(9610): 417-40.

Black, R. E, Victora, C. G., Walker, S. P., Bhutta, Z., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J. and Martorell, R. (2013). Maternal and child under-nutrition and overweight in low-income and middle-income countries. *Lancet* 382: 427–451.

Black, R. E., Allen, L. H. and Bhutta, Z. A. (2006). Maternal and Child Under-nutrition: Global and regional exposures and health consequences. *Lancet* 371: 243–260.

Brinkman, H. J., de Pee, S., Sanogo, I., Subran, L. and Bloem, M. W. (2009). High food prices and the global financial crisis have reduced access to nutritious food and 86 worsened nutritional status and health. *Journal of Nutrition*, 140(1): 153S-161S. doi:10.3945/jn.109.110767.

Cardoso, M. A., Augusto, R. A., Bortolini, G. A. and Oliveira, C. S. M. (2016). Effect of Providing Multiple Micronutrients in Powder through Primary Healthcare on Anaemia in Young Brazilian Children : A Multicentre Pragmatic Controlled Trial, *63*, 1–13. [https://doi.org/10.1371/journal. pone. 0151097] site visited on 09/03/2018.

Caulfield, L. E. and Black, R. E. (2004). Zinc deficiency. *Comparative Qualifications of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors*, pp257–279. Available from: https://doi.org/10.1007/ s12263-011-0248-4] site visited on 09/06/2018.

Chandyo, R., Ulak, M., Adhikari, R., Sommerfelt, H. and Strand, T. (2015). Prevalence of Iron Deficiency and Anaemia among Young Children with Acute Diarrhea in Bhaktapur, Nepal. *Healthcare* 3(3): 593–606.

Creed-kanashiro, H., Bartolini, R., Abad, M. and Arevalo, V. (2016). Original Article Promoting multi-micronutrient powders (MNP) in Peru : acceptance by caregivers and role of health personnel, 152–163. [https://doi.org/10.1111/mcn.12217] site visited on 30/05/2018.

Daelmans, B., Martines, J., Saadeh, R., Dewey, K. G. and Brown, K. H. (2003). Special Issue Based on a World Health Organization Expert Consultation on Complementary Feeding. *Food and Nutrition Bulletin* 24(1): 1–141.

Darnton-Hill. I and Nalubola. N (2002) Fortification strategies to meet micronutrient needs: successes and failures; *Proceedings of the Nutrition Society* 61: 231-241.

De-Regil, L. M., Suchdev, P. S., Vist, G. E., Walleser, S. and Peña-Rosas, J. P. (2011). Home fortification of foods with multiple micronutrient powders for health and nutrition in children under two years of age. *Cochrane Database of Systematic Reviews*, Issue 9. Art. No.: CD008959. DOI: 0.1002/14651858.CD008959.pub2.

Detzel, P. and Wieser, S. (2015). Current evidence suggests that food fortification deficiency at the population level , particularly in infants and young children Food Fortification for Addressing Iron Deficiency in Filipino Children : Benefits and Cost-Effectiveness Food Fortification for Addressing Iron Deficiency in Filipino Children : Benefits and Cost-Effectiveness. [https://doi.org/10.1159/000375144] site visited on 30/03/2018.

Dewey K. (2001). The challenges of promoting optimal infant growth. *Journal of Nutrition* 131(7): 1879-1880 [http://jn.nutrition.org/content/ 131/7/1879] site visited on 16/01/2018.

Enzama, W., Afidra, R., Johnson, Q. and Verster, A. (2017). Africa maize fortification strategy 2017–2026. Online: Smarter Futures.

Ewusie, J. E., Ahiadeke, C., Beyene, J. and Hamid, J. S. (2014). Prevalence of anaemia among under-5 children in the Ghanaian population: estimates from the Ghana demographic and health survey. *BMC Public Health*, *14*(1), 626. (Cited 30 March 2018). Available from: https://doi. org/10.1186/1471-2458-14-626.

FAO and WFP (2010). *The State of Food Insecurity in the World*. Addressing food insecurity in protracted crises. Rome, Italy. 59pp.

Fischer, A. A., Laing, E., Stockel, J. E. and Townsend, J. W. (1991).Handbook for Family Planning Operations Research Design. Population Council, New York, 45pp.

Frost, M. B., Forste, R. and Haas, D. W. (2005). “Maternal Education and Child Nutritional Status in Bolivia: Finding the Links.” *Social Sciences and Medicine* 60(2): 395-407.

Gera, T. and Sachdev, H. P. S. (2002) Effect of iron supplementation on incidence of infectious illness in children: systematic review. *British Medical Journal* 325: 1142-196.

Gibson, R. S. (1990). *Principles of Nutritional Assessment*. Oxford University Press, Oxford. pp 165-166, 169-170, 201.

Giovannini, M., Sala, D., Usuelli, M., Livio, L., Francescato, G. and Braga, M. (2006). Double-blind, placebo-controlled trial comparing effects of supplementation with two different combinations of micronutrients delivered as sprinkles on growth, anaemia, and iron deficiency in Cambodian infants. *Journal of Pediatrics Gastroenterology and Nutrition* 42(3): 306–12.

Gleason, G. and Scrimshaw. N.S. (2007). An overview of the functional significance of iron deficiency. In: Kraemer K, Zimmermann M, eds. *Nutritional anaemia.* Basel, Switzerland: Sight and Life Press. pp46–49.

Glover-Amengor, M., Agbemafle, I., Hagan, L. L., Mboom, F. P., Gamor, G., Larbi, A. and Hoeschle-Zeledon, I. (2016). Nutritional status of children 0–59 months in selected intervention communities in northern Ghana from the africa RISING project in 2012. *Archives of Public Health* 74(1): 12.. [https://doi.org/10. 1186/s13690] site visited on 12/02/2018.

Gupta, P., Singh, K., Seth, V., Agarwal, S. and Mathur, P. (2015). Coping Strategies Adopted by Households to Prevent Food Insecurity in Urban Slums of Delhi, India. *Journal of Food Security* 3(1): 6–10. [https://doi.org/ 10.12691/JFS-3-1-2] site visited on 12/07/2017.

Handa, S. (1999). “Maternal education and child height”. *Economic Development Culture Change* 47 (2): 421–39.

Hatloy, A., Hallund, J., Diarra, M. M. and Oshaug, A. (2000). Food variety, socioeconomic status and nutritional status in urban and rural areas in Koutiala (Mali). *Journal of Public Health Nutrition* 3(01): 57-65.

Ho, K. and McLean, J. (2011). The Implementation of In-Home Fortification and Nutrition Education to Combat Anaemia and Micronutrient Deficiencies Among Children 6-23 Months in Rwanda Phase 1 Final Report, 10.

Hurrell, R. F., Reddy, M. and Cook, J. D. (1999). Inhibition of non-haem iron absorption in man by polyphenol-containing beverages. *British Journal of Nutrition* 81: 289–295.

Iqbal, K., Zafar, T., Iqbal, Z., Usman, M. and Bibi, H. (2015). Effect of Iron Deficiency Anaemia on Intellectual Performance of Primary School Children in Islamabad, Pakistan. 14: 287–29.

Jane, P. K. (2011). Msc thesis entiled “Assessment of nutrient contents of foods widely grown and consumed in morogoro municipality” Department of Food technology, Nutrition and consumer sciences. Sokoine University of Agricuture, Morogoro, Tanzania.

Jayatissa, R., Senarath, U. and Siriwardena, I. (2014). Evaluation of Multiple Micronutrient Supplementation Programme in Sri Lanka 2009-2012. Medical Research Institute, Ministry of Health and UNICEF: Colombo.

Jefferds, M. E., Mirkovic, K. R., Subedi, G. R., Mebrahtu, S., Dahal, P. and Perrine, C., G. (2015). Predictors of micronutrient powder sachet coverage in

Nepal. Maternal and Child Nutrition, 11(4); 77–89. (Cited 17 November 2018).: Available from: https://doi. org/10. 1111/mcn.12214.

Kabubo-Mariara, J., Ndenge, G. K. and Mwabu, D. K. (2009). Determinants of children's nutritional status in Kenya: Evidence from Demographic and Health Surveys. *Journal of African Economies* 18(3): 363–387.

Kahimba, F. C., Mbaga, S., Mkoko, B., Swai, E., Kimaro, A. A., Mpanda, M., Liingilie, A. and Germer, J. (2015). Analysing the current situation regarding biophysical conditions and rainfed crop-, livestock-and agroforestry systems. Available from: site [http://project2.zalf.de/transsec/public/media/upload/product/pdf/83905803646d86cb3ba323cdc201860b.pdf] site visited on 30/06/2017.

Katega, I. B. and Lifuliro, C. (2013). Rural Non-Farm Activities and Poverty Alleviation in Tanzania: A Case of selected villages in Chamwino and Bahi Districts in Dodoma Region. Final report submitted to Research on Poverty Alleviation (REPOA).

Kayunze, K. A., Mwageni, E. A. and Mdoe, N. S. Y. (2009). Do various methods of food security determination give similar results? Evidence from Rufiji District, Tanzania. *Eastern and Southern Africa Journal of Agricultural Economics and Development* 6: 125 -145.

Kennedy, G. L., Pedro, M. R., Seghieri, C., Nantel, G. and Brouwer, I. (2009). Dietary diversity score is a useful indicator of micronutrient intake in non-breast-feeding Filipino children. *Journal of Nutrition* 137: 472– 477.

Khatri-Chhetri, A. and Maharjan, K. L. (2006). Food insecurity and coping strategies in rural areas of Nepal: A case study of Dailekh District in Mid-Western Development Region. *Journal of International Development and Cooperation* 12(2): 25–45.

Kuchenbecker, J., Jordan, I., Reinbott, A., Herrmann, J., Jeremias, T., Kennedy, G., Krawinkel, M. B. (2015). Exclusive breastfeeding and its effect on growth of Malawian infants : results from a cross-sectional study. [https://doi.org/10.1179/2046905514Y.0000000134] site visited on 12/07/2017.

Kyu, H. H., Pinho, C., Wagner, J. A., Brown, J. C., Bertozzi-Villa, A. and Vos, T. (2016). Europe PMC Funders Group Global and national burden of diseases and injuries among children and adolescents between 1990 and 2013 : *Findings from the Global Burden of Disease 2013 Study* 170(3): 267–287.

Lundeen, E., Schueth, T., Toktobaev, N., Zlotkin, S., Ziauddin, S. M. and Houser, R. (2014). Daily use of Sprinkles Micronutrient powder for 2 months Reduces Anaemia Among children 6 to 36 months of age in the Kyrgyz Republic : A cluster-Randomized Trial. *Food and Nutritional Bulletin* 31(3): 90-99.

Masalawala, R., Shapiro, A. F. Ingram, M. and Rinehart, B. (2010). Food Security in Tanzania, Seven Original Concept Paper: Director of Business Development, Millennium Promise; Adjunct, Columbia SIPA Capstone Workshop, spring 2010, Kampala, Uganda. 13pp.

Mda, S., Raaij, J. M. A. Van, Villiers, F. P. R. De. and Kok, F. J. (2013). Impact of Multi-Micronutrient Supplementation on Growth and Morbidity of HIV-Infected South African Children, *Journal of Public Health Nutrition* 4: 4079–4092. [https://doi.org/10.3390/ nu5104079] site visited on 30/06/2018.

Meerman, J. and Aphane, J. (2012). Impact of High Food Prices on Nutrition.Chapter for the Proceedings for FAO's Expert Consultation on Policy Responses to High and Volatile Food Prices. FAO Nutrition Division (ESN).

Mekbib, E. (2014). Magnitude and Factors Associated with Appropriate Complementary Feeding among Mothers Having Children 6-23 Months-of-Age in Northern Ethiopia; A Community-Based Cross-Sectional Study. *Journal of Food and Nutrition Sciences*, *2*(2): 36-91. [https://doi.org/10.12691/JFS-3-1-2] site visited on 12/07/2017.

Melse-Boonstra, A. and Mwangi, M. N. (2016). What is causing anaemia in young children and why is it so persistent? *Jornal de Pediatria*, 21–23. [https:https://doi. org/10.1016/j. jped.2016.04.001] site visited on 12/03/2017.

Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC) (2015). Tanzania Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) 2015-16. Dar-es-Salaam, Rockville: MoHCDGEC, MoH, NBS, OCGS, ICF. Available from: [http://www.dhsprogram.com/pubs/pdf/FR321/FR321.pdf] site visited on 03/05/2017.

Mirkovic, K. R., Perrine, C. G., Subedi, G. R., Mebrahtu, S., Dahal, P., Staatz, C. and Jefferds, M. E. D. (2017). Predictors of micronutrient powder intake adherence in a pilot programme in Nepal, *Journal of Public Health Nutrition* 19(10): 1768–1776. [https://doi.org/10.1017/S13689800 15003572] site visited on 02/07/2018.

Mirkovic, K. R., Perrine, C. G., Subedi, G. R., Mebrahtu, S., Dahal, P., Staatz, C. and Jefferds, M. E. D. (2015). Predictors of micronutrient powder intake adherence in a pilot programme in Nepal. *Journal of Public Health Nutrition* 19(10): 1768-1776.

MMWR (1998). Centers for Disease Control and Prevention. Recommendations to prevent and control iron deficiency in the United States. 47 (No. RR-3).

MoHCDGEC (2015). The National Road Map Strategic Plan to Improve Reproductive, Maternal, Newborn, Child and Adolescent Health in Tanzania: 2016-2020. Sharpened One Plan. RCHS, Directorate of Preventive Services, United Republic of Tanzania, Dar es Salaam.

MoHCDGEC (2016). [Tanzania Mainland], Ministry of Health (MoH) [Zanzibar] National Bureau of Statistics (NBS); Office of the Chief Government Statistician (OCGS), and ICF International. Tanzania and Demographic Health Survey and Malaria Indicator Survey (TDHS-MIS) 2015–2016; MoHCDGEC: Dar es Salaam, Tanzania; MoHSW, MoH, NBS, OCGS and ICF International: Rockville, MD, USA.

Naser, I. A., Jalil, R., Manan, W., Muda, W., Suriati, W., Nik, W. and Abdullah, M. R. (2014). Association between household food insecurity and nutritional outcomes among children in Northeastern of Peninsular Malaysia. Available fromhttps: //doi.org/10.4162/nrp.2014.8.3] site visited on 30/05/2017.

National Bureau of Statistics (NBS) (2010). Tanzania Demographic and Health Survey 2010 - 2011. Dar es Salaam, Tanzania.

National Bureau of Statistics (NBS) (2013). Tanzania Demographic and Health Survey 2013 - 2014. Dar es Salaam, Tanzania.

National Bureau of Statistics (NBS) (2015). Tanzania Demographic and Health Survey 2015 - 2016. Dar es Salaam, Tanzania.

National Bureau of Statistics (NBS) [Tanzania] and ICF Macro (2011). Tanzania Demographic and Health Survey 2010. Dar-es-Salaam: NBS and ICF Macro.

National Bureau of Statistics (NBS) [Tanzania] and ICF Macro. (2011). Tanzania Demographic and Health Survey 2010; NBS and ICF Macro: Dar es Salaam, Tanzania.

Olack, B., Burke, H., Cosmas, L., Bamrah, S., Dooling, K., Feikin, D. R., Breiman, R. F. (2011). Nutritional status of under-five children living in an informal urban settlement in Nairobi, Kenya. *Journal of Health, Population and Nutrition* 29(4): 357-363.

Oldewage-Theron, W. and Kruger, R. (2008). Food variety and dietary diversity as indicators of the dietary adequacy and health status of an elderly population in Sharpeville, South Africa. *Journal of Nutrition* 27(1-2): 101-133.

Olney, D.K., Talukder, A., Iannotti, L.L., Ruel, M.T. and Quinn, V. (2009). Assessing impact and impact pathways of a homestead food production program on household and child nutrition in Cambodia. *Food Nutrition Bulletin* 30(4): 355-369.

Osei, A., Pandey, P., Spiro, D., Nielsen, J., Shrestha, R., Talukder, Z., Quinn, V. and Haselow, N. (2010). “Household food insecurity and nutritional status of children aged 6-23 months in Kailali district of Nepal.” *Food and Nutrition Bulletin* 37(4): 134-140.

Pauw, K. and Thurlow, J. (2011). Agricultural Growth, Poverty, and Nutrition in Tanzania. *Food Policy* 36(6): 795– 804.

Ponce, X., Ramirez, E. and Delisle, H. (2006). A more diversified diet among Mexican men may also be more atherogenic, *The Journal of Nutrition* 136: 2921-2927.

Radimer, K. L., Olson, C. M., Greene, J. C., Campbell C. C. and Habicht, J. P. (1992). “Understanding hunger and developing indicators to assess it in women and children.” *Journal of Nutrition Education* 24: 1 S36-S44.

Rebhan, B., Kohlhuber, M., Schwegler, U., Koletzko, B.V. and Fromme, H. (2009). Infant feeding practices and associated factors through the first 9 months of life in Bavaria, Germany. *Journal of Health, Pediatric Gastroenterol Nutrition* 49(4): 467-73.

Roba, K. T., Connor, T. P. O., Belachew, T. and Brien, N. M. O. (2016). Infant and Young Child Feeding (IYCF) Practices Among Mothers of Children Aged 6 – 23 Months in Two Agro-ecological Zones of Rural Ethiopia. *Journal of Nutrition and Food Sciences* 5(3): 185–194.

Salam, R. A., Macphail, C., Das, J. K. and Bhutta, Z. A. (2013). Effectiveness of Micronutrient Powders (MNP) in women and children. *Journal of Public Health*, 13(Suppl 3), S22. [https://doi.org/10.1186/1471-2458-13-S3-S22] site visited on 30/04/2018.

Sawadogo, P. S., Martin-Prevel, Y., Savy, M., Kameli, Y., Traissac, P. and Traore, A.S. (2006). An infant and child feeding index is associated with the nutritional status of 6-23month-old children in rural Burkina Faso. *Journal of Nutrition* 136: 656–663.

Sazawal, S., Dhingra, P., Dhingra, U., Gupta, S., Iyengar, V., Menon, V. P. and Black, R. E. (2014). Compliance with Home-based Fortification Strategies for Delivery of Iron and Zinc : *Its Effect on Haematological and Growth Markers Among 6-24 Months Old Children in North India* 32(2): 217–226.

Schauer, C. and Zlotkin, S. (2003). Home fortification with micronutrient Sprinkles—a new approach for the prevention and treatment of nutritional anaemia. *Journal of Pediatrics* 8: 87–90.

Scott, M. I. (2001). Book Review: Feeding and Nutrition of Infants and Young Children: Guidelines for the WHO European Region, With Emphasis on the Former Soviet Countries. *Journal* of Clinical *Nutrition* 17(3): 265–266.

Serdula, M. (2010). Maximizing the impact of flour fortification to improve vitamin and mineral nutrition in populations. *Food Nutrition Bulletin* 31(1 Suppl): S86–S93.

Series, L. N. (2012). Scientific Rationale : Benefits of Breastfeeding. *Journal of Pediatric and Neonatal Individualized Medicine* 2012; 1–7.

Severi, S., Bedogoit, G., Manzierjl, A. M., Poljl, M. and Battistioi, N. (1998). practices on the micronutrient content of foods, *Journal of Cancer Prevention* 7: 331–335.

Silversides, A. (2009). Long road to Sprinkles. *Canadian Medical Association Journal* 180(11): 1098.

Smarter Futures (2016) Report of Maize Scoping Discussed in the Tanzania Maize fortification strategy meeting on 3-7 October 2016.

Steyn, N. P., Nel, J. H., Nantel, G., Kennedy, G. and Labadarios, D. (2006). Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? *Public Health Nutrition* 9(5): 644-650.

Sthapit, B. R. (2004). Bicultural diversity in the sustainability of developing country food systems, *Journal of Food and Nutrition* 25: 143–155.

Suchdev, P. S., Ruth, L. J., Woodruff, B. A., Mbakaya, C., Mandava, U., Flores-Ayala, R. and Quick, R. (2016). Selling Sprinkles micronutrient powder reduces anaemia, iron deficiency, and vitamin A deficiency in young children in Western Kenya: a cluster-randomized controlled trial. *The American Journal of Clinical Nutrition*, 95(5): 1223–1230. [http://doi.org/10.3945/ajcn.111.030072] site visited on 10/04/2018.

Susan, N. K. (2013). MSc thesis entitled “Maternal Occupation and the Nutritional Status of Mothers and Children under the Age of Five Years in Msambweni Location, Kwale District -Kenya.” Department of Food Technology and Nutrition, Unit of Applied Human Nutrition. Kenyatta University, Nairobi, Kenya. I56pp.

Swindale, A. and Bilinsky, P. (2006). Household dietary diversity score (HDDS) for measurement of household food access: indicator guide, Version 2. Food and Nutrition Technical Assistance Project, (FANTA), Academy for Educational Development (AED), Washington, D.C. 75pp.

Tanzania Food and Nutrition Center (2014). Tanzania National Nutrition Survey. In: *high level steering committee on nutrition*. Dar es Salaam. 45pp.

Tanzania Food and Nutrition Centre (TFNC) (2004). Prevention and control of iodine deficiency disorders in Tanzania. Second National IDD Survey. TFNC Report No. 2002. Dar es Salaam, Tanzania: TFNC.

Tanzania Food and Nutrition Centre (TFNC) (2014). Tanzania National Nutrition Survey 2014 final report. Ministry of Health and Social Welfare. 12015, Dar es Salaam. Available from [http://www.unicef.org/esaro/ Tanzania_National_ Nutrition_Survey_2014_Fi nal_Report_180] site visited on 02/07/2018.

Torheim, L. E., Ferguson, E., Penrose, K. and Arimond, M. (2010). Women in resource-poor settings are at risk of inadequate intakes of multiple micronutrients. *Journal of Nutrition* 140: 2051–2058.

Torheim, L. E., Ouattara, F., Diarra, M. M., Thiam, F. D., Barikmo, I. and Hatloy, A. (2004). Nutrient adequacy and dietary diversity in rural Mali. Association and determinants. *European Journal of Clinical Nutrition* 58: 594–604.

Twaweza (2017). Hunger pangs: Food insecurity in Tanzania, Sauti za Wananchi, Brief No. 39, Available from: [http://www.twaweza.org/uploads/files/SzW-FoodSecurity-ENFINAL.pdf] site visited on 20/03/2018.

UNICEF and NBS (2016). Child Poverty Report [http://www.nbs.go.tz/nbstz/ index.php/english/statistics-by-subject/ panel -survey- statistics/762-child-poverty] site visited on 12/07/2017.

UNICEF/AED (2010). Infant and Young Child Feeding Programme Review: Consolidated Report of Six-Country Review of Breastfeeding Programmes.

UNICEF/UNU/WHO (2001). Iron Deficiency Anaemia. Assessment, Prevention and Control.A Guide for Programme Managers. IDA Consultation, World Health Organization. Geneva.

Vandevijvere, S., De Vriese, S., Huybrechts, I., Moreau, M. and Van Oyen, H. (2010). Overall and within-food group diversity are associated with dietary quality in Belgium. *Journal of Public Health* 134: 211-9.

WHO (2001). The optimal duration of exclusive breastfeeding: report of an expert consultation. In: World Health Organization, Geneva, Switzerland.

WHO (2011). Use of multiple micronutrient powders for point-of-use fortification of foods consumed by pregnant women. Geneva. [http://apps.who.int/iris/ bitstream/10665/44 650/1/9789241502030_eng.pdf] site visited on 18/01/2018.

WHO (2014). Infant and young child feeding: Fact sheet N°342. Geneva: WHO. [http://www.who.int/mediacentre/factsheets/fs342/en/] site visited on 30/09/2017.

Woldemariam, G. and Timotiows, G. (2002). Determinants of the Nutritional Status of Mothers and Children in Ethiopia. *Calverton, Maryland* 2002; 1–36.

Woldemichael A., Kidane, D. and Shimeles, A. (2017). A Tax on Children? Food Price Inflation and Health, Working Paper Series N° 276, African Development Bank, Abidjan, Côte d’Ivoire.

World Bank. (2015). Tanzania Nutrition at glance. Japan Trust Fund for Scaling Up Nutrition, Report. Dar-es-Salaam.

World Health Organization (2006). Complementary feeding in the WHO Multicentre Growth Reference Study. *Acta Paediatrica* 450: 27–37.

World Health Organization. World Health Statistics (2015). Available online: [http://apps.who.int/iris/bitstream/10665/170250/1/9789240694439_eng.pdf?ua=1] site visited on 17/09/2018.

Young, M. F., Avula, R. and Girard, A. W. (2017). Acceptability of multiple micronutrient powders and iron syrup in Bihar, India, 1–8. [https://doi.org/10.1111/mcn.1257] site visited on 20/08/2012.

Zimmermann, M. B. (2008). Iodine requirements and the risks and benefits of correcting iodine deficiency in populations. *Journal of Trace Elements in Medicine and Biology* 22(2): 81-92.

Zlotkin, S. and Schauer, C. (2003). Use of microencapsulated iron (II) fumarate sprinkles to prevent recurrence of anaemia in infants and young children at high risk. *Bull World Health Organ* 81:108–15.

Zlotkin, S. H., Schauer, C., Christ of ides, A., Sharieff, W., Tondeur, M.C. and Hyder S.M. (2005). Micronutrient sprinkles to control childhood anaemia. *Plos Medicine Journal* 2(1): 66-79.

Zlotkin, S. H., Schauer, C., Christofides, A., Sharieff, W., Tondeur, M. C. and Hyder, S.M. (2005). Micronutrient sprinkles to control childhood anaemia. *Journal of Nutrition* 2(1): 81-90.

Zlotkin, S. H., Christofides, A. L., Hyder, S. M. Z., Schauer, C. S., Tondeur, M. C. and Sharieff, W. (2004). Controlling iron deficiency anaemia through the use of home-fortified complementary foods. *Indian Journal Pediatrics* 71: 1015–1020.

APPENDICES

EFFICACY OF HOMEMADE FOOD FORTIFICATION WITH MICRONUTRIENT POWDERS (MNP) IN REDUCING IRON DEFICIENCY ANAEMIA AMONG CHILDREN AGED 6-59 MONTHS IN KILOSA DISTRICT.

Appendix 1: Questionnaire

ROPORT

i) ID No……………………

ii) ii) Village name …......................................

iii) iii) District…………………………

iv) iv) Health facility…………………....

v) v) Name of respondent………………………………………….

vi) vi) Name of village health workers…………………………….

SECTION A: SOCIOECONOMIC AND DEMOGRAPHIC INFORMATION

1. What is your family average monthly expenditure (TZSs)?

i) Less than 39,000/= ii) 40,000-59,000 iii) 60,000-99,000
iv) Greater than 100, 000/=

2. Level of education

i) Informal education 11) Primary school ii) Secondary school

iii) Diploma /Degree

3. Age of child…… **4.** Age of caregiver/Mother…..
5. Marital status

i) Single ii) Married iii) Divorced iv) Widow
v) Cohabitated

6. Sex of the child F /M

SECTION B: FEEDING PRACTISES AND HOUSEHOLD DIETARY DIVERSITY

1) Did you breastfeeding your baby for six month? Yes/NO

2) At what age did you start fed your baby with other food apart from milk?

i/At age of two month ii/ Three month iii/ Four month iv/Five month vi/Six month

3) In the 24 hours did you fed your baby with carbohydrate based foods? Yes/No

4) In the 24 hours did you fed your baby with any of Red meat? Yes/No

5) In the last 24 hours did you fed your baby with fish? Yes/No

6) In the 24 hours did you fed your baby with white meat? Yes/No

7) In the 24 hours did you give your baby fruits? Yes/No

8) In the 24 hours did your baby consume any daily product? Yes/No

9) In the 24 hours did you fed your baby egg? Yes/No

SECTION C:

HOUSEHOLD FOOD SHORTAGE, CAUSES AND COPING STRATEGIES

1) Did your family experience food shortage? Yes/No

2) What are the causes of food shortage?

I/Low production ii/Floods iii/High prices of foods iv/Climate change v/Drought

3) Did the food shortage affect the daily family consumption? Yes/No

4) How did you copy with situation of food shortage?

i/ Less preferable foods ii/Less expensive foods iii/ Seasonal vegetable and fruits iv/Reduce meals per day

SECTION D:

PREPARATION AND COMPLIANCE OF FORTIFIED FOOD

PART A: PREPARATION

1) What food or drink do you use MNP with?

i) Porridge ii) Milk iii) Tea v) Water

vi) Pap vii) others, mention

2) When do you use MNP?

i) Before cooking ii) After cooking, iii) In the cooking pan iv) In the bowl v) In Hot food vi) In Cold food

3) Do you always use the whole sachet? Yes/NO

4) How long after mixing MNP do you wait before feeding the child?

Time: …………………..minutes

5) Has MNP changed the way that you prepare your child food? Yes/No

PART B: COMPLIANCE

3) Number of empty sachets (Collect all empty sachet)

No ____________

4) Number of full sachets:

No ____________

5) have you lost or thrown an empty sachet of MNP during the last 30 days?

i) Yes…………………ii) No...........................iii) I am not sure……………………………….

6) Have you given MNP to children or persons other than your young child who was included in the study?

i) Yes……………………………………ii) No..

7) Who eats MNP?

i) Youngest child ii) All children iii) Mother v) Whole family vi) Neighbors

SECTION E:

MOTHERS PERCEIVED BENEFITS AND SIDE EFFECTS OF MNP

1) Are there changes you have noticed on your child because of using the MNP? Yes/No

2) If yes, explain……………………………………………………………………..

…………………………………………………………………………………………

3) Have you noticed any changes with your child when she/he goes to the bathroom? Yes/No

If yes, choose from the list

i) Loose stool ii) hard stool iii) Dark stools iv) others specify

4) Side effects (number of episodes):

Diarrhea: ______ Vomiting: ______ Stool discoloration: _____ Loose stool: ___

6) Have you noticed any difference in the behavior of your child?

i) Child becoming ‘’more active ii) Child has more energy iii) No noted changes at all

iv) A and B v) Others, mention

7) Have you noticed any difference in the physical appearance of your child? Select from the list

i) Child skin become fresh ii) Child skin become “bright iii) No changes occurred

iv) A and B v) Others, specify

8) Have you noticed any change in the health of your child?

i) Good growth ii) Gaining weight iii) Good health iv) Less sick than before

v) No changes in the health of the child

9) What did you do after you noticed any of the negative changes?

i) Stop using MNP? ii) Reduce the amount? iii) Go to health center?

10) How would you describe your child’s appetite level after three month of intervention?

i) Excellent ii) Good iii) Fair Poor IV/ I don’t know

11) How would you describe your child’s activity level after the three month of intervention?

i) Very active ii) Active Moderately iii) Active Occasionally

iv) Active v) Inactive vi) No comment

SECTION F: ANTHROPOMETRIC AND BIO-CHEMICALMEASUREMENTS OF UNDERFIVE CHILDREN

7) Monitoring of Anthropometric measurements at the baseline and every after a month for three months.

Anthropometric measurements	**0 month**	**1st month**	**2ndmonths**	**3rd months**
Length (cm)				
Weight (Kg)				
HC(cm)				
MUAC (cm)				
Hb (g/dl/l)				

Appendix 2: Follow-up Survey Questionnaire

i) Child ID……………. ……. ii) Caregiver ID……………………………

iii) Date of Follow up………….. iv) Date of Sprinkles start……………………..

1. Easy to use

i) Yes ii) No

2. Child likes?

i) Yes ii) No

3) Did you notice a change in color when MNP was added to food?

i) Yes ii) No....................... iii) I am not sure……

4) If color change, what color did it change to?

i)Yellow……..ii)Orange ....iii)Red ……..iv)White ……… v)Don't Know……………

5) Did the food change taste when MNP was added?

i) Yes…………..ii)No………………

6) If taste changed, what was the taste?

i) Sour …………ii) Sweet......................iii) Don't know ……………

7) How many times the child finished the whole fortified food portion

i) Every time

ii) Almost every time

iii) Sometimes

iv) Never

8) If the child doesn't finished the fortified food portion what do you with the remain fortified food?

i) Kept it and fed it to the child later

ii) Fed it to the child's siblings

iii) Threw it away