EMPOWERING HOUSEHOLDS IN WESTERN UGANDA WITH IMPROVED TRADITIONAL MILLET PORRIDGES AS COMPLEMENTARY FOOD FOR MITIGATION OF CHILD MALNUTRITION

BY

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DEDICATION

To my beloved husband Peter for the support and encouragement extended to me throughout this study period and my precious children Joseph, Joanna, Judith and Baby Jonan who have been a great source of inspiration for my studies.

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ACRONYMS

AOAC	Association of Official Analytical Chemists
CSB	Corn Soy Blend
FAO	Food and Agriculture Organisation of the United Nations
FANTA	Food and Nutrition Technical Assistance
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
LAB	Lactic Acid Bacteria
MUAC	Mid-Upper Arm Circumference
RDA	Recommended Dietary Allowance
RNI	Recommended Nutrient Intake
RUSF	Ready to Use Supplementary Food
RUTF	Ready to Use Therapeutic Food
SAM	Severe Acute Malnutrition
SPSS	Statistical Package for Social Scientists
UBOS	Uganda Bureau of Statistics
UDHS	Uganda Demographic Health Survey
UNICEF	United Nations Children's Emergency Fund
WHO	World Health Organisation

DEFINITIONS

Bioavailability-Availability of a nutrient in the gastrointestinal tract for absorption and assimilation.

Child Mortality Rate- Probability of dying between the first and fifth birthday per 1000 live birth in a given year.

Complementary food - Food needed alongside breast milk to meet the nutritional requirements of an infant.

Food fortification - The process of adding the content of essential micronutrients, i.e. vitamins and minerals in a food, so as to improve its nutritional value and quality.

Infant Mortality Rate - Probability of dying before the first birthday per 1000 live birth in a given year.

Malnutrition - The cellular imbalance between supply of nutrients and energy and the body's demand for them to ensure growth, maintenance and specific functions.

Millet-based porridges - Porridges with any proportion of millet flour either fermented or not.

Moringa millet porridge - Fermented millet porridge with 7% moringa leaf powder.

Pumpkin millet porridge - Fermented millet porridge with 17% pumpkin flesh powder.

Recommended Dietary Allowance - Reference value for each nutrient sufficient to meet the requirements of 97- 98% of healthy individuals in a particular life stage or sex group.

Stunting - Children with height for age below normal values for a reference population.

Severe acute malnutrition – Weight for height characterized by visible severe wasting, or by the presence of nutritional oedema

Traditional millet porridges – Porridges traditionally consumed by children in Bujenje County

Underweight – Children with weight for age below the normal values for a reference population.

Wasting – Children with weight for height/length for age below normal values for a reference population.

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5. Perfomance of *Moringa oleifera* and pumpkin (*Curcurbita maxima*) improved finger millet porridges as complementary food among moderately wasted children in Western Uganda (Food and Nutrition Bulletin). **Under review**

GENERAL ABSTRACT

Child malnutrition is a problem in Western Uganda where finger millet porridge is a common complementary food. The aim of this thesis was to empower households in Western Uganda with improved millet porridges as a mitigation strategy for child malnutrition. The study involved analysis of the factors responsible for the poor nutritional status among children in Bujenje County of Western Uganda, formulation of improved millet porridges and their evaluation in both hospital and community settings. Data on child nutritional status and its contributory factors was collected using anthropometric measurements and questionnaires respectively. Proximate analysis of composite flours was done according to Association of Official Analytical Chemists (AOAC) methods while agar diffusion technique and a seven point hedonic scale were used to analyse the antimicrobial and sensory attributes of the developed porridges respectively. Porridge flours were formulated using finger millet (*Eleusine coracana*), pumpkin flesh (*Curcurbita maxima)* and *Moringa oleifera* leaf powders with the target of providing not less than 60% Recommended Nutrient Intake for protein, vitamin A, iron and zinc. They were fermented using lactic acid fermentation starter cultures. Evaluation of the rehabilitative effect of moringa and pumpkin millet porridges among children with severe acute malnutrition (SAM) in Mulago hospital against the control of F-100 milk; and among moderately malnourished children in Bujenje County against the control of traditional millet porridge, was carried out. Data was processed using SPSS version 20.0 for windows; and descriptive and inferential statistics computed at $p< 0.05$ level of significance. The factors contributing to the poor nutritional status of children in Bujenje County were diarrhoea; lower levels of maternal education, millet porridges, health care practices and household income. Nutritional value and perfomance of traditional millet porridges were significantly improved by incorporation of 7% moringa leaves and 17% pumpkin flesh together with lactic fermentation, without compromising on acceptance. The improved millet porridges also had antimicrobial activities against common selected diarrhea pathogens. The rehabilitative value for the improved millet porridges was found to be 92-97% compared to F-100 milk (the

hospital rehabilitation ration). At the community level, children fed on moringa and pumpkin millet porridges had a quicker recovery rate from wasting and underweight and significantly reduced incidences of diarrhoea compared to children fed on the traditional millet porridge. The technologies involved in the production of improved millet porridges can therefore be adopted by mothers to mitigate child malnutrition in Western Uganda.

CHAPTER 1: GENERAL INTRODUCTION

1.1 Background

Child malnutrition is a global public health problem since it is a major contributing factor to child mortality, morbidity, intellectual and physical disability (Kabir et al., 2012). Globally an estimated 165 million, 10 million and 52 million of children below five years of age are stunted, underweight and wasted, respectively (UNICEF, 2012). Deficiencies of vitamin A, iron and zinc are also common especially among children from developing countries (UNICEF, 2013).

Uganda's most common forms of child malnutrition are high rates of chronic malnutrition and micronutrient deficiencies especially for iron and vitamin A. Thirty three percent of preschool children in Uganda are stunted, 14% underweight, 5% wasted and 49% anaemic (UBOS and ICF, 2012). Zinc deficiency is estimated to range between 20% to 69%, while 20% are vitamin A deficient (FANTA-2, 2010). Uganda Demographic and Health Surveys have consistently ranked the Western parts of Uganda as very high prevalence areas for child stunting with rates above 40 % (Statistics and Macro, 2001, UBOS and ICF, 2012). Infant malnutrition is correlated with inadequate immune response and increased risk of childhood mortality (Arimond and Ruel, 2004). The infant and under-five mortality rates in Uganda are estimated at 54 and 90 deaths per 1,000 live births respectively and 40% of the death occurring among children below five years is contributed by child malnutrition (UBOS and ICF, 2012).

Basing on the UNICEF conceptual frame work, dietary intake and diseases are the immediate determinants of child malnutrition being influenced by underlying and basic factors (UNICEF, 1990). In Uganda, stunting and underweight rates sharply increase when weaning foods are introduced. Increased exposure to infections as well as inappropriate and /or inadequate feeding practices may be contributing to faltering nutritional status among children (UBOS and ICF, 2012). Disease burden resulting from parasites (malarial and hookworms), diarrhoeal disease and acute respiratory infections are common. Other causes of malnutrition are poor child care practices and socio-economic and cultural characteristics (FANTA-2, 2010).

Finger millet porridge is a predominant complementary food in Western Uganda (Harvey et al., 2010). Millet porridge is recommended as a weaning food since it is one of the least allergenic and easy to digest cereal foods (Singh and Raghuvanshi, 2012). However, it has low energy and nutrient density (Singh and Raghuvanshi, 2012), is limited in essential amino acids (Usha and Lakshmi, 2010, Bachar et al., 2013) and has a high content of anti-nutrients such as phytates and tannins (Lei, 2006, Singh and Raghuvanshi, 2012). These contribute to poor digestibility of protein and starch and reduce the overall availability of vitamins and minerals in millet. These shortcomings of millet porridges suggest inadequate dietary intake for children who use it mainly as a complementary food.

Both moringa and pumpkin are locally available food resources with a potential to bridge the nutritional value gap in the millet as well as address the morbidity factors of infection as per claims of their antimicrobial properties (Dhiman et al., 2009, Fahey, 2005, Usha et al., 2010). Lactic acid fermentation is a potential household food preparation technology underutilized in Western Uganda but can also help abate the nutritional functional problems related to finger millet such as poor bioavailability of iron and zinc and low digestibility of starch and protein (Singh and Raghuvanshi, 2012, Ogbe and Affiku, 2012).

This study therefore intended to address the child nutrition and health problem in Western Uganda by empowering households with improved millet porridges using locally available resources.

1.2 Research problem

Data on the causes of child malnutrition in Western Uganda is scanty despite persistent reports of high stunting levels in this area. Nutritional deficiencies during the first three years of life can cause irreversible damage to intellectual and physical development (Aemro et al., 2013). Millet porridge is a common complementary food in Western Uganda. The porridge has low energy and nutrient density and therefore does not supply all the nutrients required for growth of children in right amounts. Utilisation of the nutrients in millet porridge is also hampered by presence of various anti-nutrients such as pytates and tannins. These affect digestibility of starch and protein and bio-availability of iron and zinc.

Households in Western Uganda are characterised by low income and limited revenue base as a result of which they mainly use millet porridges as complementary foods for their children. This influences the health and nutrition status of their children leading to severely malnourished children who are often treated at nutrition rehabilitation centres, only to return later to rehabilitation centres after relapse due to lack of an affordable nutritious complementary food at home. It is feasible to improve millet porridge using locally available foods such as moringa (*Moringa oleifera)* and pumpkin *(Curcurbita maxima)* which together with fermentation can create nutritious complementary food based on locally available resources. This can provide a sustainable solution to child malnutrition in resource constrained and technologically under developed areas of Western Uganda.

1.3 Justification of the study

The study will provide background information to base nutritional interventions. Use of moringa, pumpkin and lactic acid fermentation to address malnutrition will provide an affordable, feasible and sustainable solution to child malnutrition since this is a local food-based strategy. Improving the nutritional status of children will offer enhanced protection from a range of disabilities and diseases, help children grow and learn, and improve health and productivity for adults not only in Uganda but also regionally as the information will be disseminated. The morbidity and mortality rates will be reduced in children due to increased nutrient intake, bioavailability of nutrients and health promoting properties associated with moringa and fermentation. Reducing malnutrition and morbidity among children will reduce poverty not only through improved productivity and ability to compete, but also through savings to government and families in treating illnesses. Effects of malnutrition on education and intellectual potential of school children such as mental disabilities, absenteeism and repetition of school years shall be minimized.

1.4 Purpose of the study

The purpose of this study is to empower Ugandan households to tackle child malnutrition with locally affordable and sustainable food technology.

1.5 Objectives

1.5.1 Overall objective

The overall objective of this study is to improve millet porridge as a complementary food for the management of child malnutrition in Western Uganda.

1.5.2 Specific objectives

The specific objectives of the study are;

1. Identification of factors responsible for malnutrition among children aged 7-36 months in Bujenje County of Western Uganda.
2. Improvement of the nutritive value and safety of traditional millet porridges for children aged 7-24 months in Bujenje County of Western Uganda.
3. Evaluation of the rehabilitative performance of moringa and pumpkin millet porridges among children with severe acute malnutrition (SAM) in a hospital setting in Uganda.
4. Evaluation of the performance of moringa and pumpkin millet porridges as complementary foods in a community intergrated approach among moderately malnourished children in Western Uganda.

1.6 Research questions

1. What are the factors responsible for child malnutrition among children aged 7-36 months in Bujenje County of Western Uganda?
2. Can the nutritional value and safety of traditional millet porridge used in Bujenje County be improved by fortification with moringa, pumpkin and fermentation?

3. What is the nutritional rehabilitative value of moringa and pumpkin porridges among children with SAM in a hospital setting in Uganda?

4. What is the effect of moringa and pumpkin millet porridges on the nutritional and morbidity status of moderately malnourished children in Bujenje County, Western Uganda?

5. Can the technology utilized for making improved millet porridges be scaled up among households in Western Uganda?

1.7 Limitations of the study

- For ethical reasons, it was not possible to 100% replace F-100 milk with experimental porridges during their evaluation for efficacy among malnourished children.

CHAPTER 2: GENERAL LITERATURE REVIEW

2.1 Global prevalence of child malnutrition and its health implications

Globally 26% of the world's children below five years were stunted and 16% underweight in 2011. Sub-Saharan Africa and South Asia accounted for the biggest percentage of this prevalence. The percentage of children who were stunted in sub-Saharan Africa was 40% while for South Asia was 39%. Prevalence of underweight in South Asia was 33% and 21% for sub-Saharan Africa. Global prevalence for wasting has been reported to be 8%, the highest rates of 16% reported in South Asia, while in sub-Saharan Africa it was 9% (UNICEF, 2012). Severe and widespread deficiencies of iron, zinc and vitamin A are also reportedly common among children from developing countries, with severe health consequences (UNICEF, 2013). Iron deficiency anaemia is reported as responsible for approximately 21,000 deaths, and a reduction of 2 million disability-adjusted life years (DALYs) among children under 5 years of age (Black et al., 2008). Vitamin A deficiency is said to be a widespread public health problem in developing nations, where it affects more than 130 million preschool children (Fanta-2, 2010). Every year 10 million children have xerophthalmia, 500,000 of them become blind and 1-3 million die from the consequences of vitamin A deficiency (West and Darnton-Hill, 2008). Zinc deficiency is responsible for approximately 4% of deaths and 16 million lost Daily Adjusted Life Years (DALYs) among children under five in low-income countries (Bruno et al., 2005).

Using –2 z-scores as cut offs, stunting, underweight and wasting account for 21.4% of child mortality and 21.1% of child disease burden among children below five years in low income countries (Black et al., 2008). Of the 14.6% deaths attributable to wasting, only 4.4% were due to severe wasting, and hence10.2% of the deaths were due to moderate wasting (Michaelsen et al., 2009). Malnourished children are also prone to frequent infections that are more severe and longer-lasting than those in well-nourished children, and may lead to a spiral of ever-worsening nutritional status (Ashworth and Ferguson, 2009). According to the National Centre for Health

Statistics (NCHS) reference, the risk of death from diarrhoea in children who are moderately underweight is 5.4 times higher than in well-nourished children while for pneumonia, malaria, and measles, it is 4.0, 4.5, and 3.0 respectively (Caulfield et al., 2004).

2.2 Determinants of child malnutrition

The UNICEF Conceptual Framework explains the causal pathway for malnutrition, from basic to immediate causes (Figure 2.1). The immediate causes of malnutrition for children in Uganda are the high disease burden resulting from malaria, diarrhoeal disease and acute respiratory infections, as well as inadequate dietary intake resulting from suboptimal infant feeding practices (FANTA-2, 2010). These are influenced by underlying factors such as household food security, maternal/child care and health services/unhealthy environment which are in turn influenced by basic causes (UNICEF, 2006). The immediate determinants can be said to be operating at individual level, impacting on the child directly, the underlying determinants at household and community levels, while most basic factors operate at the political, ideological, economic or policy levels (FANTA-2, 2010). Child birth order, location whether rural or urban, family income, education and household size are among the socio-economic and demographic factors influencing child nutrition in most developing countries (Girma and Ganebo, 2002, UBOS and ICF, 2012).

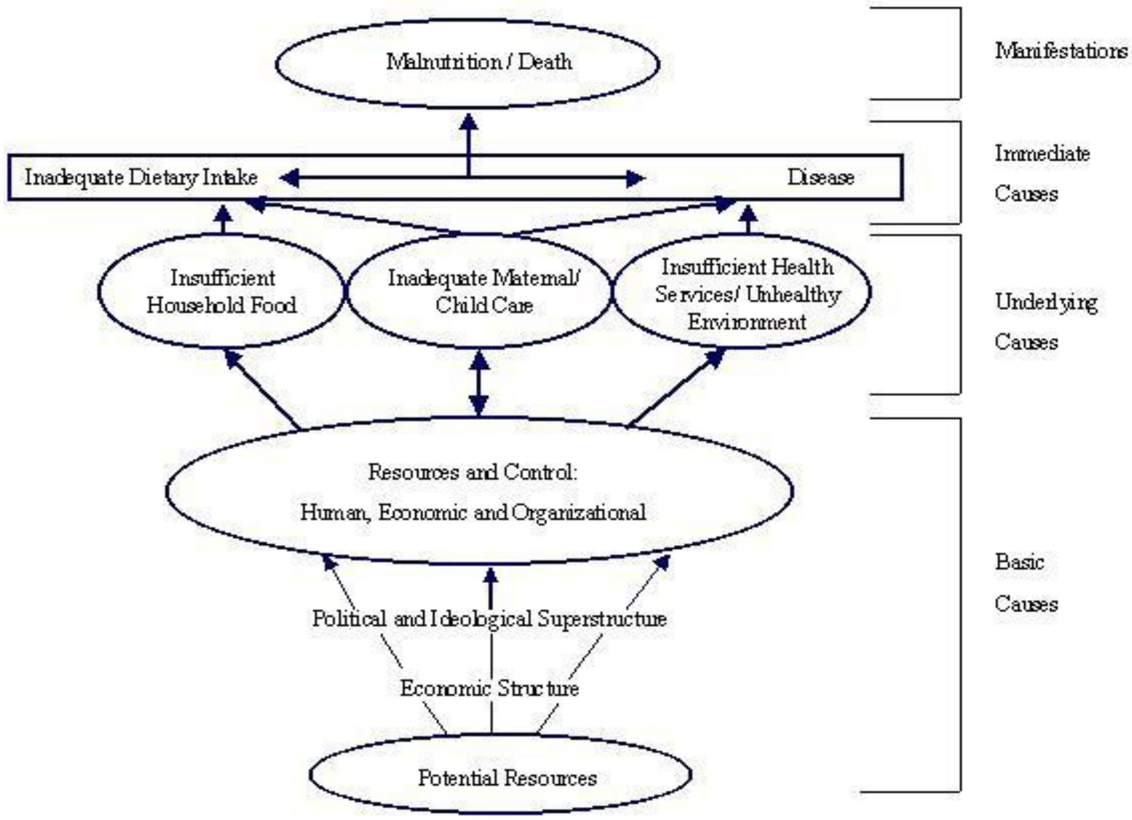

Figure 2. 1: Conceptual Framework for determinants of child malnutrition

Source: (UNICEF, 1990)

2.3 Child feeding practices in Uganda

Feeding practices of children have a direct impact on both actual food intake and disease prevalence. According to UBOS and ICF (2012) report, 98% of mothers in Uganda breastfeed for some period of time and of these, 53% start breastfeeding within the first hour after giving birth. About 41% of the mothers use prelacteal feeds, a practice that is especially common among the educated and high income groups. Only 63 and 46 percent of children fulfill WHO recommendations of exclusive breastfeeding for 6 months and breastfeeding up to two years respectively (UBOS and ICF, 2012). Sixty seven percent of children aged 6-8 months are introduced to solid, semi-solid or soft foods. These include mainly cereals, grains, roots and tubers. During this period, children need nutritionally balanced, calorie dense supplementary foods in addition to breast milk. This is due to inability of breast milk to cater for the nutritional requirements of an infant after six months (WHO, 2005). For children in Western Uganda, use of millet porridge as a complementary food is common (Harvey et al., 2010).

2.4 Nutritional requirements for young children

Infants and young children are especially vulnerable to malnutrition in the first two years of life. This is because they have a high growth velocity, energy and nutrient needs, and yet limited gastric capacity (Compaore et al., 2011). It is also during this period that the brain reaches almost 90% of adult size (Michaelsen et al., 2009). Table 2.1 shows the recommended daily quantities of energy, proteins, iron, vitamin A and zinc for children aged 7-36 months.

Table 2. 1: Recommended nutrient intake (RNI) for children aged 7-36 months

Nutrient	6-8 months	9-11 months	12-23 months	24-36 months
Energy (k cal)	615	686	894	1022
Protein (g)	9.1	9.6	10.9	13
Vitamin A (µg)	400	400	400	300
Iron (mg)	11	11	7	7
Zinc (mg)	4.1	4.1	4.1	3

References: (Dalmau et al., 2015, Dewey and Brown, 2002, Ruel, 2003)

Because of the increasing challenges in meeting children's nutritional requirements, a minimum meal frequency of 2 meals per day for breast feeding children aged 6-8 months, 3 meals per day for breastfeeding children aged 9-23 months and 4 meals per day for non-breastfeeding children aged 9-23 months have been recommended by WHO. A daily consumption of animal source foods, vitamin A rich fruits and vegetables and a minimum of 4 foods/food groups for children aged 6-23 months have also been recommended by World Health Organisation (PAHO, 2003, WHO, 2005).

2.5 Disease burden among children in Uganda

Malaria, acute respiratory infections, diarrhea and HIV/AIDS are highly associated with child malnutrition in Uganda (FANTA-2, 2010). This is especially noticeable during the rainy season, when health facility supply and staffing are lowest and when child care is poor especially during farming activities (FANTA-2, 2010). Diarrhoea is associated with a decrease in dietary intake of about 40-50 percent lower for energy and protein among children in Uganda, which is associated with up to 80% of weight faltering (FANTA-2, 2010).

2.6 Formulation of complementary foods

The formulation and development of weaning foods from local and readily available raw materials has received a lot of attention in many developing countries since it is cost effective, sustainable and can be adapted to different cultural, dietary traditions and locally feasible strategies (Usha and Lakshmi, 2010, Ruel et al., 2004). In Uganda just like in most developing countries, protein energy malnutrition usually occurs during the crucial transitional phase when children are weaned from liquid to semi-solid foods because of poor quality complementary foods (Arise et al., 2014, UBOS and ICF, 2012). Current child feeding recommendations state that children aged 6 to 23 months should be fed on animal source foods daily, especially if they do not have access to fortified foods or vitamin and mineral supplements (PAHO, 2003). Unfortunately, families that cannot afford animal source foods on a regular basis are also the ones that have limited access to fortified foods or vitamin and mineral supplements (Ruel et al., 2004).

The major criteria for good quality weaning food are high balanced-protein content, high calorie value per unit of food volume, soft texture with low fibre content, adequate vitamin and mineral contents, and absence of anti-nutritional factors (PAHO, 2003). Diets based largely on plant sources do not meet these requirements and need to be improved by processing, (dehulling, germinating, fermenting) and fortification (de Pee and Bloem, 2009).

2.7 Lactic acid fermentation

Lactic acid fermentation is a biological process by which sugars such as glucose, fructose and sucrose, are converted into cellular energy and the metabolic by product lactate (Lei, 2006). Lactic acid bacteria (LAB) are a large group of closely related bacteria that have similar properties such as lactic acid production which is an end product of fermentation. They include *lactobacillus, lactoccocus, streptococcus and leuconostoc species* (Blandino et al., 2003). LAB are capable of producing antimicrobial substances which inhibit or prevent certain microorganisms; among others many of the diarrhoea causing pathogens. It is believed that by producing these substances, LAB contribute to the maintenance of the existing intestinal micro flora and the inhibition of pathogenic microorganisms and thereby reduce or prevent diarrhea (Guslandi, 2003).

2.8 Nutritional potential of finger millet, moringa and pumpkin flours

Millet is a collective term referring to a number of small seeded annual grasses that are cultivated as grain crops mostly in temperate, sub-tropical and tropical regions. It is referred to as a poor man's cereal and is an important staple food in parts of eastern and central Africa, and India.The millets include five genera of the *Panaceae* family (*Panicum, Setaria, Echinochloa, Pennesetum and Eleusine*) (Singh and Raghuvanshi, 2012). Finger millet *(Eleusine coracana)* is the most popular in Western Uganda. It has good amounts of fat, energy, iron, zinc, thiamine, riboflavin and niacin but is limited in essential amino acids (Singh and Raghuvanshi, 2012). Nutritive value of millet is also limited by high concentrations of anti-nutrients such as phytates and tannins, and these reduce bioavailability of some nutrients especially iron and zinc (Bachar et al., 2013).

Moringa trees have been used in Senegal and Haiti by health workers to treat malnutrition that mostly appear in children during the weaning period(Fahey, 2005). *Moringa oleifera* leaves and fruits are highly nutritious, and a significant source of beta-carotene, protein and iron (Manfo et al., 2014). Moringa plants are rich in phytochemicals (compounds produced by plants that have health benefits). Recent studies indicate that the leaves and seeds contain complex chemical compounds with antibiotic and antioxidant properties that can boost the body's own natural immune system and help alleviate a host of ailments (Kumar and Pari, 2003).

Pumpkins are quick turnover crops of 3-4 months. They require minimum labour and can stay 12 months after harvest before going bad. Pumpkins contain relatively high amounts of proteins, iron, zinc and good amounts of caroteinoids which are the primary sources of vitamin A for most people with low income (Usha & Lakshmi, 2010). Pumpkin seeds are edible kernels of pumpkin fruit and are high in calories mainly from proteins and fats. In addition, they are packed with fibre, vitamins, minerals and numerous health promoting antioxidants (Elinge et al., 2012). Since the amount of organic acids and cellular tissues are low in infants, pumpkins can be consumed to cure stomach and intestinal disorders (Dhiman et al., 2009).

CHAPTER 3: FACTORS CONTRIBUTING TO CHILD MALNUTRITION IN WESTERN UGANDA

3.1 Introduction

Amongst several other factors, the UNICEF conceptual framework identified dietary intake and morbidity patterns as dependent variables, being influenced by socio-economic, demographic and cultural factors in communities and households where malnourished children are nurtured (UNICEF, 1990).The 2002 Uganda Demographic Health Survey (UDHS) ranked the Western parts of Uganda including the areas from Masindi to Kisoro districts as having very high prevalence areas for child stunting, with rates above 40% (UBOS and ICF, 2001). Current demographic reports indicate that the situation has not improved much with rates still above 40% in Western Uganda (UBOS and ICF, 2012). Common use of millet porridges as complementary foods has been reported in these areas (Harvey et al., 2010). Data on factors responsible for the poor nutritional status among preschool children in Western Uganda is scanty. Such data is necessary to guide interventions, since the causes of malnutrition are multifactorial. Given the very high prevalence of child stunting in Western Uganda, data on the socio-economic and demographic characteristics, feeding practices, morbidity status and dietary intake and the contribution of millet porridges to malnutrition in this area are essential to help guide development of contextually appropriate interventions. A study of the factors responsible for the poor nutritional status among children aged 7-36 months in Bujenje County of Masindi District; Western Uganda was therefore carried out.

3.1.1 General Objective:

The general objective for the study was to determine the factors contributing to malnutrition among children aged 7-36 months in Bujenje County of Western Uganda.

3.1.2 Specific objectives

The specific objectives were:

i). Determination of the socio-economic and demographic characteristics of households with children aged 7-36 months old in Bujenje County of Western Uganda.

ii). Assessment of the dietary practices and intake for children aged 7-36 months old in Bujenje County of Western Uganda.

iii). Determination of the nutritional status for children aged 7-36 months old in Bujenje County of Western Uganda.

iv). Determination of morbidity status and health care practices for children aged 7-36 months old in Bujenje County of Western Uganda.

v). Determination of the factors contributing to child nutritional status in Bujenje County of Western Uganda.

3.1.3 Research question

What are the socio-economic and demographic characteristics, dietary practices and morbidity factors contributing to child malnutrition in Bujenje county of Western Uganda?

3.2 Literature review

3.2.1 Causes of malnutrition in Western Uganda

The causes of malnutrition are multisectoral embracing food, health and caring practices. Selected causal factors for poor child nutrition in Uganda which are likely to have an impact in Western Uganda include;

3.2.2 Poor quality complementary foods

There is limited intake of animal products in majority of Ugandan children (UBOS and ICF, 2012). Millet porridge is a common complementary food in Western Uganda (Harvey et al., 2010). It is a bulky food, with low nutrient density, poor bioavailability of iron and zinc, low digestibility of starch and protein and poor antimicrobial properties against infections (Lei, 2006). This makes children relying heavily on this porridge as a complementary food highly vulnerable to nutrient deficiencies. Other common foods in Masindi District include sorghum, sesame, sweet potatoes, pumpkins, beans, cassava, maize and bananas (matooke) (Ring and Develo, 2009).

3.2.3 Iron deficiency

Iron is a very essential nutrient to the body. Its deficiency contributes to lowered resistance to disease, increased susceptibility to infection and poor cognitive development (Galloway, 2003). The causes of iron deficiency are poor iron assimilation, insufficient iron intake and increased iron requirements due to growth and repeated bouts of malaria (Massawe, 2002).Good sources of iron include meat, fish, poultry and organ meats like liver, heart and kidney. However intakes of such foods is low among low income earners. The most abundant dietary sources of iron include cereals, pulses, fruits and vegetables but these have poor bioavailability (King and Burgess, 2000). Supplementation with iron and folic acid, deworming tablets and fortification of foods with iron are some of the strategies aimed at reducing iron deficiency anaemia in Uganda (Fanta-2, 2010). However, they are not yet very effective in Uganda. This is aggravated by the fact that many low income households do not use fortified foods and supplements. Only seven percent of preschool children in Uganda receive iron supplements (UBOS and ICF, 2012). This has serious implications on the health and nutritional status of children in cereal dominated communities of Western Uganda.

3.2.4 Vitamin A deficiency

Vitamin A is an essential micronutrient for the immune system, vision and growth. Its deficiency is associated with childhood blindness and mortality (West and Danrton-Hill, 2008) especially from measles and severe diarrhoea diseases (Black et al., 2008). Vitamin A is found in animal foods especially milk, liver, cod-liver oil, fish, red palm oil and butter yet these are not easily available to the poor. The vitamin is also found in form of precursors called proVitamin A in plants such as mangoes, papayas, carrots, pumpkins and dark leafy vegetables (UBOS and ICF, 2012). Vitamin A deficiency can appear under certain conditions related to diet, child's age, associated infections and weaning from breast milk. Children under the age of 4 years especially if they suffer from Protein Energy Malnutrition (PEM) are highly vulnerable (Ashworth, 2003). In Uganda strategies such as fortification of foods and bi-annual supplementation for all children aged 6-59 months have been used to address vitamin A deficiency. Kendo mills is fortifying sugar with vitamin A and a small fraction of Maganjo Grain Millers and Unga 2000 in Uganda is fortified with iron, zinc, and vitamin A (FANTA-2, 2010). However, only 57% of these children receive vitamin A supplements and many at risk children consume primarily unprocessed foods with no vitamin A fortificants (UBOS and ICF, 2006).

3.2.5 Zinc deficiency

Zinc plays a central role in cellular growth, tissue differentiation, protein synthesis and immune function. The main source of zinc is animal products and the daily requirement of zinc is difficult to meet in populations that consume staple foods with high phytates content since bioavailability is reduced (Bruno et al., 2005). Inadequate zinc intake in young children leads to dermatitis, hair loss, poor appetite, growth failure and weakened immunity, which renders children particularly vulnerable to diseases such as pneumonia, malaria, diarrhoea and acute respiratory infections (Black et al., 2008). Low zinc levels have some bearing on the high rates of stunting among young children in Uganda (Fanta -2, 2010). The risk of zinc deficiency is considered to be of public health concern when prevalence of low serum zinc concentration is greater than 20% of population and when prevalence of inadequate dietary intake is greater than 25%. When prevalence of low height- for- age is greater than 20%, zinc deficiency can also be implicated. In such cases an intervention to improve population zinc status is advised (Bruno et al., 2005). WHO recommends that all children with severe diarrhoea who are seen at a health facility be provided with zinc supplements (FANTA-2, 2010). This strategy is effective as a therapeutic measure but it is not sustainable in poor economies like Uganda.

3.2.6 Morbidity factors

Masindi district is characterised by high levels of infections especially malaria and worms and these may affect dietary intake and utilisation (Ring and Develo, 2009).

Diseases cause loss of appetite, reduced food intake and increased loss and reduced absorption of nutrients leading to malnutrition (FANTA-2, 2010). Malaria is highly endemic in Uganda and in some parts of Western Uganda 36% of child death is reported to be associated with malaria (Reddy, 1991). Coexistence of the high prevalence of malnutrition with infections among children has also been shown in Uganda suggesting that poor immune function might be a result of inadequate nutrition (Kikafunda et al., 1998).

3.3 Study design and methods

3.3.1 Study area

The study was carried out in Masindi District found in Mid-Western Uganda (Appendix 1). The District is rural based and is bordered by Democratic Republic of Congo in the West, Hoima District to the South West, Gulu in the North, Apac in the East, Kiboga in the South and Nakasongola District in the South East. The district is at an average altitude of 1295 metres, situated between latitudes 1 22' and 2 20' North of the equator, longitude 31 22'and 32 23' east of Greenwich. The District is relatively poor compared to other districts in Uganda and is characterised by a diverse ethnic composition of 55 tribes. The infant mortality rate is 97 per 1000 live birth compared to the national one of 76/1000 and 22% of the children below five years are underweight compared with the national one of 16%. The average household size is 4.9. The District has a favourable climate with an annual long term rainfall of 1,304 mm. The major crops grown are millet, sorghum, sesame, sweet potatoes, pumpkins, beans, cassava, maize and bananas. The health status of the population is poor with a high prevalence of infections and communicable diseases. Malaria is the major disease with morbidity at 37%. Other common sicknesses include respiratory infections and acute diarrhea (Ring and Develo, 2009).

3.3.2 Study design and setting

The study was cross sectional and analytical in nature, and covered the two sub-counties in Bujenje County namely Budongo and Bwijanga. The study subjects and respondents were children aged 7-36 months and their caretakers respectively, in a household.

3.3.3 Sample size determination

The sample size was calculated according to the formula $n = Z^2pq/d^2$ (Israel, 2003).

Where

p = prevalence of stunting among children under five years in Western Uganda

= 45% (UBOS and ICF, 2012) .

q = 1-p = proportion not stunted = 55% and

d = error of assumption = 5%.

z = normal distribution at 95% confidence interval (1.96)

The sample size according to the formula was calculated as 380 households.

3.3.4 Household sampling procedure

Figure 3.1 shows that 636 households with 7-36 months old children were recruited from Budongo and Bwijanga sub-counties by random cluster sampling basing on the sampling frame used by the 2012 Uganda Demographic and Health Survey report. Children were recruited from 23 clusters (n=10 in Budongo and n=13 in Bwijanga). This matched the national distribution and was representative of Bujenje County of Western Uganda (Ring and Develo, 2009). Only children from households with mothers/caretakers present at the visitation time were recruited for the study. In cases where many children below five years in the household were found, the youngest was selected.

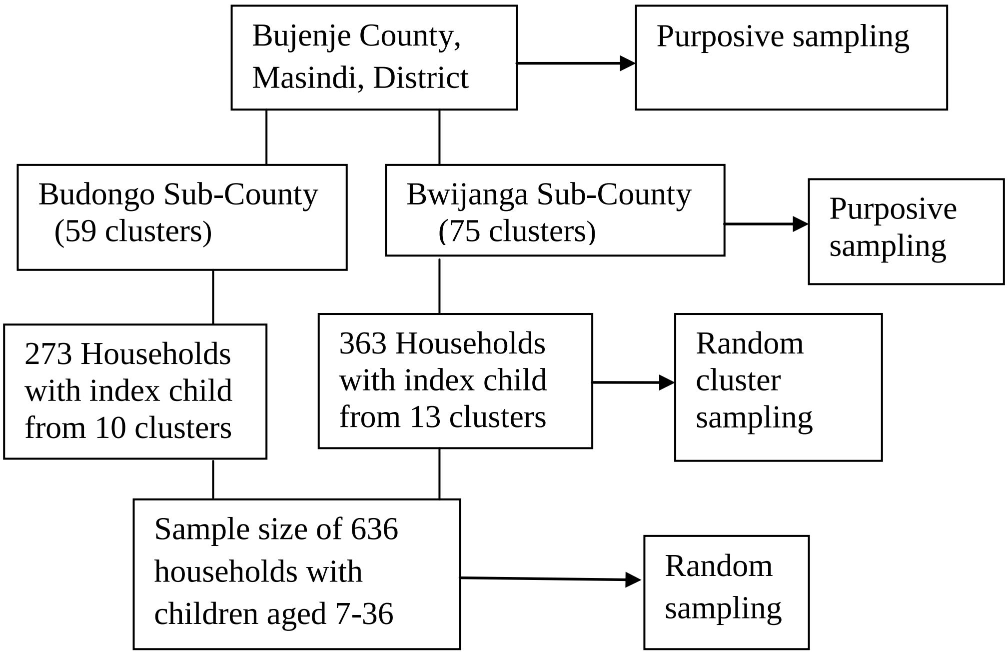

Figure 3. 1: Sampling frame

3.3.5 Determination of household socio-economic and demographic characteristics and children's dietary practices and morbidity status

Structured questionnaires were used for collecting data on household socio-economic and demographic characteristics and children's dietary practices and morbidity status (Appendix 3).

3.3.6 Determination of dietary diversity and intake

Dietary diversity data was collected using 12 foods/food groups. The proportion of children who received four or more foods/food groups of the 12 foods/ food groups were regarded to have received minimum dietary diversity (WHO, 2005).

3.3.7 Determinationof nutrient intake from the 24-hour recall data

Assessment of dietary intake was done quantitatively using repeated twenty-four hour recalls. For each child, two repeated twenty-four hour recalls were carried out on non-consecutive days. A list of all meals, dishes, food items and beverages consumed in the last 24 hours were recorded by trained interviewers. Food models and common household measures were used to assist in recalling the portion size of the food (Gibson and Ferguson, 2008).

The East African Food Composition Tables (West et al., 1987) and Nutrisurvey program (Juergen, 2003) were used to calculate the amounts of kilocalorie, protein, vitamin A, iron and zinc from the 24-hour recall data. Calculation of usual nutrient intakes from actual intake from 24 hour recall data was done to validate the 24-hour recall (Pereira et al., 2010). Since meals were mostly composed of plant foods and almost no fortified and animal foods, low levels of bioavailability were assumed (5% for iron and zinc) basing on international guidelines (Doets et al., 2008). Iron and zinc supply from meat, fish and poultry were considered twice as bio-available as iron and zinc from vegetable sources. Iron and zinc intakes were derived by multiplying the amounts obtained in the 24 hour recall by % absorption. Vitamin A from animal and plant sources was expressed as retinol equivalents based on Food Agriculture Organisation conversion factors (Schweiggert et al., 2011). A child's intake of a nutrient was classified as inadequate when the nutrient intake of the individual was less than the corresponding Recommended Nutrient Intake (RNI) (Dewey and Brown, 2002). Minimum meal frequency for breastfeeding children was categorised basing on WHO recommendations of a minimum of 2 and 3 meals for children aged 6-8 months and 9-23 months respectively (PAHO, 2003). The minimum meal frequency for non-breastfeeding children was based on WHO (2005) recommendation of 4 meals.

3.3.8 Measurement of nutritional status

Anthropometric measurements were taken using calibrated equipment and standardized techniques (Lohman et al., 1998). Standing height/ length was taken using Short's Height Measuring Board (Short Productions, Woonsocket, RI) and recorded to the nearest 0.1 cm. Body weight was taken using light weight-SECA mother–infant scales with a digital screen that were designed and manufactured under the guidance of UNICEF. All measurements were taken in duplicate with the children wearing light clothing and no shoes. Each measurement was taken by the same person to eliminate inter-examiner error.

Nutritional status indices for height-for-age (HAZ) and weight-for-age (WAZ) and weight-for-height (WHZ) were calculated using ENA for SMART 2010 software and interpreted using WHO 2006 reference standards (Group, 2006).

3.3.9 Statistical analysis

Data was entered, cleaned and analyzed using SPSS (Statistical Package for Social Scientists) version 20.0 for windows. Descriptive frequencies and means were used to analyse data. Chi-square test was used to detect the influence of household socio-economic and demographic characteristics on feeding practices, morbidity patterns and nutrient intake. The effect of minimum dietary diversity score and meal frequency on nutrient intake was also assessed using chi-square tests. Multiple linear regressions were used to identify factors contributing to the poor child nutritional status. The proportion of variances of the model were checked for multi-collinearity and a tolerance of >0.1 accepted. A p-value of <0.05 was accepted as indicating statistical significance.

3.3.10 Ethical approval

This study was reviewed and ethically cleared by The Aids Support Organisation (TASO) internal review board (TASOIRC/029/13-UG-IRC-009) and then approved by the Uganda National Council of Science and Technology (HS 1315). Verbal and written consent was obtained from the parents of the study children.

3.4 Results

3.4.1 Socio-economic and demographic characteristics of households

Table 3.1 shows data on the socio-economic and demographic characteristics of the study children’s households. Households with less than five members were 48.4% and 33.5% of the household members were aged less than five years. The mean househod size was 4.5. Mothers/caretakers who were aged 18-35 years were 82.6% and 72.3% of the mothers/caretakers had monogamous marriages. Primary education was the highest level of education attained by 72.3% of the mothers/caretakers. Households which earned less than 50,000 Ugandan shillings ($19.2) per year were

Table 3. 1: Distribution of households in Bujenje County by their socio-economic and demographic characteristics

Parameter	Frequency	% of N
Household size	**636**	**100**
Less than 5 members	308	48.4
5-7 members	237	37.3
Above 7 members	91	14.3
Age of household members	**1880**	**100**
Less than 5years	630	33.5
Above 5 years	1250	66.5
Maternal age	**636**	**%**
<18 years	13	2.0
18-35 years	525	82.6
36-60 years	96	15.1
>60 years	2	0.3
Marital status	**636**	**100**
Single/divorced/separated	119	18.7
Polygamous marriage	57	9.0
Monogamous marriage	460	72.3
Maternal education	**636**	**100**
Informal education	53	8.3
Primary	460	72.3
Secondary	113	17.8
Post secondary	10	1.6
Household income	**636**	**100**
<50,000	295	46.4
50,000-100,000	178	28.0
100,000-150,000	80	12.6
150,000-200,000	25	3.9
200,000-250,000	22	3.5
250,000-300,000	13	2.0
>300,000	23	3.6
Maternal occupation	**636**	**100**
Unemployed	11	1.8
Farmer	406	63.8
Casual labourer	95	14.9
Business	89	14.0
Civil servants	35	5.5

46.4%. The percentage of households which earned more than 50,000 tended to reduce with higher incomes and farming was the most common occupation among 63.8% of the mothers/caretakers. The socio-economic and demographic characteristic in this County therefore reflected low levels of education and income, and high involvement in agriculture.

3.4.2 Feeding practices of study children

Table 3.2 shows the feeding practices of study children in Bujenje County. The percentage of children who were exclusively breastfed was 70.8%. Only 16% of the study children breastfed for two years and beyond. Complementary foods were introduced at the right time to only 11.3% of the children. Improper timing of complementary foods was significantly common among polygamous families, mothers with lower maternal education (primary) and those aged less than 18 years at p = 0.033, 0.012 and 0.001 respectively. Millet porridge was a common complementary food among 53.1% of the study children. The percentage of study children that had adequate DDS was 49.7% while 37.6% of the study children had adequate meal frequency. The percentage of children with adequate DDS and meal frequency was significantly higher among children aged 25-36 months ($p<0.01$). Low levels of maternal education were associated with inadequate DDS and meal frequency at p=0.005 and 0.001 respectively. About 28.6% of the children relied on family meals. The meals were mostly composed of cereals (72.6%), pulses legumes and nuts (71.9%) and roots, tubers and plantain (66.5%). There was minimal consumption of eggs (4.4%), fruits (7.5%), fish (13.5%), meat, poultry and offals (14.3%) and milk (17.5%).

The dietary practices of majority of the study children were therefore inappropriate especially among households with low levels of maternal education and age.

Table 3. 2: Distribution of study children in Bujenje County by their feeding practices

Feeding practices	Frequency	Percentage of N
Exclusively breastfed	**636**	**100**
Yes	450	70.8
No	186	29.2
Breastfeeding duration	**370**	**100**
Less than 2 years	312	84
2 years and above	58	16
Introduction of complemetary foods	**636**	**100**
Early introduction	335	52.7
Timely introduction	72	11.3
Late introduction	229	36.0
Common complementary foods	**636**	**100**
Millet porridge	338	53.1
Milk	81	12.7
Maize porridge	24	3.8
Soya porridge	8	1.2
Cassava porridge	3	0.6
Family meal	182	28.6
Adequate DDS (4 or more food groups)	**636**	**100**
7-12 months	77	12.1
12-25 months	243	38.2
25-36 months	316	49.7*
Adequate meal frequency	**636**	**100**
7-12 months	176	27.6
12-25 months	239	34.8
25-36 months	221	37.6*

DDS = Dietary diversity score; * Significantly high percentages ($p < 0.05$)
Adequate meal frequency: 2 meals for breastfeeding children aged 6-8 months
3 meals for breastfeeding children aged 9-23 months
4 meals for non-breastfeeding children aged 6-23 months

3.4.3 Nutrient adequacy among study children in Bujenje County basing on their age

Table 3.3 shows the mean kilocalorie, protein, vitamin A, iron and zinc intakes for different age groups of study children, and the proportion of children with inadequate nutrient intake. The mean vitamin A, iron and zinc intakes for children aged 7-12 months were below the recommended nutrient intake (RNI). The percentage of children with inadequate intakes of protein, iron and zinc was significantly higher among children aged 7-12 months, (p<0.001. Inadequate iron and vitamin A intakes were significantly observed among children from households with lower levels (primary) of maternal education at p< 0.001 and p=0.039 respectively. Children from households with more than three children under five years had significantly high percentages of inadequate energy and protein intake at p=0.001 and 0.015 respectively.

In this study therefore, inadequate intakes of protein, vitamin A, iron and zinc were significantly high among children aged 7-12 months and children's nutrient intake was influenced by low levels of maternal education (primary) and high numbers of children under five years in a household (more than 3 children).

Table 3. 3: Nutrient adequacy among study children in Bujenje County basing on their age

Nutrient per day	WHO RNI	Mean intake (95% CI)	Median	%<RNI
Energy (kcal)				
7-12 months	830	508.28 (469.35-601.22)	453.80	57.8
13-24 months	1092	845.14 (799.91-890.37)	836.20	52.4
25-36 months	1150	926.28 (881.60-970.96)	906.10	48
Protein (g)				
7-12 months	11	18.80 (15.71-21.90)	14.30	75.2*
13-24 months	13	30.23 (27.95-32.51)	26.50	43.3
25-36 months	13	33.77 (31.17-36.36)	29.30	32.5
Vitamin A (µg)				
7-12 months	500	341.85 (267.53-416.17)	185.00	73.6*
13-24 months	300	425.87 (356.14-495.60)	278.10	48.4
25-36 months	300	415.56 (369.59-461.2)	305.70	44.8
Iron (mg)				
7-12 months	11	5.47(4.50-6.44)	5.00	79.2*
13-24 months	7	7.70 (7.22-8.18)	7.40	50.7
25-36 months	7	8.33(7.83-8.82)	7.95	43
Zinc (mg)				
7-12 months	3	2.84(2.40-3.28)	2.35	81.6*
13-24 months	3	4.77 (4.42-5.13)	4.40	46.2
25-36 months	3	5.26 (4.92-5.60)	4.95	37.4

*Significantly high percentages (P<0.05). RNI = Recommended Nutrient Intake
References: (Dalmau et al., 2015, Dewey and Brown, 2002)

3.4.4 Dietary diversity score (DDS) and nutrient adequacy.

Table 3.4 shows the association between DDS and nutrient adequacy. Majority of children with adequate dietary diversity Score had adequate energy, protein, vitamin A, iron and zinc intakes while majority of children with inadequate dietary diversity score also had inadequate energy, protein, vitamin A, iron and zinc intakes. The Odds Ratio (OR) in all cases was greater than 1.

Children with adequate DDS therefore had high chances of getting adequate energy, protein, vitamin A, iron and zinc from the diet.

Table 3. 4: Nutrient adequacy among study children basing on dietary diversity score

Nutrient	**Dietary Diversity Score**		**OR (95% CI)**
	%Adequate	**%Inadequate**	
Energy (k cal)			
% Adequate	57.2	42.8	2.56 (1.85-3.53), **p<0.001**
%Inadequate	34.3	65.7	
Protein			
% Adequate	69.8	30.2	3.66 (2.63- 5.09), **p<0.001**
%Inadequate	38.7	61.3	
Vitamin A			
% Adequate	64.6	35.4	1.98 (1.41-2.78), **p<0.001**
%Inadequate	47.9	52.1	
Iron			
% Adequate	89	11	4.41 (2.87-6.79), **p<0.001**
%Inadequate	64.6	35.4	
Zinc			
% Adequate	96.7	3.3	8.04 (4.10-15.79), **p<0.001**
%Inadequate	78.6	21.4	

OR= Odds Ratio, CI=Confidence Interval; Adequate DDS = 4 or more food groups

3.4.5 Nutrient adequacy among study children basing on meal frequency

Table 3.5 shows that majority of children with adequate meal frequency had adequate dietary intake of energy and protein while majority of children with inadequate meal frequency also had inadequate dietary intake of energy and protein. The Odds Ratio (OR) in all cases was greater than 1.

Children with adequate meal frequency therefore had high chances of adequate energy and protein intake.

Table 3. 5: Nutrient adequacy among study childrenbasing on meal frequency

Nutrient	Meal frequency		OR (95% CI)
	% Adequate	**% Inadequate**	
Energy			
% Adequate	62.8	37.2	2.72 (1.93-3.84), **p <0.001**
% Inadequate	50.4	49.6	
Protein			
% Adequate	62.8	37.2	1.66 (1.18-2.34), **p =0.002**
% Inadequate	50.4	49.6	

OR= Odds Ratio, CI=Confidence Interval
Adequate meal frequency: 2 meals for breastfeeding children aged 6-8 months
3 meals for breastfeeding children aged 9-23 months
4 meals for non-breastfeeding children aged 6-23 months

3.4.6 Morbidity patterns and health seeking practices among study children in Bujenje County basing on their age

Morbidity patterns and health seeking practices among study children are shown in Table 3.6 below. Malaria, diarrhoea and respiratory infections were common sicknesses among study children. Diarrhoea was most prevalent among children aged 7-12 months (p=0.025). Prevalence of diarrhoea in children was significantly noted among households with mothers/caretakers less than 18 years of age and with lower levels of maternal education at p = 0.035 and 0.011 respectively. Health care practices among study children were not statistically different. Half of the study children were fully vaccinated against tuberculosis, polio and measles.

Disease incidences were therefore common among children in Bujenje County and were influenced by maternal education and age.

Table 3. 6: Distribution of study children in Bujenje County by their morbidity patterns and health care practices

Parameter	Frequency	Percentage
Morbidity patterns		
Sick in last 2 weeks to study	**510**	**100**
7-12 months	104	20.4
13-24 months	179	35.1
25-36 months	227	44.5
Malaria	**368**	**100**
7-12 months	71	19.3
13-24 months	139	37.8
25-36 months	158	42.9
Diarrhoea	**173**	**100**
7-12 months	69	44.9*
13-24 months	58	28.5
25-36 months	46	26.6
Respiratory infections	**310**	**100**
7-12 months	70	22
13-24 months	109	34.3
25-36 months)	139	43.7
Health care practices		
Received vitamin A supplements in last 6 months	**429**	**100**
7-12 months	142	33.1
13-24 months	143	33.3
25-36 months)	144	33.6
De-wormed in last 6 months	**429**	**100**
7-12 months	142	33.1
13-24 months	143	33.3
25-36 months)	144	33.6
Fully immunised	**392**	**100**
Yes	196	50
No	196	50
Visited health centre when sick	**347**	**100**
7-12 months	118	34.0
13-24 months	117	33.7
25-36 months	112	32.3

*Significantly high percentage ($p<0.05$)

3.4.7 Nutritional status of the study children

Figure 3.2 shows the nutritional status of children in Bujenje County. A total of 7.4% children in Bujenje County were wasted, out of which 1.7 and 5.7% were severely and moderately wasted respectively. A total of 11.7% of the children were underweight, out of which 9.1% and 2.6% were moderately and severely underweight respectively. Prevalence for stunting was 30.7% with 23.1% and 7.6% being moderately and severely stunted respectively.

Stunting, underweight and wasting were therefore prevalent among children in Bujenje County of Western Uganda.

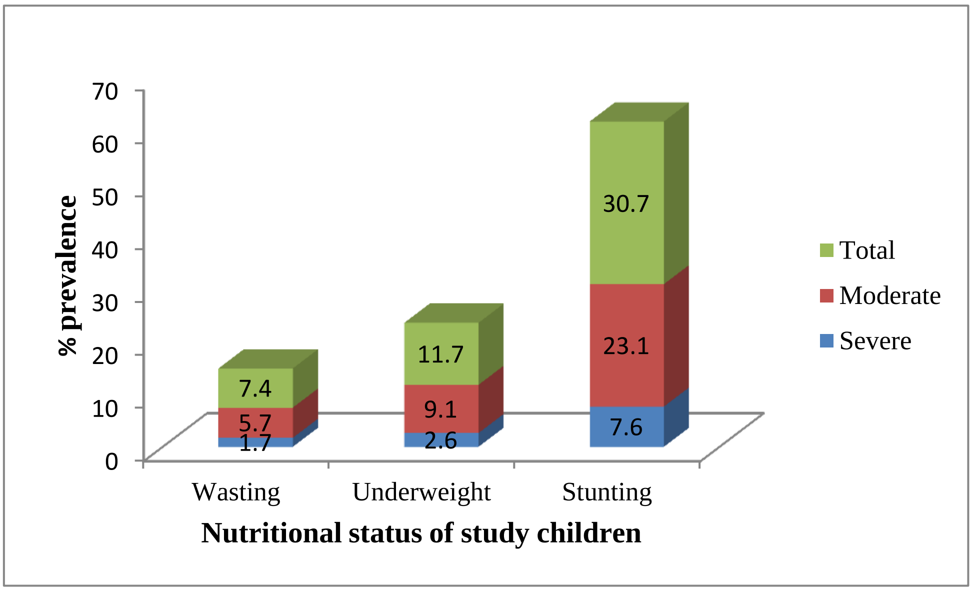

Figure 3. 2: Prevalence of wasting, underweight and stunting among study children

3.4.8 Association of socio-economic and demographic characteristics and nutritional status

Table 3.7 shows the association between socio-economic and demographic factors and the nutritional status of children in Bujenje County. Stunting was significantly higher in Bwijanga sub-county (p = 0.017). Wasting and underweight were significantly higher in Budongo sub-county at p = 0.001 and 0.041 respectively. Boys were more stunted and underweight than girls in both sub-counties at p = 0.024 and p = 0.042 respectively. Stunting was significantly high among children aged 25-36 months (p = 0.002) while wasting was significantly high among children aged 13-

24 months (p = 0.026). Wasting was significantly high among households with lower levels of maternal education (p=0.027).

Poor nutritional status in Bujenje County was therefore associated with demographic and socio-economic factors such as location, sex, age of children and primary levels of maternal education.

Table 3. 7: Prevalence of wasting, underweight and stunting basing on socio-economic and demographic factors

Factor	Stunting (%)	Underweight (%)	Wasting (%)
Sub-county			
Budongo	8.3	6.2*	4.9**
Bwijanga	22.4**	5.5	2.5
Age of child			
7-12	3.0	2.8	1.6
13-24	8.1	4.4	4.1**
25-36	19.6**	4.5	1.7
Sex			
Male	20.4*	8.5**	3.8
Female	10.3	3.2	3.6
Maternal Education			
No formal education	8.3	1.7	0.6
Primaryeducation	13.1	7.9	6.8*
Secondary education	4.2	0.8	0
Post secondary	5.1	1.3	0

*significant by chi-square at $p < 0.05$; p**significant by chi-square at $p < 0.01$

3.4.9 Factors contributing to the nutritional status of children in Bujenje County

Table 3.8 shows the contribution of health care practices, maternal education, diarrhoea, household income and millet porridge to the nutritional status of children in Bujenje county. About 76.1% of wasting (weight for height) in study children was significantly contributed by health care practices and household income. Diarrhoea, maternal education and millet porridges contributed to 75.3% of underweight (weight for age) in children, while 81.7% of stunting (Height for age) in study children was contributed by diarrhoea, millet porridge and maternal education.

In this study population therefore, diarrhoea, maternal education, millet porridges, health care practices and income contributed to the poor child nutritional status.

Table 3. 8: Determinants of children nutritional status in Bujenje County

Predictor	**Weight for height**		**Weight for age**		**Height for age**	
	Coefficient(β)	p-value	Coefficient(β)	p-value	Coefficient(β)	p-value
(Constant)	1.881	0.198	-7.321	0.010	-15.297	0.002
Maternal education	0.029	0.909	0.889	**0.039**	0.765	**0.039**
Health care practices	0.586	**0.020**	-0.585	0.577	0.331	0.212
Diarrhoea	-0.308	0.179	1.206	**0.023**	1.319	**0.008**
Household income	0.501	**0.041**	-0.955	**0.020**	-0.429	0.161
Millet porridge	-0.057	0.804	0.853	**0.044**	0.882	**0.022**
R Square	**0.761**		**0.753**		**0.817**	
R Square adjusted	**0.618**		**0.435**		**0.581**	

$Y^1 = 1.881+0.586x_1+0.501x_2$ $Y^2=-7.321+0.889_{x3}+1.206x_4+0.853_{x5}$

$Y^3 = -15.297+0.765x_3+1.319x_4+0.882x_5$

Y^1=Change in wasting, Y^2= Change in underweight and Y^3=change in stunting

x_1= Health care practices; x_2= Household income; x_3= Maternal education; x_4= Diarrhoea and x_5= millet porridge.

3.5 Discussion

3.5.1 Socio-economic and demographic characteristics of households in Bujenje County

The mean household size of 4.5 in the study is lower than the reported 4.7 for Masindi district and the national one of 4.9 (Ring and Develo, 2009, UBOS and ICF, 2012). Household size of 4.5 is fairly good to allow better child care practices. However the big percentage of children under five years of age in some households can create a dependency burden. Majority of the mothers/caretakers had attained primary education. This is the basic level of education for many people with minimal income in Uganda (UBOS and ICF, 2012). Majority of the households were monogamous. This could perhaps promote better child care practices from both parents especially at such a tender age. Majority of the mothers being aged 18-35 years reflects maturity and perhaps ability to care for children well. According to Girma and Genebo (2002), younger women from 15-19 years and older women 45-49 years are the most affected by malnutrition and this can influence child care. The total household income was quite small and in most cases it was got after selling harvest at the end of the season. Such low and unreliable incomes could influence the feeding and medical treatment received by children in this County. Farming was the most common occupation for household members since Uganda has an agro-based economy (UBOS and ICF, 2012). High involvement of women in farming is common in Uganda perhaps because of their low levels of education and their cultural roles as mothers.

3.5.2 Feeding practices of study children

All children in the study had ever been breastfed. The importance of breastfeeding to a child cannot be underscored since breast milk provides ideal nutrition for infants (Kramer and Kakuma, 2012). The percentage of exclusively breastfed children was higher than the national one of 63 percent while the percentage of children who breastfed for less than two years was higher than the national one of 53% (UBOS and ICF, 2012). Exclusive breastfeeding requires a child to receive breast milk without any additional food or drink and is recommended by World health organisation for the first six months (Dewey, 2003). Exclusive breastfeeding promotes motor development in children (Kramer and Kakuma, 2012) and protects infants from gastrointestinal infections (Dewey, 2003). The percentage of exclusively breastfed children was better than the national one because this was a rural based community where majority of mothers had no formal employment. Shorter duration of breastfeeding found in this study area could be due to early introduction of complementary foods by majority of mothers. Such a practice displaces breast milk (WHO, 2005). Longer duration of breastfeeding is associated with greater linear growth and this explains why early introduction of complementary foods was associated with stunting in this study area. Timely introduction of appropriate complementary foods could be instrumental in reducing the high stunting levels that were found in this part of Western Uganda (Simondon et al., 2001). Some mothers introduced complementary foods late and yet infants are developmentary ready for complementary feeding at 6 months (Naylor and Morrow, 2001). Such a practice deprives the child of the required nutrients in addition to breast milk since after six months it becomes increasingly difficult for infants to meet their nutrient requirements from breast milk alone (Kramer and Kakuma, 2012).

The percentage of study children who were able to meet the minimum recommended dietary diversity of 4 or more foods/food groups is higher than the national one of 13% especially among children aged 12-36 months. This could be due to better food security in rural areas compared to urban places in Uganda (UBOS and ICF, 2012). Current study findings are also comparable to a study in Bangladesh where 41.9% of children aged 6-23 months had adequate DDS (Kabir et al., 2012) and the infant and young children feeding indicators in two African countries of 34.7% (Aemro et al., 2013). Foods/food groups decreased as the child's age decreased indicating the complexity of obtaining suitable complementary foods for the younger age. Low dietary diversity among children aged 7-11 months can be compared with reported percentages of 81 and 82 in South Asian countries like Bangladesh and Nepal respectively (Joshi et al., 2012, Kabir et al., 2012). Such low percentages in present study findings could be due to few varieties of infant foods in rural areas, cultural practices and poor economic status. Meal frequency in this study improved with age and can be compared to national reports of 45%. It is lower than 99.7% reported in Ghana (Pelto and Armar-Klemesu, 2011) and 90% reported in Bangladesh (Kabir et al., 2012) and such a sharp difference can be linked to differences in food habits and availability of foods. Association of low levels of maternal education with inadequate DDS and meal frequency as found out in this study have also been reported by other studies and shows the role played by parental education and care in meeting appropriate dietary diversity and meal frequency (Aemro et al., 2013, Kabir et al., 2012, Pelto and Armar-Klemesu, 2011).

3.5.3 Common complementary foods in Western Uganda

Millet porridge was the most common complementary food in this study area just like Harvey, Rambeloson and Omar (2010) findings in South Western Uganda. This was because it was available and therefore affordable. Most of the porridges were of low viscosity compared to the recommended by World Health Organisation. This suggests inadequate nutrient intake especially for children aged 7-12 months who strongly relied on these porridges.

Introduction of a child to a family meal immediately after exclusive breastfeeding by some mothers is commendable since children have to adjust to family meals gradually. However if done with no special complementary food for the child like in this study, it may not be able to cater for the specific needs of this vulnerable group. Infants and young children require special foods of adequate nutrient density, consistency and texture (PAHO, 2003). This is necessary not only to promote digestibility of foods in infants but also to increase nutrient intake among young children since they have high nutrient requirements with limited gastric capacity (Compaore et al., 2011). The composition of family meals was mainly plant-based with minimal vegetables and fruits. This is contrary to World Health Organisation's recommendations where children aged 7-24 months should receive animal source foods, vitamin A rich fruits and vegetables daily (PAHO, 2003, WHO, 2005). Consumption of milk which is strongly recommended in young children, was very low even among non-breastfeeding children. Such feeding practices could soon affect growth, physiological maturation and development in children.

3.5.4 Dietary intake among study children

High inadequate nutrient intakes in this study reflect the poor quality complementary foods given to children in this County. Global figures also show that malnutrition among children mainly occurs from 6-18 months, because of the introduction of poor quality complementary foods (Michaelsen et al., 2009, Victora et al., 2010). These results are comparable to a study in South Western Uganda by Harvey, Rambeloson and Omar (2010) where the mean energy and protein intakes among children aged 24-59 months were 996 k calories and 17.7 g respectively. The percentages of children with inadequate vitamin A, iron and zinc in this study are also comparable to 52%, 57% and 78%, respectively among children aged 24-59 months in South Western Uganda (Harvey et al., 2010). Minimal consumption of vegetables and fruits deprived children of the cheap and abundant sources of vitamin A and iron in this study locality. Such practices are common in most communities with little income and nutritional knowledge but they limit nutrient intake (Michaelsen et al., 2009). Children aged 7-12 months had significantly high percentages of inadequate protein, zinc and iron intakes. This is because of their increased protein and iron requirements compared to other age groups and yet with limited gastric capacity. The significantly low DDS among these children also contributed to this occurance. Protein intake in this study is however very different from a study in Spain among children aged 7-36 months where the protein intake was twice more than the recommended (Dalmau et al., 2015). This sharp difference is due to over consumption of animal-source foods in the reported study which is quite contrary in this study. Children with a low dietary diversity score (<3 foods/food groups) had inadequate intakes of kilocalorie, protein, vitamin A, iron and zinc since dietary diversity score reflects dietary quality and adequacy (Arimond and Ruel, 2004). A study in Somalia showed a strong association between low DDS with inadequate energy intake among children below 5years (McGarry and Shackleton, 2009). Association of low DDS with inadequate vitamin A, iron and zinc shows that DDS can be used as a measure of micronutrient adequacy in children from low socio-economic status (Steyn et al., 2006). Since this is a farming community, households need to be mobilised to utilise available food resources like vegetables and fruits for improvement of their children's micronutrient intakes.

Study reports have also shown a strong association between diets with acceptable meal frequency and dietary diversity score with high adequacy ratios for energy, protein, zinc and iron especially in developing countries (Ruel, 2003). Dietary diversity score in this study location is therefore of special importance since even introduction of a variety of foods/food groups of plant origin to these children can have an impact on nutrient adequacy especially during this vulnerable age.

Inadequate meal frequency was associated with inadequate energy and protein intake. This corresponds with reports by McGarry and Schackleton (2009) and Ruel (2003). Since the composition of meals was of low nutrient content, children benefited greatly from increased uptake. Increase in number of meals helped children to build up the quantities consumed in a day and this promoted higher energy and protein intake at the end of the day. Meal frequency is considered as a proxy for energy intake from foods (WHO, 2005).

3.5.5 Morbidity patterns among study children

Malaria, respiratory infections and diarrhoea were common ailments in children just like in national reports (UBOS and ICF, 2012). Children with diarrhoea were found to be more than two times likely to be underweight and stunted as indicated by the odds ratio. Malaria, diarrhoea and acute respiratory infections are higly associated with child malnutrition in Uganda. Infections reduce both appetite and food intake (FANTA-2, 2010). In Uganda, diarrhoea is associated with a decrease in dietary intake of 40-50% lower for energy and protein and this could result in poor nutritional status (FANTA-2, 2010). Diarrhoea was significantly common among children aged 7-12 months. Children at this stage are independent and put dirty thing s in their mouth that could result in diarrhoea related infections (UBOS and ICF, 2012). This is a farming community where prepared porridges were left for long before feeding the children while mothers were working in gardens. Reports of poor toilet facilities in this place have also been made and could impact the environmental hygiene in this place which could easily affect children at such a vulnerable stage (Ring and Develo, 2009).

The percentage of children taken to a health facility when sick is lower than the national one of 72% and could be due to long distances to health centres. Immunisation, vitamin A supplementation and de-worming medication are some of the government programs aimed at addressing health aspects in children (UBOS and ICF, 2012). The percentage of children who were immunised though low was better than the national percentage of 40%. Health practices such as visiting a health facility when sick, de-worming, immunisation and giving of supplements can reduce the magnitude and severity of infections, promote feeding and therefore quick recovery.

3.5.6 Socio-economic and demographic factors influencing morbidity status dietary practices and intake among study children

Inadequate energy and protein intake in this study was associated with three or more children under five years in a household. Child nutrition in early age is very sensitive to feeding/weaning practices, care, exposure to infection and these may not be possible if the children are many (Girma and Genebo, 2002). In this study, lower levels of maternal education were associated with inadequate feeding practices such as early introduction of complementary foods, low dietary diversity score (<4 foods/food groups) and inadequate meal frequency. They were also associated with inadequate iron and vitamin A intakes and high diarrhoea incidences. According to Girma and Genebo (2002), mothers who are educated can utilise available resources for improving their children's feeding practices and therefore nutrient intake. The Uganda demographic and health survey (2012) reported that mothers of higher educational level (post secondary) frequently de-wormed and immunised their children. This could partly reduce diarrhoea incidences during this vulnerable age. Polygamous families were associated with early introduction of complementary foods and early weaning. Short birth intervals among these families were noted and could be responsible for this. In this study, early introduction of complementary foods, inadequate meal frequency and dietary diversity score, diarrhoea incidences and inadequate energy and protein intake were common among children of mothers aged less than 18 years. Such young mothers lack nutritional knowledge and experience concerning child care practices.

3.5.7 Nutritional status of study children

Wasting and stunting levels are comparable to the national figures of 5% and 33% (UBOS and ICF, 2012). Stunting levels were lower than 45% reported by the 2002 national reports for Western Uganda perhaps because of the season data was collected. In Uganda malnutrition among preschool children has been reported to be highest during farming activites (FANTA-2, 2010). Underweight levels are also comparable to the national figures of 14 and are lower than the 2007 Masindi District reports of 22% (Ring and Develo, 2009). According to World Health Organisation classification of children's nutritional status, these levels are poor, unacceptabily high and demand for an intervention (WHO, 1997). Wasting represented failure of children to receive adequate nutrition in the period immediately preceding the study and may have been as a result of inadequate food intake or a recent episode of illness causing loss of weight and onset of malnutrition. Stunting on the other hand represented failure to receive adequate nutrition over a long period of time and is affected by recurrent and chronic illness. Underweight takes into account both chronic and acute undernutrition and it is an overall indicator of a population's nutritional health (UBOS and ICF, 2012).

3.5.8 Socio-economic and demographic factors associated with the nutritional status of children in Bujenje County

Stunting levels were higher in Bwijanga sub-county because of the significantly high diarrhoea cases and shorter periods of breastfeeding in the sub-county when compared to Budongo ($p<0.001$). Short periods of breastfeeding could not allow linear growth in children while persistent diarrhoea never allowed linear growth to recover (FANTA-2, 2010). Higher levels of wasting and underweight in Budongo sub-County could be due to socio-economic factors such as income and maternal education, which were lower when compared to Bwijanga sub-county at $p=0.001$ and 0.011 respectively. Stunting and wasting levels were significantly higher for males than females just like in the national reports (UBOS and ICF, 2012). This has been reported by other studies and is quite common in the abscence of discriminary practices but its mechanism is not clear (Jooste et al., 1998, Ngare and Muttunga, 1999). Wasting tended to appear quite early in children (12-17months) compared to stunting (18-23months). This is around the complementary feeding period when many nutrient inadequacies and diarrhoea infections are common especially given the poor quality complementary foods in majority of households. Wasting unlike stunting develops very first. Stunting levels tended to be highest after 18 months.

This is the common age for stunting in communities with poor complementary foods (Arise et al., 2014, Victora et al., 2010). Lack of nutritious weaning foods affected these children. It is also common for children to get less care from mothers after breastfeeding has ceased as mother's are freed for economic activities outside households (Ricci et al., 1996). Wasting levels tended to reduce with age because of reductions in infections like diarrhoea as children grew and perhaps the building up of the body immunity achieved as children get older.

Socio-economic characteristics of households such as low income and maternal education were associated with wasting and underweight levels in children. High wasting and underweight levels in children of low socio-economic classes has been reported by other studies (Teshome et al., 2009, UBOS and ICF, 2012). Good income helps you to feed children nutritious foods, afford supplements and medical care which are key to good nutritional status. Stunting and underweight levels were influenced by low levels of maternal education. Women who are educated can utilise available resources for improving their children's feeding practices and therefore nutrient intake (Girma and Ganebo, 2002). In this study, women with secondary education significantly visited health days where immunisation, deworming and vitamin A supplements were given. Good health practices could minimise chances of children becoming stunted and underweight. Low levels of maternal education (primary) in this study also negatively influenced nutrient intake and diarrhoea incidences. According to the UNICEF conceptual frame work, dietary intake and disease incidences are the immediate determinants of malnutrition.

3.5.9 Morbidity and dietary factors contributing to poor nutritional status of children in Bujenje County

Diarrhoea was contributed to underweight and stunting in children. Infections affect dietary intake and utilization and this has a negative effect on both underweight and stunting (Girma and Ganebo, 2002). After an acute infection, weight gain recovers relatively rapidly for underweight but linear growth is slower and this can be a challenge in places where infections occur frequently as linear growth hardly gets a chance to recover resulting in persistent stunting levels (FANTA-2, 2010). Health care practices were associated with wasting since good treatment practices like visiting a health facility/provider, vitamin A supplementation and deworming medication can prevent or reduce the severity of disease and hence growth faltering.

The contribution of millet porridge to underweight and stunting levels reflects the inadequacies in millet porridge. Such challenges of low nutrient density, poor quality of amino acids and high content of pytates and tannins have to be addressed for it to serve as a proper complementary food. Most of the child malnutrition problems in Ugandan set in as soon as children are introduced to complementary foods (UBOS and ICF, 2001). Global figures on nutritional status have also shown that malnutrition among children below 5 years of age develops mainly during the period from 6 to 18months (Victora et al., 2010). This period, which is the complementary feeding period, is therefore of special importance and needs to be given consideration. This is a pathetic situation for children in this County, especially given the fact that most of the households could not afford animal foods, fortified foods and supplements as recommended by WHO for such children (PAHO, 2003). These feeding practices are contrary to the World Health Organisation recommendations and influenced children’s nutritional status in this County (Ruel et al., 2004). Wasting was not attributed to dietary factors since it can also be sparked off by a recent disease occurance. However, according to Kikafunda, Walker, Collett and Tumwine (1998), association of wasting with infections suggests low immune function which might be as a result of inadequate nutrition.

3.6 Conclusions

Study findings in Bujenje County indicate that diarrhoea; low levels of maternal education, millet porridges, health care practices and income were contributors to the poor nutritional status in Bujenje County of Western Uganda. Households had limited resources which they could not effectively tap for the improvement of their children’s nutrition and health.

3.7 Recommendations

Household members need to be empowered with knowledge and skills that will help them utilise the potential resources available. Improvement in knowledge and skills will help households meet not only the dietary requirements for their children but also reduction of the high diarrhoeal incidences that contributed to poor child nutrition in this part of Western Uganda.

CHAPTER 4: IMPROVEMENT OF TRADITIONAL MILLET PORRIDGES

4.1 Introduction

Baseline studies in Western Uganda indicated that among other factors, diarrhoea low levels of maternal education and millet porridges contributed to poor child nutritional status. About 43-82 % of the children aged 7-24 months consumed less than recommended dietary intake of energy, protein, vitamin A, iron and zinc due to deficiencies in millet porridges. Given the high prevalence of child malnutrition in Bujenje County, sustainability of local based strategies will need to take into account the cost-effectiveness, feasibility of different options and integration of food security strategies into existing dietary practices. Interventions to improve quality of family foods include use of special recipes made with locally available ingredients and use of home processing technologies such as soaking, germination, malting and fermentation of foods (Lazzerini et al., 2013). A recent review of programmes has highlighted greater emphasis on providing food supplements for treatment of malnutrition rather than promotion of local based programmes with long-term impacts (Ashworth and Ferguson, 2009).

Millet porridge has the potential of serving as a complementary food in Western Uganda since it is available and cheap. However its limitations in nutrient content and utilisation need to be addressed to make it a suitable complementary food since young children have limited gastric capacity. The period between 7-24 months in the life of a child is characterised by rapid growth and development (WHO, 2012) necessitating feeding on appropriate complementary foods which provide adequate nutrient intake to avoid growth faltering among children.

Both moringa and pumpkin powders are reported to be significant sources of beta-carotene, protein, iron and zinc (Ogbe and Affiku, 2012, Usha et al., 2010). Use of Moringa and pumpkin in Western Uganda is not new. Moringa leaves are a common herbal concoction for children with diarrhea, while pumpkins are popular as a crop that can be relied on in time of scarcity. Use of such locally available resources and bio-enrichment processing techniques like fermentation at household level can help improve on both the nutrient content and nutritional functionality of millet porridges. This can be achieved due to improved digestibility of starch and protein and bioavailability of iron and zinc (Singh and Raghuvanshi, 2012). In addition, moringa and lactic acid fermentation are reported to have antimicrobial properties (Ogbe and Affiku, 2012, Bruno et al., 2005, Kumar and Pari, 2003, Mbugua and Njenga, 1992). Such properties would promote the safety and keeping quality of millet porridges especially in farming communities where porridges for children are kept for long before being served.

The aim of this study therefore was to improve on the nutritional functionality and safety of millet porridges using simple technologies like fermentation and biofortification with locally available food resources such as moringa and pumpkin in technology underdeveloped and resource constrained areas of Western Uganda.

4.1.1 General objective

To improve the nutritional functionality and safety of traditional millet porridges using moringa, pumpkin and fermentation.

4.1.2 Specific objectives

i). Determination of proximate composition, vitamin A, zinc and iron contents in millet, pumpkin and moringa.

ii). Formulation and development of millet porridge flour optimised for protein, vitamin A, iron and zinc using moringa, pumpkin and fermentation.

iii). Determination of antimicrobial properties for the developed millet-based porridges.

iv). Development of recipes for preparation of ready to serve porridges from the improved millet porridge flours as complementary food.

v). Determination of sensory qualities for the ready to serve porridges

4.1.3 Research question

Can the nutritional value and safety of traditional millet porridges be improved using moringa, pumpkin and fermentation?

4.2 Literature review

4.2.1 Millet porridges

Millet porridge forms an abundant source of protein, iron, energy, calcium and zinc among cereals (Obilana, 2003) especially for households with low income. Millet has low energy and nutrient density. Thicker millet porridge is more energy dense but it is highly viscous and young children cannot ingest it in good amounts even when they are in good health (Ruel et al., 2004). Finger millet contains 44.7% of the total essential amino acids and its insufficient amounts of lysine hinder growth in children (Singh and Raghuvanshi, 2012). It contains various anti-nutrients such as phytates, tannins, phenols and enzyme inhibitors (Bachar et al., 2013). These anti- nutrients form complexes with enzymes of the digestive tract and so reduce protein and starch digestibility. They also form complexes with iron and zinc and reduce their solubility and availability. The physiological consequences of consuming anti- nutrients-rich foods are reduced growth in children due to low metabolizable energy and bioavailability of amino acids (Onyango et al., 2005) .

4.2.2 Nutritional composition of *Moringa oleifera* leaves and seeds

The seeds and leaves of moringa are a significant source of beta-carotene, vitamin C, protein, iron, calcium and potassium. One tablespoon of leaf powder provides 14% of the protein, 40% calcium, 23% iron and most of the vitamin A for the recommended dietary intake (RDI) of a child aged 1-3 years (Fuglie, 2005). The seeds contain more fat, protein and zinc compared to the leaves (Fuglie, 2001). Drying of the leaves condenses the nutrients so that a large dose of nutrition can be gained from a small spoonful of dried leaf powder (Table 4.1). This is very important for young children since their nutrient requirements are high and yet they have limited gastric capacity (Michaelsen et al., 2009). Drying of leaves should however be done indoors and storage done in opaque, well-sealed plastic container since sunlight will destroy vitamin A (Fuglie, 2005).

Moringa contains eight essential amino acids that cannot be synthesized by the body and have to be obtained from dietary sources, and compare well with that of milk and eggs (Fuglie, 2005). It is also a source of sulphur containing amino acids methionine and cystine, which are often in short supply especially in cereals (Usha and Lakshmi, 2010, Fuglie, 2005). The high quality and easily digested protein in moringa leaves is attributed to the quality of amino acids (Zongo et al., 2013). Moringa seed and leaf powders can therefore be added to soups, sauces, porridges and baby food to boost nutrient content in small amounts with no discernible effect on the taste of food (Zongo et al., 2013, Fuglie, 2001).

Table 4. 1: Nutritive value of *Moringa oleifera* leaves relative to a selection of foods

Fresh leaves	Dried leaf powder
4 times vitamin A in carrots	10 times vitamin A in carrots
7 times vitamin C in oranges	½ times vitamin C in oranges
4 times calcium in milk	17 times calcium in milk
3 times potassium in bananas	15 times potassium in bananas
¼ times iron in spinach	25 times iron in spinach
2 times protein in yogurt	9 times protein in yogurt

(Fuglie, 2001)

4.2.3 Antimicrobial properties of *Moringa oleifera* leaves and seeds

Moringa plants are rich in phytochemicals (compounds produced by plants that have health benefits) with known powerful antioxidant ability such as kaempferol and rutin (Fahey, 2005). Moringa leaf and seed are natural antihelmintics, while the leaf is also an outstanding immune builder (Ogbe and Affiku, 2012)**.** Moringa oleifera extract is also reported to have antibacterial properties and is widely used in treatment of bacterial infection, fungal infection and diarrhea (Patel, 2001). Research studies have also shown evidence of antibacterial activity against *Salmonella typh i*(Doughari et al., 2007). *Moringa oleifera* leaf ethanol extract exhibited broad spectrum activity against the test organisms *Escherichia coli* and *Staphylococcus aureus* (Bukar et al., 2010). Using the Minimum Inhibitory Concentration (MIC) and disc diffusion method, powder from moringa fresh leaf juice exhibited highest zones of inhibition against *Shigella shiga, Shigella sonnei and Staphylococcus aureus* compared with fresh leaf juice (Rahman et al., 2009).

The chloroform extract from seed was reported to be active against Escherichia *coli* and *Salmonella typhimurium* (Bukar et al., 2010). The antimicrobial activity of moringa seeds and fruits is due to the presence of an array of phytochemicals, but most importantly due to activity of a short polypeptide named 4 (a'-L-rhamnosyloxy) benzyl-isothiocynate. The peptide may act directly on microorganisms and result in growth inhibition by disrupting cell synthesis or synthesis of essential enzymes (Bukar et al., 2010).

4.2.4 Nutrient composition of pumpkin flesh and seeds

Pumpkin is an annual plant with leafy green vegetable. It has a climbing stem of up to 12m long and a fruit with a round fibrous flesh. Pumpkins possess some top quality essential nutrients that are required for many processes in the human body. Many disease-fighting nutrients are found in large quantities in pumpkin flesh for example zinc, potassium, pantothenic acid, carotene, magnesium, vitamin C, E and dietary fibre (Usha and Lakshmi, 2010). Alanine, glutamic acid and serine are the highest amino acids in pumpkin flesh. The highest amounts of essential amino acids are valine and leucine, while the least is methionine (Aleknaviciene et al., 2009).

Mineral intake in diets can be increased by consumption of pumpkin flesh (Fedha et al., 2010). Pumpkin flesh however contains tannins and these form complexes with protein that are responsible for growth depression, low protein digestibility and amino acid availability (Gibson et al., 2006). Incorporation of 20% pumpkin flesh flour (*Curcurbita moschata*) in weaning mix of sorghum (*Sorghum vulgare*), whole gram (*Vigna radiate*) and rice powder (O*ryza sativa*) demonstrated a significant increase in protein, carbohydrates, beta-carotene and antioxidants content (Usha and Lakshmi, 2010).

Pumpkin seeds have received considerable attention in recent years because of their nutritional and health protective values. They are good sources of protein, fats, carbohydrate and minerals especially zinc (Atuonwu and Akobundu, 2010). Pumpkin seeds have a higher protein content and fairly high concentration of amino acids than the flesh. This aspect of pumpkin seeds make them suitable for fortification (Mohammad, 2004). Research studies have shown that these seeds not only contain nutritionally important bio-compounds but are also sources of other phyto-compounds which at certain critical levels have significant anti-nutritional effects (Elinge et al., 2012). These compounds include oxalate, phytate, nitrate and cyanide. It also has considerable pharmacological activities such as antifungal, antibacterial, anti-inflammation activities and antioxidant effects (Atuonwu and Akobundu, 2010). Table 4.2 shows the nutrient composition of finger millet, moringa (leaf and seed) and pumpkin (flesh and seed).

Table 4. 2: Nutrient composition of finger millet, moringa and pumpkin per 100g of edible portion

Name of food stuff	Energy K calories	Protein g	Vitamin A mg	Zinc (mg)	Iron (mg)
Finger millet[1,]	378	7.7	8.3	2.3	3.9
Moringa pods[2]	26	2.5	0.1	0.5	5.3
Moringa leaf powder[2]	205	27.1	16.3	3.3	28.2
Pumpkin seeds[3,4]	559	30.2	16µg	7.8	8.8
Pumpkin powder,[3,4]	175	15.7	3.1	3	1.5

Source: (Bachar et al., 2013)[1]**,** (Fuglie, 2001) [2],(Usha and Lakshmi, 2010)[3](Mohammad, 2004)[4]

4.2.5 Benefits of lactic acid fermentation

Fermentation is one of the most economic and effective measures of reducing ant-nutrient factors in foods. Studies have shown that both spontaneous fermentations as well as fermentation with starter cultures significantly reduce the phytic acid content in millet (Bruno et al., 2005). The tannin content is also reduced leading to increased absorption of iron (Onyango et al., 2005). Similarly as a result of lactic acid fermentation, the protein and starch digestibility can be elevated in millet (Lei, 2006). This is due to degradation of complex storage proteins by endogenous and microbial proteases during fermentation (Onyango et al., 2005). Iron and zinc availability is achieved by a reduction of phytates and tannins in both finger millet and moringa powders by lactic acid fermentation (Thierry et al., 2013, Onyango et al., 2005, Lei, 2006). Using fermented foods as complementary foods has the benefits of enhancing not only the nutritive value of food but also food safety. Fermented cereals are generally weakly buffered and will therefore easily achieve a low pH. Efficient lactic acid fermentation will normally produce a pH of 4 or less at which growth of bacteria pathogens is inhibited (Mbugua and Njenga, 1992). Fermentation improves flavour, preserves food through formation of acidulants, alcohol and antibacterial compound. It also helps control and prevent infections of the intestine (Lei, 2006).

4.2.6 Codex requirements for complementary food

Standards have been set concerning production of good quality complementary feeds. 100ml of ready-for- consumption complementary food should provide the following;

- Not less than 60 kcal and not more than 85 kcal for energy.
- Total protein quantity of not less than 3g and not more than 5.5g per 100 available calories.
- Fat of not less than 3g and not more than 6g per 100 kcal
- A minimum of 75µg vitamin A while the highest should be 225µg expressed as retinol.
- Iron content of atleast 1mg and the maximum of 2mg
- Zinc content of 0.5 mg minimum

(Codex, 2011).

4.3 Materials and methods

The basic preparation processes for millet-based porridge flours are shown in Figure 4.1. The raw materials comprised of finger millet (*Eleusine coracana*), *Moringa oleifera* leaves and pumpkin (*Curcubita maxima)* flesh. A commonly used farmer's variety of finger millet known as 'Mugaali' was bought from the local market, cleaned, dried and ground into flour. Moringa *oleifera* leaves were harvested, cleaned and dried indoors before being ground into flour by a local miller (mortar and pestle). A farmers' variety of *Curcubita maxima*, identified as 'Okamanyaota' pumpkin was harvested when mature (120 days), washed, peeled and seeds removed.

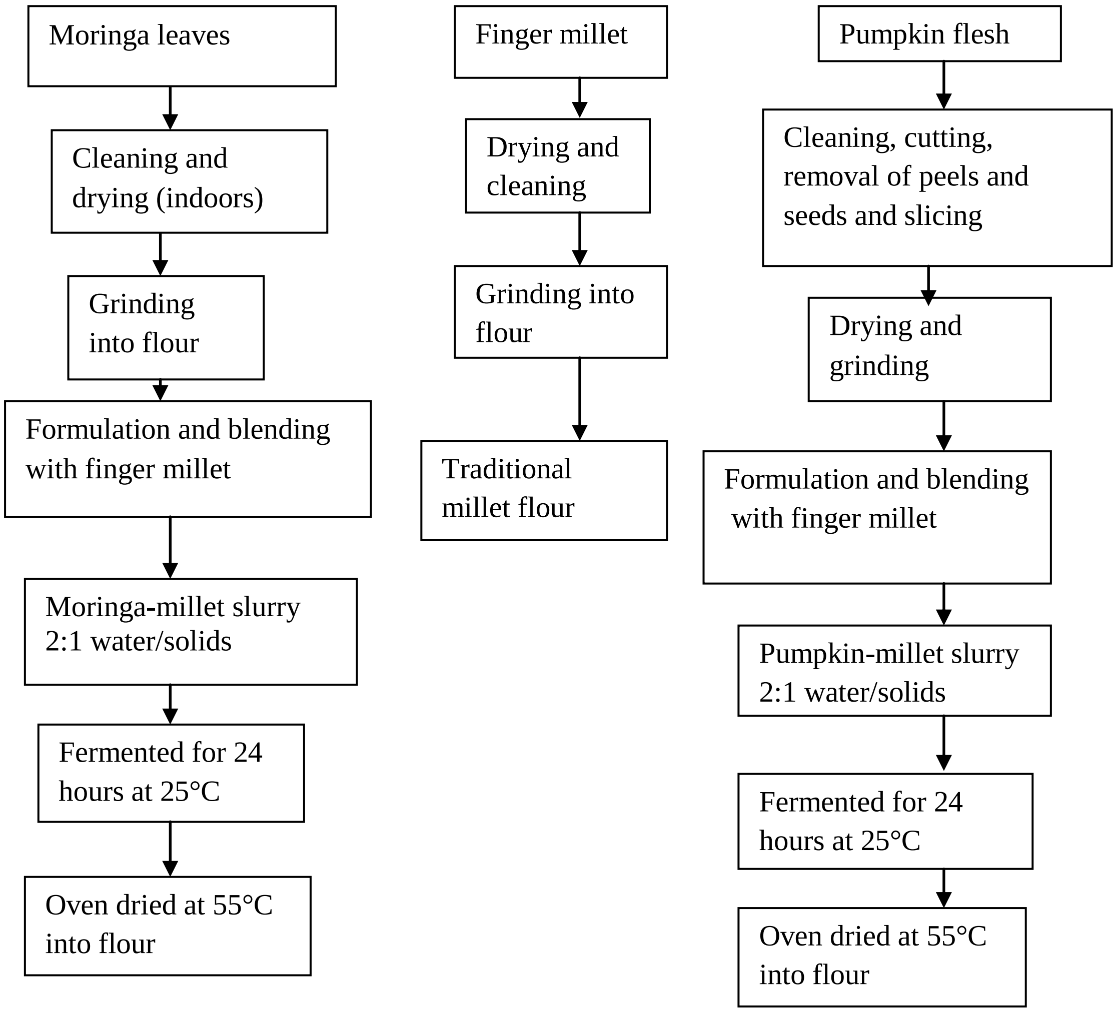

Figure 4. 1: Preparation of millet-based porridge flours

The flesh and seeds were sun dried for about 3-4 days before they were milled separately into flour using a grinding machine. Formulation and blending of the flours was done before fermentation and the slurries were oven dried at 55°C.

4.3.1 Proximate composition for millet, moringa and pumpkin flours

Millet, pumpkin (flesh and seeds) and moringa (leaves and seeds) flours were analysed for proximate composition, zinc, iron and vitamin A contents in triplicate according to AOAC methods (AOAC, 2012). The Kjeldah method (Jung et al., 2003) was used to determine the protein content (N × 6.25), while fat was determined by solvent extraction (Sukhija and Palmquist, 1988). Carbohydrates were determined by the difference of the sum of all the proximate composition from 100%. The calorific (energy) value was obtained by multiplying the value of carbohydrate, protein and crude fat by the Atwater factors of [energy content = (g carbohydrate x 4) + (g fat x 9) + (g protein x 4] (Papadopoulos et al., 1986). Iron and zinc were determined using the atomic absorption spectrophotometer 210VGP Buck Scientific (Jorhem and Engman, 2000), while vitamin A was determined by column chromatography (Parvin et al., 2014).

4.3.2 Formulation of the porridge flours

This was done basing on our baseline data. Study findings showed that in 43-82% of the studied children, the daily energy, protein, vitamin A, iron and zinc requirements were not met. Table 4.3 shows how these porridges were used to feed children in Bujenje County and the percentage of daily recommended nutrient intake (RNI) they contributed among children aged 7-24 months. The average amount of porridge served to children varied from 150 to 300 millilitres per serving per day, and depended on the age of a child. Children were given porridges approximately 2 to 3 times a day (servings) depending on their age. The percentage of the recommended nutrient intake (RNI) met by these porridges was quite small, and varied from zero to 55% depending on the nutrient and the age of the child.

The porridge flours were developed using finger millet, pumpkin (*Curcubita maxima*) flesh and *Moringa oleifera* leaf flours so as to provide not less than 60% daily requirements for protein, iron and zinc and while maximising vitamin A (300-500µg) in 450 to 900 mls daily intake of porridges by children aged 7-24 months. The target for daily intake amounts of porridges and the percentage RNI were based on the dietary survey carried out as part of the baseline study. Given that vitamin A content in millet flour was found to be almost zero, pumpkin flesh and moringa leaf flours were formulated with millet flour at calculated rates of 300µg, 400µg and 500µg based on the RNI for vitamin A for children aged 7-24 months (Dewey and Brown, 2002).

Table 4. 3: Baseline nutrient intake from traditional millet porridges

Variable	7-8 months	9-12 months	13-23 months
Serving amount	150 mls	200 mls	300 mls
Amount of solids	10 g	15 g	20 g
Number of servings	1.75±0.18	2.65±0.06	2.95±0.04
Energy			
Recommended intake	200 k cal	300 k cal	550 kcal
Total intake	69.5 k cal	157.8 k cal	234.1 k cal
% RNI covered	35	53	42
Protein			
Recommended intake	9.1 g	9.6 g	10.9 g
Total intake	1.6 g	3.7	5.6
% RNI covered	18	39	51
Vitamin A (RE)			
RNI	250 µg	300 µg	400 g
Total intake	0 µg	0 µg	0 µg
% RNI covered	0	0	0
Iron			
Recommended intake	11 mg	11 mg	11 mg
Total intake	1.8 mg	4.0 mg	6.0 mg
% RNI covered	16	36	55
Zinc			
Recommended intake	2.8 mg	2.8 mg	2.8 mg
Total intake	0.4 mg	0.9 mg	1.3 mg
% RNI covered	14	32	46

Iron: Assuming medium iron bioavailability (10%). Zinc: Assuming moderate bioavailability (30%)
Recommended Nutrient Intake (RNI) references: World Health Organisations Recommendations (Ruel et al., 2004, Dewey and Brown, 2002)

Six complementary porridge flours (M1, M2, M3, P1 P2 and P3) were formulated as follows:

Flour 1 (M1): *Finger millet*: *Moringa oleifera leaf powder* (95: 5).

Flour 2 (M2): *Finger millet: Moringa oleifera leaf powder* (93: 7)

Flour 3 (M3): *Finger millet: Moringa oleifera leaf powder* (91: 9)

Flour 4 (P1): *Finger millet: Curcubita maxima flesh flour* (88: 12)

Flour 5 (P2): *Finger millet: Curcubita maxima flesh flour* (83: 17)

Flour 6 (P3): *Finger millet: Curcurbita maxima flesh powder* (79: 21)

Composite flours were then analysed for protein, vitamin A, iron and zinc. Those providing not less than 60% of RNI in the end prepared product were selected for further evaluation. The formulated porridges consisted of two versions (fermented and non-fermented) and were compared with the control of traditional millet porridges (fermented and non-fermented) to ascertain the quality effect of moringa leaf, pumpkin flesh and fermentation on the formulated porridges.

4.3.3 Fermentation of the flours

The flours were fermented using lactic acid fermentation starter cultures prepared according to a method described by Mbugua (1992). The flours were each slurred with water (50% solids), inoculated with 5% culture and incubated at room temperature for up to 24 hours.

The pH and titratable acidity in the porridges were measured to determine if fermentation had taken place. It was measured using Metrohm 605 pH meter Swiss made, calibrated to 7.005. Ten millilitre samples of each of the porridges were put in a beaker. Five drops of 1% phenolphthalein solution were added and titration done to first persistent pink colour with 0.1 Normal NaOH. Titratable acidity was calculated on the basis of lactic acid equivalent according to the formula;

$$\%\ \text{lactic acid} = \frac{ml alkali \times normality alkali \times relative molecular mass of lactic acid}{Weight of sample in grams}$$

4.3.4 Preparation of ready to drink millet porridges

Fourteen types of porridges were prepared on the day of the test. They included the control of traditional millet porridge either fermented or non-fermented and porridges with different amounts of moringa leaf and pumpkin flesh flours. 200 mls of smooth slurries made from 10-20% flour solids were mixed with I litre of boiling water in cooking pots and the mixture stirred for at least 10 minutes to obtain smooth textured porridges. To ensure a comparable consistency in porridges, the total amount of water, flour and cooking time were adjusted for each of the porridge through visual examination by checking the fluidity of the porridge. The cooked porridges were kept in plastic jugs to maintain the serving temperature and then sweetened before tasting.

4.3.5 Sensory evaluation of the millet-based porridges

According to Gomiero *et al.* (2003) organoleptic parameters such as colour, aroma, taste, consistency and appearance are key measures of product quality (Compaore et al., 2011). Porridge samples from the different formulations were subjected to sensory evaluation with mothers, using a seven point hedonic scale of 1-7, where 1 = dislike very much; 2 = dislike moderately; 3 = dislike slightly; 4= neither like, nor dislike; 5 = like slightly; 6 = like moderately and 7 = like very much (Carpenter et al., 2000). Twenty two mother panelists aged 22-35 years, from Bujenje County were used to evaluate the formulated porridges in terms of colour, consistency, flavour, taste and overall acceptability. The mother panellists had children less than two years of age and were used because they determined the choice for children's feeds and were also familiar with millet porridges. Each panelist was presented with 7 disposable cups containing different blinded porridge samples per day for two days. The porridges were provided at the interval of 5-10 minutes. On the first day non-fermented millet -based porridges were presented while on the second day; fermented millet-based porridges were presented. Spoons for evaluating each porridge sample and bottled water for rinsing of the mouth in between testing of the porridges were also provided. Rinsing the mouth minimised the carry-over taste effects from previous samples. Each treatment was evaluated three times by each panellist. Five types of porridges were selected randomly and subjected to analysis of variance to determine panellist effect (Appendix 5). The most acceptable porridges were standardized by a Bostwick Consistometer (Mouquet et al., 2006) and their nutrient composition analysed.

4.3.6 Viscosity of acceptable formulated porridges

For this study 100g millet flour, 150g millet with 7% moringa leaf and 120g millet flour with 17% pumpkin flesh powders were each mixed separately with 1000 millilitres of clean tap water. They were brought to boil and left to simmer for at least 10 minutes while stirring to ensure a smooth consistency for porridges. The porridges were cooled to 40°C, the recommended temperature for young children. The flow distance of the porridges was measurement by a Bostwick consistometer in triplicate (Mouquet et al., 2006) and their viscosities were computed.

4.3.7 Determination of antimicrobial properties

Antimicrobial properties for the porridges were determined over a 24 hour period to gauge the inhibitory properties against selected test pathogens. Agar diffusion technique was used to monitor the growth of pathogens on selective media by measuring the zones of inhibition against diarrhoea causing bacteria of *Escherichia coli, Salmonella typhi***,** *Shigella shiga* and *Staphylococcus aureus* (Doughari et al., 2007). These bacterial cultures were obtained from the Department of Public Health, Bacteriology and Toxicology, University of Nairobi. Their concentration was standardised to 0.39 optical densities before being inoculated in the media using a spectrophotometer at 600nm.

The growth media for the test pathogens were Baird parker for Staphylococcus *aureus*, Violet Red Bile Agar for *Escherichia coli*, Brilliant green agar for *Salmonella typhi***,** and MacConkey Agar for *Shigella shiga*. 15-20 millilitres of autoclaved molten agar in Mccarthey bottles had their temperature cooled to 45°C in water bath and inoculated with 0.2 ml of test pathogen inocula standardised to 0.39 optical densities in BHI at 600nm. The inoculated molten agar was then poured into plates and allowed to set. Three equidistant points were marked and holes of 1 cm diameter made using a cork borer. About 0.2 mls of each of the porridges were put into the marked holes, allowed to set for 15 minutes and then incubated at 35°C for 24-48 hours. The antimicrobial inhibition by the porridges was determined by measuring the diameters of the colony free halos around the holes with porridge samples.

4.3.8 Determination of the cost of porridges

The ingredients for making the porridges were costed to determine their affordability by the households. The costing was based on the local market prices. Costed ingredients included millet flour, moringa leaf powder, pumpkin flesh powder and sugar. Sugar costed 3,000/=, millet flour costed 1,000/=, moringa leaf powder costed 2,000/= and pumpkin flesh flour costed 1,000/= Ugandan shillings per kilogram at the time the study was carried out. The costs for the formulated porridges per kg and the costs of the different porridges consumed per day by children of different age groups in both Ugandan shillings and dollar currency are shown in Table 4.4 below.

The total cost for 1kg of formulated moringa and pumpkin millet porridges were 1170 and 1100 Ug shs (Ugandan shillings) respectively, while the cost for traditional millet porridge was 1100 Ug shs. The costs for the different age groups per day were determined basing on the costs per kg, and did not differ significantly from the cost of the traditional millet porridge.

Table 4. 4: Total cost of millet-based porridges per day for the different age groups

Traditional millet	**Cost (Ug shs)**	**Moringa millet**	**Cost (Ug shs)**	**Pumpkin millet**	**Cost (Ug shs)**
Ingredients		**Ingredients**		**Ingredients**	
100% millet	1,000/-	93% millet	930/-	83% millet	830/-
5% sugar	100/-	5% sugar	100/-	5% sugar	100/-
		7% moringa	140/-	17% pumpkin	170/-
Total cost/kg	**1100/-**	**Total cost/kg**	**1170/-**	**Total cost/kg**	**1100/-**
Age group		**Age group**		**Age group**	
7-8months (60g/day)	66 Shs $ 0.03	7-8months (80g/day)	94 Shs $ 0.04	7-8months (72g/day)	79 Shs $ 0.03
9-11months (60g/day)	66 Shs $ 0.03	9-11months (90g/day)	105 Shs $ 0.04	9-11m (75g/day)	83 Shs $ 0.03
12-23months (90g/day)	99 Shs $ 0.04	12-23months (120g/day)	140 Shs $ 0.06	12-23m (105g/day)	116 Shs $ 0.05

4.3.9 Data analysis

Version 20 SPSS Inc., Chicago, IL was used for data analysis. Means of nutrient compositions, bacteria inhibition halos, pH and titratable acidity in the fermented porridges were compiled. Chi-square tests were used for comparing percentage acceptance of the porridges by mothers. Analysis of variance in nutrient compositions was carried out and differences among means were compared by Least Significant Difference (LSD) test. In all statistics, $p<0.05$ was regarded as significant.

4.4 Results

4.4.1 Nutrient composition of finger millet (*Eleusine coracana*), pumpkin (*Curcubita maxima*) and *Moringa oleifera*.

Table 4.5 shows the results for proximate and micronutrient composition of millet, pumpkin (flesh and seeds) and moringa (leaves and seeds) flours.

Table 4. 5: Proximate and micronutrient composition of millet, pumpkin and moringa

Variable	Millet flour	Pumpkin seeds	Pumpkin flesh	Moringa seeds	Moringa leaves
Proximate composition					
Moisture %	10.44±0.02	5.4±0.20	10.99±0.01	3.65±0.03	7.56±0.02
Protein %	9.42±0.02	23.12±0.06	13.73±0.03	23.26±0.10	21.03±0.07
Fat/oil %	1.44±0.04	26.51±0.01	1.09±0.09	26.00±0.20	6.45±0.05
Fibre %	4.51±0.08	32.68±0.02	7.08±0.1	24.95±0.02	10.57±0.10
Ash %	2.58±0.04	3.96±0.02	7.57±0.10	4.33±0.03	11.10±0.05
Carbohydrates %	82.07±0.02	23.34±0.30	70.53±0.10	23.44±0.22	51.16±0.04
Energy(kcal)	375.99±0.9	424.23±0.4	346.88±0.10	420.77±0.77	332.15±0.15
Micro nutrient					
Vitamin A (µg/100g	0.02±0.03	126.85±0.8	2705.88±0.08	268.13±0.13	6076.37±0.7
Iron mg/100g	10.18±0.18	8.71±0.03	8.34±0.10	7.51±0.51	12.44±0.44
Zinc mg/ 100g	1.33±0.03	8.54±0.54	2.19±0.19	4.65±0.65	2.50±0.10

Values are expressed on dry weight basis

Finger millet flour had the highest carbohydrate content while pumpkin flesh had the highest amounts of moisture. The seeds of both moringa and pumpkin contained higher amounts of protein, energy and zinc compared to the leaves and flesh. There was more vitamin A and ash (minerals) in pumpkin flesh and moringa leaf powders than in their seeds.

4.4.2 The pH and titratable acidity in fermented millet-based porridges

The pH and titratable acidity in fermented millet-based porridges is shown in Table 4.6 below. Titratable acidity of pumpkin is lowest at 0.091, followed by 0.095 for the traditional millet porridge while moringa porridge had the highest titratable acidity of 1.00. The pH of pumpkin improved millet was significantly the highest while the titratable acidity was significantly the lowest among the fermented millet porridges.

Table 4. 6: The pH and titratable acidity(%) in fermented porridges

Variable	Traditional millet	Pumpkin millet	Moringa millet	P-value
pH	3.57±0.006	3.46±0.012	3.64±0.12	0.000
Titratable acidity	0.095±0.002	0.091±0.006	0.100±0.006	0.002

Each assay carried out in triplicate

4.4.3 Organoleptic properties of the nutritionally optimised millet porridges

Sensory evaluation data for the finger millet porridges by mother panelists are shown in Table 4.7. Majority of the mothers preferred the flavour of fermented porridges to non-fermented porridges. Mothers also showed higher preferance in taste, colour and acceptability of porridges made from fermented moringa and pumpkin fortified flours than for the non-fermented porridges. Addition of 9% moringa *oleifera* leaf powder and 21% pumpkin flesh flours in millet porridges resulted in less desired porridges in colour and overall acceptability. Pumpkin millet porridge with 17% pumpkin flesh flour had the best overall acceptability among the experimental porridges.

Table 4. 7: Sensory evaluation data for the experimental porridges compared with traditional millet porridges in percentages

Porridge	Colour			Taste			Flavour			Acceptability		
	C5	C6	C7	T5	T6	T7	F5	F6	F7	A5	A6	A7
F1	18.2	27.3	54.5	18.2	31.8	50.0	22.7	45.5	31.8	22.7	27.9	49.4
FF1	13.6	39.8	46.6	18.9	33.7	47.4	22.0	45.2	32.8	28.2	31.2	40.6
F3	31.8	45.5	22.7	23.6	42.8	33.6	28.0	49.0	23.0	27.7	36.4	35.9
FF3	13.6	50	36.4	21.0	41.8	37.2	24.6	43.0	32.4	27.3	35.9	36.8
F6	18.2	31.2	50.6	18.0	37.8	44.2	13.7	45.5	40.8	22.2	37.3	40.5
FF6	16.7	29.7	53.6	15.0	37.7	47.3	18.4	39.8	41.8	18.2	34.3	47.5

7= Like very much; 6=like moderately and 5=Like slightly. F1= Traditional millet flour, FF1=Fermented traditional millet flour, F3 = 7% moringa fortified millet flour, FF3= Fermented 7% moringa fortified millet flour; F6=17% pumpkin fortified millet flour and FF6= Fermented 17% pumpkin fortified millet flour

4.4.4 Viscosity of acceptable porridges

The viscosities of the acceptable millet-based porridges are shown in Table 4.8 below and can be related to the standard /maximum for porridges of 3000cP. Moringa improved millet porridges had the highest amounts of flour solids and yet with the lowest viscosity of 2177 cP. Traditional millet porridge had the lowest amount of solid matter. Pumpkin millet porridge had higher amounts of flour solids and lower viscosity of 2612 cP compared to the one of the traditional millet porridge of 2830 cP.

It is therefore clear that moringa and pumpkin millet porridges had better viscosity when compared to the traditional millet porridge.

Table 4. 8: Viscosity of acceptable porridges at 40^{o}C

Porridge sample	Amount of flour solids /100mls porridge	viscosity cP
Traditional millet porridge	10 g	2830±1.0
Fermented traditional millet porridge	11 g	2672±0.1
Non- fermented pumpkin millet	11 g	2612±2.0
Fermented pumpkin millet porridge	13 g	2612±0.5
Non- fermented moringa millet	15 g	2177±1.2
Fermented moringa millet porridge	15 g	2177±1.0

Values are means of triplicate determinations, cP = Centipoise

4.4.5 Nutrient composition of organoleptically acceptable millet-based porridges

Table 4.9 shows the nutrient composition of organoleptically accepted ready to use moringa and pumpkin millet porridges compared with the traditional millet porridge.

Moringa millet porridge was higher in energy, protein, zinc, vitamin A and iron content when compared with all porridges. Pumpkin millet porridge was better than the traditional millet porridge in protein, vitamin A and zinc contents. Only moringa millet porridges could meet the iron, zinc and energy recommendations of the CODEX Alimentarus Guidelines on formulated supplementary foods. The carbohydrate content slightly reduced after fermentation.

Table 4. 9: Nutrient composition of organoleptically acceptable millet-based porridges

Nutrient	F1	FF1	F3	FF3	F6	FF6	Recommended value (g)*
Carbohydrates (g/100g)	81.61± 0.61[a]	81.06±0 .06[a]	79.67± 0.20[a]	79.61± 0.3[a]	79.91± 0.01[a]	79.85± 0.02[a]	64±4
Protein (mg/100g)	9.24± 0.10[a]	9.34± 0.10[a]	10.25± 0.27[b]	10.37± 0.30[b]	10.01± 0.17[ab]	10.15± 0.15[b]	≥ 15
Energy (kcal/100g)	396.86 ±0.85[a]	401.39± 0.34[b]	402.02± 0.20[b]	406.10± 0.10[c]	396.28± 0.10[a]	396.61± 0.10[a]	400-426
Micronutrients							
Vitamin A (µg/100g)	0.001± 0[a]	0.003± 0[a]	333.3± 0.30[d]	329.20± 0.18[e]	312.8± 0.08[b]	319.5± 0.05[c]	
Iron (mg/100g)	10.13± 0.10[a]	10.33± 0.10[a]	17.92± 0.20[d]	17.99± 0.4[c]	9.80± 0.01[a]	9.91± 0.10[a]	16
Zinc (mg/100g)	2.15± 0.10[b]	2.21± 0.10[b]	3.20± 0.20[a]	3.37± 0.10[a]	2.01± 0.01[b]	2.32± 0.10[b]	3.2

Recommended value reference: Codex alimentarius reference (Ijarotimi and Keshinro, 2012)
Values are means of triplicate determinations expressed on dry weight basis.
F1= Traditional millet flour, FF1=Fermented traditional millet flour
F3 = 7% moringa fortified millet flour, FF3= Fermented 7% moringa fortified millet flour
F6=17% pumpkin fortified millet flour and FF6= 17% Fermented pumpkin fortified millet flour

4.4.6 Antimicrobial activity of the porridges

The diameters of inhibition halos against test pathogens of *E. coli*, *S. aureus*, *S. typhi* and *S.shiga* are shown in Table 4.10. Fermented traditional millet porridge, moringa and pumpkin porridges showed growth inhibition against tested diarrhoea pathogens as indicated by inhibition halos. Moringa millet porridges had the highest inhibitory effect against test pathogens *E. coli, S. aureus, S. typhi* and *S. shiga* while pumpkin millet porridges significantly inhibited growth of *S. aureus.* According to inhibition halos, *S. aureus* was the most inhibited by all the porridges (Appendix 8).

Incorporation of moringa and pumpkin plus fermentation therefore showed inhibitory growth against the tested pathogens.

Table 4. 10: Diameters of inhibition halos (mm) for microorganisms in fermented porridges

Variable	FF1	FF3	FF6
E. coli halo size	0.93±0.03	1.03±0.09	1.33±0.12
S. aureus halo size	1.00±0.06	1.33±0.09	1.27±0.19
S. typhi halo size	0.37±0.09	0.43±0.08	0.53±0.18
S. shiga halo size	0.53±0.18	0.53±0.18	1.10±0.15

Each assay carried out in triplicate; FF1= Fermented millet porridge
FF3 = Fermented 7% moringa fortified millet flour
FF6 = Fermented 17% pumpkin fortified millet flour

4.4.7 Nutrient Intakes derived from the Improved millet porridges

Table 4.10 shows the number of servings, amount per serving, amount of solids in the serving, and the RNI expected to be met by the porridges. After adjusting on the viscosity of traditional millet porridge and the expected number of porridge servings per day according to WHO guidelines for infant feeding, traditional millet porridges showed the potential of catering for ≥ 60% energy requirements in children aged 7-24 months. However, the iron and zinc gaps still remained especially for children aged 7-11 months. Traditional millet porridges still have a big challenge of catering for vitamin A requirements. Moringa and pumpkin millet porridges have the potential of meeting ≥ 60% RNI for energy, protein, vitamin A, iron and zinc among children aged 7-24 months in Bujenje County of Western Uganda.

Table 4. 11: Nutrient intakes from the improved millet porridges compared to recommended nutrient intakes (RNI) by WHO

Variable	7-12 months	13-11 months	12-23 months
Serving			
Number of servings	4	3	3
Amount of serving	150 mls	200 mls	300 mls
Amount of solids			
Traditional millet	15 g	20 g	30 g
Pumpkin millet	18 g	25 g	35 g
Moringa millet	20 g	30 g	40 g
Energy (WHO, RNI)	200 k cal	300 k cal	550 k cal
Traditional millet	238.1 kcal (119)	238.1 k cal (79)	357.1 k cal (64)
Pumpkin millet	285.6 kcal (143)	297.5 k cal (99)	416.4 k cal (76)
Moringa millet	324.9 kcal (162)	365.5 k cal (122)	487.3 k cal (89)
Protein (WHO, RNI)	9.1g	9.6g	10.9g
Traditional millet	5.5g (61)	5.5 g (58)	8.3 g (76)
Pumpkin millet	7.2 g (80)	7.6 g (79)	10.7 (98)
Moringa millet	8.3 g (91)	9.3 g (97)	12.4 g (114)
Vitamin A (WHO, RNI)	250 µg	300 µg	400 µg
Traditional millet	0.002 µg (0)	0.002 µg (0)	0.003 µg (0)
Pumpkin millet	230.0 µg (92)	234.4 µg (78)	328.1 (82)
Moringa millet	263.4 µg (105)	296.3 µg (98)	395.16 (99)
Iron (WHO, RNI)	11 mg	11 mg	11mg
Traditional millet	6.0 mg (55)	6.0 mg (55)	9.1 mg (83)
Pumpkin millet	7.1 mg (65)	8.9 mg (96)	11.9 mg (108)
Moringa millet	14.4 mg (131)	16.2 mg (147)	21.6 mg (196)
Zinc (WHO, RNI)	2.8 mg	2.8 mg	2.8 mg
Traditional millet	1.3 mg (46)	1.3 mg (46)	1.9 mg (69)
Pumpkin millet	1.7 mg (60)	2.0 mg (62)	2.7 mg (99)
Moringa millet	2.0 mg (96)	3.0 mg (108)	4.0 mg (144)

Iron: Assuming medium iron bioavailability (10%).
Zinc: Assuming moderate bioavailability (30%)
Numbers in brackets represent % WHO-RNI.
Pumpkin millet porridge = 17% Pumpkin flesh powder
Moringa millet porridge = 7% Moringa leaf powder
References: World Health Organisations Recommendations (Dewey and Brown, 2002, Ruel et al., 2004).

4.5 Discussion

4.5.1 Nutrient composition of the raw materials used in the formulation

Studies have reported carbohydrate content of 79.5%, iron content of 9.9 mg and crude fibre content of 4.8% in finger millet, which are very similar to the present study findings (Bachar et al., 2013, Obilana, 2003, Singh and Raghuvanshi, 2012). The protein content in this study is within the reported range of 5.6-12.7 mg by Singh and Raghuvanshi (2012), while the fat content is within 1.3-1.8 g reported by Bachar et al. (2013). Present study findings on ash and zinc content of finger millet are also within 1.7-4.13 mg and 0.92-2.55 mg per 100g finger millet flour respectively reported by other scholars (Amadou et al., 2013, Bachar et al., 2013). Gopalan et al. (1999) have reported 45 μg carotene per 100 g of finger millet while nap.edu reported 6 retinol equivalent (Singh and Raghuvanshi, 2012). Present study findings concur with Bhaskaracharya (2001) reports of finger millet being a very poor source of β-carotene with values ranging from 0 to 1 μg/100g (Singh and Raghuvanshi, 2012).

Results for *Moringa oleifera* leaves compare closely with findings by Ogbe and Affiku (2012) but contrast for zinc and energy content in moringa leaves. Ogbe and Affiku (2012) reported 6.0 mg of zinc and 1440 k cal energy against 2.5 mg zinc and 332.15 k cal observed in the present study. Thierry et al. (2013) also reported protein content of 31.62-35.59 g and iron content of 20.34-33.68 mg which are quite higher than the present study findings. *Moringa oleifera* seeds have been reported to have high protein content of 29.63-31.36g, fat from 30.36-40.39, ash from 6-8% and 9% carbohydrates (Compaore et al., 2011). However, the reported carbohydrate content is lower than the present research findings of 23.44% while for protein, fat and ash contents, they are slightly higher. These differences in nutrient content may be attributed to differences in soils and stage of maturity of *Moringa oleifera* plants.

High moisture, carbohydrates and vitamin A levels and lower protein, fat/oil and zinc levels in the *Curcurbita maxima* flesh compared to the seed is comparable to findings by Mohammad (2004). Low moisture indicates good storage properties since growth of micro-organisms can be hindered. Findings in this study show lower levels of protein in *Curcurbita maxima* (23.12g) compared to 36.2g and 39.3g reported by Mohammad (2004) and Fedha et al. (2010), respectively. Curcurbita flesh protein of 13.73 g was also different from the 4.0 g proteins reported by Fedha et al. (2010). However present findings concur with Usha and Lakshmi (2010) results for protein, fat and ash contents of 15.69g, 1.62g and 5.7g respectively. According to Compaore et al. (2011), pumpkin seeds contain 42% protein, 13.4% carbohydrate, 42.9-57.3% lipids and 4.33-7.25% ash (minerals). These values are higher than the present study findings. The differences in nutrient composition can be attributed to the variety of pumpkin, nature of soils and maturity stage (Fedha et al., 2010).

High amounts of protein, energy and zinc in *Curcurbita maxima* and *Moringa oleifera* seeds compared to the leaf and flesh justify their suitability as good raw materials for promotion of high nutrient density diets in infant food formulation (Compaore et al., 2011). Fibre prevents constipation but high amounts of fibre in the seeds could be a challenge in infants diet since it causes irritation of the gut mucosa (Elinge et al., 2012, Mohammad, 2004). Though *Moringa oleifera* and *Curcurbita maxima* seeds have more protein, fat/oil and energy than the leaf and flesh powders, they were not suitable for fortifying finger millet porridges. This was because of their comparatively low levels of vitamin A when compared to the leaves of moringa and pumpkin flesh and the fact that finger millet had almost no vitamin A. *Moringa oleifera* leaves and *Curcurbita maxima* (pumpkin) flour have very high amounts of vitamin A which could be utilised in improving vitamin A content in millet porridges. This would promote vitamin A intake in children, build body immunity and perhaps reduce on infections in children that are common in Bujenje County (Ring and Develo, 2009). The high iron content in *Moringa oleifera* leaves could help address the iron deficiencies that are common among preschool children in Western Uganda and Uganda as a whole.

4.5.2 Effect of lactic fermentation, moringa and pumpkin flours on the organoleptic properties of the formulated porridges

The reduction in acceptability of 21% *Curcurbita maxima* finger millet porridge can be attributed to the yellow colour imparted by the carotenoids pigment naturally present in *Curcurbita maxima* (Usha and Lakshmi, 2010). The dark green colour of the *Moringa oleifera* leaves was also responsible for the reduced acceptability in finger millet porridges with 9% *Moringa oleifera* leaves powder. *Curcurbita maxima* millet porridges were more acceptable than moringa *oleifera* finger millet porridges because of being familiar foods. Studies have demonstrated the ability of 20% pumpkin flour incorporated in a weaning mix of sorghum (*Sorgum vulgare*), whole gram (*Vigna radiate*) and rice (*Oryza sativa*) to increase sensory qualities of the weaning mix (Compaore et al., 2011, Usha and Lakshmi, 2010). This could perhaps promote good nutrition because of higher intakes enhanced by palatability of the porridge. Higher preference for fermented products in terms of flavour can be attributed to the production of lactic acid, alcohols and carboxylic acids in fermented products that promote production of a variety of flavour of the existing food (Blandino et al., 2003, Lei, 2006). The oven temperatures slightly altered the colour in the process of drying. This could explain why majority of mothers preferred the colour of fermented *Moringa oleifera* and *Curcurbita maxima* improved finger millet porridges to the non-fermented formulations.

4.5.3 Effect of lactic fermentation, moringa and pumpkin flours on the nutrient content of the formulated porridges

Moringa oleifera leaf powder and *Curcurbita maxima* flesh powder were able to improve the nutrient content of finger millet porridges. Through optimisation of nutrients and costs, the nutrient content of the porridges was improved and the prices kept to the minimum. *Moringa oleifera* and *Curcurbita maxima* flesh flours had a negative impact on gelatisation of porridges compared to millet flours. This was also observed by Lakshmi (2010) when formulating weaning mix and was attributed to high pectin levels in pumpkin. This property of a weaning mix is ideal because diets

that form gel at higher concentrations allow dilution in attempts to increase the digestibility of the weaning mix without losing the density of nutrients as compared to weaning mixes with least concentration (Usha and Lakshmi, 2010). Such a property is especially vital for Bujenje County where low calorie and protein intake in children was attributed to dilution of finger millet porridges. It is also a vital property for most developing countries where low calorie and protein intake in children have been attributed to dilution of complementary foods (Hossain et al., 2005). *Moringa oleifera* finger millet porridges resulted in more nutritious porridges within the recommended maximum viscosity of 3,000 cP for easiness of feeding infants who cannot handle thicker millet porridges (Mouquet et al., 2006). There was some decrease in carbohydrate content after fermentation since lactic acid bacteria use sugars during fermentation (Thierry et al., 2013).
Moringa millet porridges had the best nutrient composition and were able to meet the energy, iron and zinc recommendations of the CODEX requirements. Studies have shown the potential of *Moringa oleifera* in improving child nutrition (Odinakachukwu et al., 2014, Thierry et al., 2013). *Moringa oleifera* has also demonstrated the potential of improving vitamin A in serum depleted rats (Thurber and Fahey, 2009). *Curcurbita maxima* finger millet porridges had better protein, vitamin A and zinc compared to the traditional millet porridges.

Consumption of pumpkins has been promoted as a means of promoting vitamin A intake among resource constrained populations (Dhiman et al., 2009). Pumpkin flours have also demonstrated the potential of providing economic and nutritious weaning mix. Studies have demonstrated the ability of pumpkin flour incorporated in a weaning mix to increase the protein and energy content of the weaning mix and this could promote better nutritional status (Compaore et al., 2011, Usha and Lakshmi, 2010). Adequate processing and judicious blending of the locally available foods has been encouraged as a measure of improving intake of nutrients among children in areas with limited resources (Lombor et al., 2009).

4.5.4 Antimicrobial properties of formulated millet porridges

All lactic fermented porridges exhibited some inhibition properties against bacterial pathogens. Lactic acid bacteria are reported to produce antimicrobial substances which inhibit certain diarrhoea causing microorganisms such as *E. coli, Salmonella typhi* and *S. shiga* (Gabriel-Ajobiewe et al., 2014, Guslandi, 2005). Efficient lactic acid fermentation is reported to produce a pH of 4 or less at which growth of pathogens is inhibited (Lei, 2006). This explains the better inhibition against *S.aureus* observed in pumpkin millet porridge with high titratable acidity. Other factors responsible for microbial inhibition by fermented foods include production of bacteriocins, hydrogen peroxide, carbon dioxide, ethanol and antibiotic like substances (Gabriel-Ajobiewe et al., 2014, Lei, 2006). Porridges fortified with moringa had better inhibitory characteristics against *S. shiga* and *S. typhi*. Such antimicrobial properties have also been reported by Rahman et al. (2009) and attributed to complex chemical compounds such as kaempferol and rutin contained in *Moringa oleifera* leaves that have antioxidant and antibiotic properties (Patel et al., 2011, Fuglie, 2005). Moringa leaf extracts are also reported to have exhibited broad spectrum activity against test organisms of *E. coli* and *S. typhi* (Bukar et al., 2010). Bacteria inhibition in porridges fortified with pumpkin could also be attributed to phytochemicals found in pumpkin (Dhiman et al., 2009). Inhibition of growth of bacteria in these porridges was therefore due to combined effects of lactic acid fermentation and presence of phytochemicals in both moringa and pumpkin flours as reported by Dhiman et al. (2009) and Patel et al. (2011). These antimicrobial properties by the formulated porridges would be vital as complementary foods in communities like Bujenje County, where high infection rate has been reported (Ring and Develo, 2009). Their application as complimentary feed and impact on the high diarrhoea incidences that are common during the weaning period in Western Uganda and in developing countries as a whole would be of both scientific and socio-economic interest.

4.5.5 Nutritional value for the traditional millet porridge

The present recipe for traditional millet porridge if intergrated in the feeding practices of Bujenje County combined with nutritional education could address children's energy needs. However, the iron and zinc gaps would still remain. These are very essential nutrients in young children whose effects cannot be neglected especially at this critical stage of growth and development. These results confirm the superiority of finger millet to other cereals in catering for energy needs of children (Obilana, 2003, Singh and Raghuvanshi, 2012). They also reflect the need for enriching the content of vitamin A, iron and zinc in millet porridges to avoid long term effects of these micronutrients deficiencies at this critical stage of growth and development in children.

Moringa and pumpkin finger millet porridge can meet the the target point of ≥60% RNI for children aged 7-36 months. The porridges were designed to be intergrated in the feeding practices of children aged 7-24 months in Bujenje County and therefore could reduce malnutrition in Western Uganda. The formulated porridges are thus better complementary foods compared to both traditional millet porridge and the traditional millet porridge. This is qualified not only by their increased nutrient content but also the antimicrobial properties they possess. Increased digestibility of starch and protein and bioavailability of iron and zinc are some of the benefits of lactic fermented millet porridges that have been reported (Onyango et al., 2005, Lei, 2006). Lactic acid fermentation has also been reported to increase iron and zinc availability, gastric digestibility of protein and starch and to reduce on the level of phytates in moringa powder (Thierry et al., 2013).

4.5.6 Conclusion

The nutritional value and safety of traditional millet porridges was improved with 7% *Moringa oleifera* and 17% *Curcurbita maxima* without negatively influencing its cost and sensory attributes.

4.5.7 Recommendations

Digestibility of protein and starch and bio-availability of zinc, iron and vitamin A in moringa and pumpkin millet porridges need further investigation. The porridges need to be evaluated for their effectiveness in rehabilitation of malnourished children in Western Uganda.

CHAPTER 5: NUTRITIONAL PERFORMANCE OF IMPROVED MILLET PORRIDGES AMONG CHILDREN WITH SEVERE ACUTE MALNUTRITION

5.1 Introduction

Almost 10 million deaths occur annually among children below 5 years of age with malnutrition rates of underweight, stunting, and wasting at 19%, 15% and 15%, respectively (Michaelsen et al., 2009). Globally, more than 29 million, or about 5% suffer from severe wasting; Asia and Africa being the most affected regions contributing 71% and 28% respectively (UNICEF et al., 2012). Severe acute malnutrition entails serious and often fatal complications if not properly treated. Therapeutic rations and micronutrient supplements are commonly being used for nutritional rehabilitation of malnourished children in Africa with positive results. Examples of such rations and foods include, Corn Soy Blend, (CSB), Unimix, Ready to Use therapeutic foods and F-100 milk. These food rations have proved effective in nutritional rehabilitation of malnourished children. However, they are expensive, require donor agencies or government support, and are available usually at nutritional rehabilitation centres or as food relief to communities. Once malnourished children are rehabilitated and discharged; or support by government or donor agencies discontinued, the children frequently experience relapse in their malnutrition conditions, and have to be taken back to the rehabilitation centres.

This study was meant to evaluate therapeutic values of the improved millet porridges among severely malnourished children in Uganda.

5.1.1 General objective

The general objective was to determine the rehabilitative value for the improved millet porridges among children with Severe Acute Malnutrition (SAM).

5.1.2 Specific objectives

1. Determination of effect of improved millet porridges on nutritional status of children with Severe Acute Malnutrition.

2. Determination of effect of improved millet porridges on serum retinol, iron, zinc and haemoglobin levels in children with Severe Acute Malnutrition.

5.1.3 Research question

What is the rehabilitative value of moringa and pumpkin millet porridges among children with Severe Acute Malnutrition (SAM)?

5.2 Literature review

5.2.1 Therapeutic feeding during the nutritional rehabilitation of children with Severe Acute Malnutrition

Ready to use therapeutic foods are used for the management of children with SAM. They include F-75, F-100 milk and Ready-to-use therapeutic (RUTF).

F-75 milk is used during the first phase of treatment for stabilization of patients with SAM while their medical complications are being treated. With its calorific value of 75/100 mls of reconstituted milk it is not intended for children to put on weight (WHO, 1999).

F-100 is recommended by World Health Organisation for the nutritional rehabilitation of children with Severe Acute Malnutrition after stabilization in inpatient care (WHO, 2013). It is given to patients with appetite and no medical complications and its target is to make children gain weight (WHO, 1999).

Ready-to-use therapeutic (RUTF) food has replaced F-100 milk in a variety of settings where SAM is treated (WHO, 2013). Most RUFTs are lipid-based pastes combining milk powder, electrolytes and micronutrients to meet recommended nutrient values for children with SAM (WHO et al., 2007). RUFT has enabled treatment of severe acute malnutrition to move outside feeding centres into the community since its risks for contamination are less compared to F-100 (UNHCR and WFP, 2011).

5.2.2 Guidelines for the management of severe acute malnutrition during rehabilitative stage

According to WHO guidelines on nutrition rehabilitation, a child is supposed to receive frequent feeds of unlimited amounts of catch up formula (at least 4-hourly). The feed should meet 150-220 kcal/kg body weight/day and 4-6g protein/kg body weight/day. Monitoring of daily weight is required. Weight gain of <5g/kg/day is regarded as poor, 5-10g/kg/day as moderate and a weight gain greater than 10g/kg/day is regarded as good (WHO, 1999). After regaining the appetite, children with severe acute malnutrition (SAM) can be managed as outpatients and treated with Ready to use therapeutic foods until recovery. The decision to transfer children from inpatient care should be determined by their clinical condition and not anthropometric measurements (WHO, 2013).

5.3 Methods

5.3.1 Study design and methodology

The study was controlled and longitudinal in design and was carried out at Mwanamugimu Nutritional unit of Mulago Hospital, Uganda (A rehabilitation centre for children with malnutrition). Majority of the children were admitted with severe acute malnutrition and clinical manifestations of edematous and non edematous kwashiorkor. They were first admitted in the stabilisation ward and treated for all ailments before the nutrition rehabilitation phase. The feeding trials administered, involved three groups of children fed on the improved millet porridges as experimental feeding rations, and F-100 milk, the therapeutic food used by Mulago hospital as the control.

Criteria for selecting study children

The criteria used for selecting study children were as follows:

a) Inclusion criteria:

The inclusion criterion was age from 7-36 months, severely malnourished with a z-score of ≤ -3 and a signed written consent form from parents/guardians.

b) Exclusion criteria

The exclusion criteria for children in the study were age less than 6 months and above 36 months and presence of congenital disorder and infections.

Baseline characteristics of study children

The study children had their baseline characteristics as shown in Table 5.1. Differences in the selected characteristics between the three children groups were not significant ($p>0.05$).

Table 5. 1: Baseline characteristics of study children

Variable	F100 milk N=25	Moringa N=26	Pumpkin N=25	P- value
Age (Mean±SE)	17.0±1.0	17.8±1.3	16.9±1.7	NS
Nutritional status (Mean±SE)				
WAZ	-3.7±0.21	-3.7±0.38	-3.7±0.27	NS
HAZ	-3.5±0.25	-3.5±0.40	-3.5±0.26	NS
WHZ	-3.2±0.46	-3.4±0.43	-3.4±0.69	NS
Sex				
Male	50.0%	53.8%	50.0%	
Female	50.0%	46.2%	50.0%	NS
Immunisation status				
Fully immunised	48%	49.2%	40%	
Partially immunised	52%	50.8%	60%	NS
Vitamin A supplementation				
Received	72%	70%	76%	
Not received	28%	30%	24%	NS
Breastfeeding status				
Still breastfeeding	12.0%	11.6%	12.0%	
Not breastfeeding	88.0%	88.4%	88.0%	NS

NS=Not significant ($p>0.05$)

5.3.2 Feeding regiment for the study children

The children's feeding regiment is shown in Table 5.2. All groups were provided with cornsoy blend, at 6.00 am and kitobero (normal hospital diet) at 12.00 pm (midday) and 6.00 pm. The control group got F-100 milk four times within 24 hours namely at 9.00am, 3.00pm, 9.00pm and 12.00 am (midnight), while experimental groups were given F-100 milk ration only at 12.00 am midnight, to provide animal protein for ethical considerations. Kitobero was composed of either beans or groundnut sauce enriched with silverfish powder, along side a starchy food like rice, ugali, plantain, cassava or potatoes.

Table 5. 2: Feeding regime for the children under rehabilitation

Time	Control (F-100 milk)	Pumpkin-millet porridge	Moringa-millet porridge
6.00am	Cornsoy blend	Cornsoy blend	Cornsoy blend
9.00am	F-100	Pumpkin- millet	Moringa- millet
12.00pm	*Kitobero	*Kitobero	*Kitobero
3.00pm	F-100	Pumpkin- millet	Moringa- millet
6.00pm	*Kitobero	*Kitobero	*Kitobero
9.00pm	F-100	Pumpkin-millet	Moringa- millet
12.00 am	F-100	F-100	F-100

*Kitobero = Normal hospital diet

5.3.3 Feed intake for the control and experimental porridge

To determine feed intake by children, clear records of amounts served and amounts left were weighed and recorded. Moringa and pumpkin millet porridges were developed to be used as complementary foods for children in Western Uganda. The objective for the development of these porridges was to avoid relapses that occur when children are discharged from rehabilitation centres due to lack of a sustainable solution at home. The developed porridges were composed of water, millet flour, 5% sugar, 7% moringa leaf and 17% pumpkin flesh flours. 200 mls of slurries made from 15% and 13% flour solids of moringa millet and pumpkin millet respectively were each mixed with 1 litre boiling water and brought to boil on a gas cooker. The porridges were allowed to simmer for 5-10 minutes and cooled to around 40°C before being served to children.

The nutrient composition of these porridges is shown in Table 5.3 below;

The energy, protein, retinol and zinc content in F-100 were higher compared to the amounts in the porridges. Only the iron content in the porridges was higher than in F-100. Iron sulphate is usually added to F-100 milk for those children with clinical signs of anaemia after they have started gaining weight.

Table 5. 3: Composition of ready to feed porridges and F-100 milk per 100 mililitres

Food type	Energy (k cal)	Protein (g)	Retinol (µg)	Iron (mg)	Zinc (mg)
F-100 milk	100	2.9	154.4	0.4	2.3
Moringa-millet	50.0	1.4	44.3	2.4	0.4
Pumpkin-millet	43.8	1.2	37.4	1.2	0.3

5.3.4 Measurement of children's nutritional status

This was done basing on WHO's guidelines (WHO, 1999). Nutritional status indices were calculated using ENA for SMART 2010 software and interpreted using WHO 2006 reference standards.Weight measurements were taken daily before the 9.00 am feed. Rate of weight gain was calculated as follows;

Rate of weight gain = $\frac{Final\ weight - Initial\ weight}{Initial\ weight \times study\ period\ in\ days}$

5.3.5 Biochemical measurements of study children

Blood samples were drawn for analysis of haemoglobin, serum iron, zinc and retinol. This was done before the first meal in the morning by a qualified medical laboratory technologist. Haemoglobin levels were analysed at the rehabilitation unit using a portable battery powered HaemoCue machine (HaemoCue AB, Angelholm, Sweden). Prevalence of anaemia was determined using World Health Organization's cut off values of 11.0g/dl haemoglobin (Kotecha, 2011). Serum iron, zinc and retinol were analysed at Lancet laboratories, Uganda. Serum retinol was determined using high-performance liquid chromatography (Pee and Dary, 2002) and any child below 0.825 µmol/l was considered serum retinol deficient (Hix J, 2006). Serum zinc concentrations were analyzed with flame atomic absorption spectrophotometer (Smith et al., 1979) and values less than 10.0 µmol/l were categorized as deficient (Riviera, 2001). Serum iron was determined using calorimetric method and a cut off of <9.0µmol/l was used for iron deficiency (Tobacco et al., 1981).

Clinical conditions were documented during the study, and defined as the number of times a child developed a medical condition/disease.

5.3.6 Discharge criterion from the nutritional rehabilitation unit

Children were discharged by medical doctors on the following basis:

a) Persistent weight gain

b) Absence of unhealthy clinical condition

c) Improved appetite as observed from feed intake.

5.3.7 Statistical analysis

Data was entered, cleaned and analyzed using SPSS (Statistical Package for Social Scientists) version 20.0 for windows (*SPSS*, *Inc.*, *ChicagoIL*). Analysis of Variance (ANOVA) and Chi-square tests were used to analyse data. Paired t-test was used to compare pre-intervention and post-intervention results, and the difference statistically tested for significance at $p < 0.05$.

5.3.8 Ethical clearance

The design and ethics of the study was reviewed and cleared by The Aids Support Organisation (TASO) internal review board (TASOIRC/029/13-UG-IRC-009), and then approved by the Uganda National Council of Science and Technology (HS 1315). Informed consent from children's mothers/caregivers was given by signing a form (Appendix 6).

5.4 Results

5.4.1 Feed intake by study children from improved millet porridges

Figure 5.1 shows the feed intakes for the children over the rehabilitation period. The feed intakes for children feeding on moringa millet and pumpkin millet porridges were higher than those feeding on F-100 milk the control, and increased at a higher rate. Feeds for the pumpkin millet porridges increased slightly higher than for moringa millet porridge.

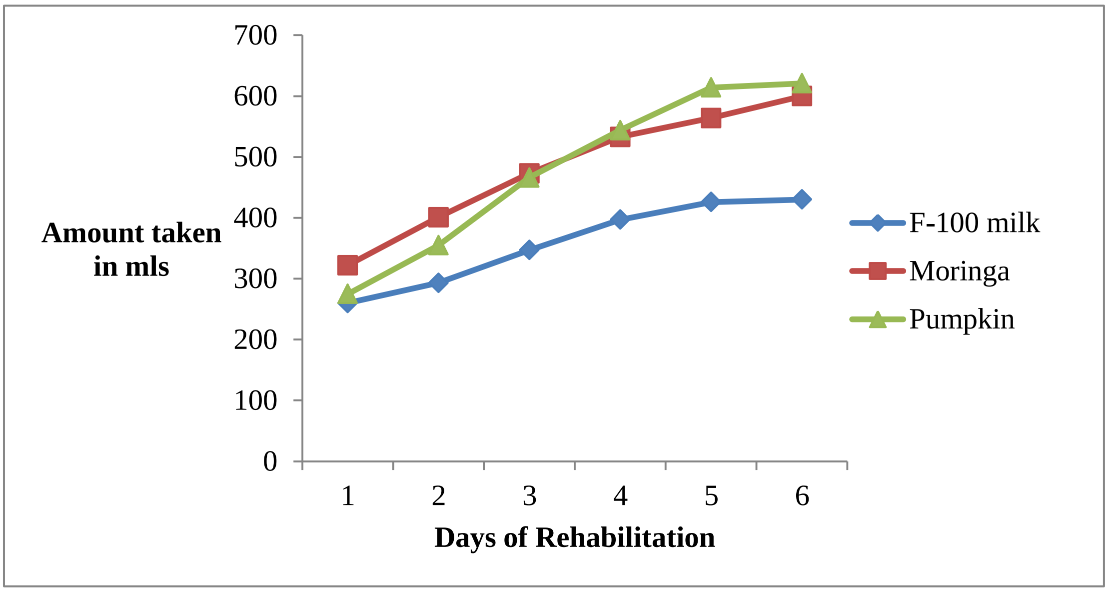

Figure 5. 1: Daily feed intakes over rehabilitation period

The superior feed intakes of the improved millet porridges over F-100 milk intake can be attributed to better palatability for the porridges compared to F-100 milk. It is therefore apparent that the porridges were more palatable than F-100 milk as demonstrated by feed intake data.

5.4.2 Nutrient intake by study children from improved millet porridges

Table 5.4 shows the average nutrient intake by the study children over the rehabilitation period. The calculated mean protein, vitamin A and zinc intakes from F-100 milk were significantly higher than from moringa and pumpkin millet porridges. However mean iron intake for moringa millet porridge was significantly higher than for the other two feeds. There was no significant difference in the energy intake per kg body weight/day derived from feeds between the three treatment groups. Children feeding on F-100 milk therefore received significantly higher protein, vitamin A and zinc compared to those feeding on moringa and pumpkin millet porridges while children feeding on moringa millet porridge received significantly higher amounts of iron.

Table 5. 4: Nutrient intake by the study children from improved millet porridges per rehabilitation group

Study feeds	Kcal/kg body weight	Protein/kg body weight	Zinc	Iron	Vitamin A
Moringa-millet	178.6±16.9a	4.7±0.3a	1.6±0.1a	9.1±0.8a	99.9±6.6a
Pumpkin-millet	157.9±12.9a	4.0±0.2a	1.1±0.1a	3.8±0.4b	78.3±7.7a
F-100 milk	188.3±13.7a	5.3±0.4b	1.9±0.1b	0.5±004b	130.8±10.8b

Intake with different superscript on the same row indicate significant statistical significance* ($p<0.05$)

5.4.3 Weight gain for the study children by feeding group

The daily weight gain per kg body weight for the study children are shown in Figure 5.2. Weight gain/kg body weightfor children feeding on F-100 milk increased rapidly to a maximum of 97.2g on the 5th day, while weight gain/kg body weight for children feeding on moringa and pumpkin millet porridges continued to increase, even on day six when majority of children were discharged. By the sixth day, weight gain per kg body weight for children fed on moringa and pumpkin millet porridges were 97 and 79% respectively of weight gain/kg body weight achieved for children fed on F-100 milk.

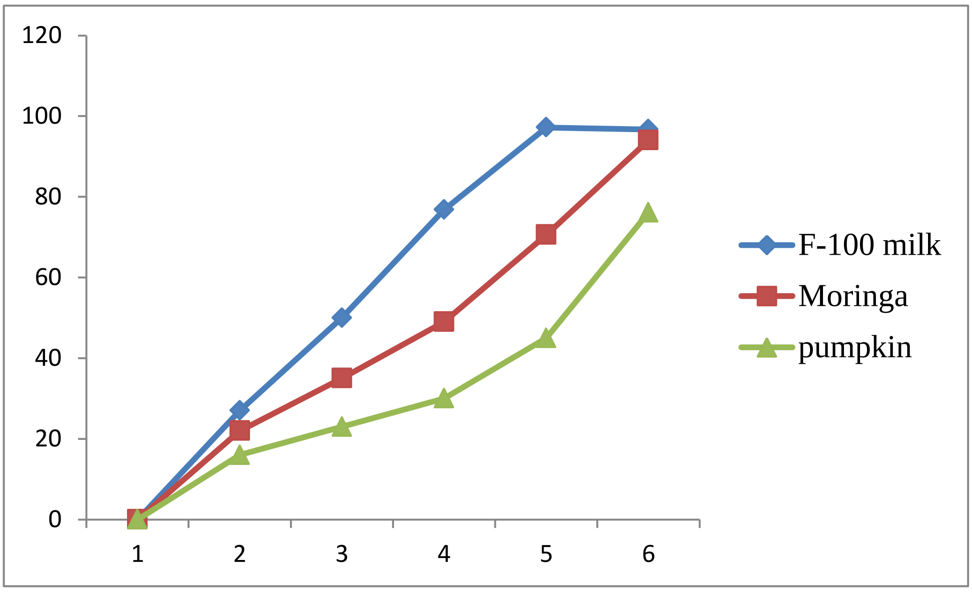

Figure 5. 2: Weight gain among study children by rehabilitation food

5.4.4 Effect of moringa and pumpkin millet porridges on haemoglobin, serum iron, zinc and vitamin A status for the study children

Table 5.5 shows the effect of feeding children on moringa, pumpkin millet porridges and F-100 milk on their haemoglobin, serum iron, zinc and retinol levels. The haemoglobin and serum micronutrient levels in children were measured twice, at the baseline before feeding them with the rations, and at the time of discharge, 5-8 days later. The mean baseline haemoglobin levels and the serum iron, zinc and vitamin A levels were below normal on admission. At the time of discharge, children fed on moringa-millet porridge had their mean haemoglobin and serum retinol levels significantly increased from 9.57-10.19g/dl and 0.55-0.69 µmol/l at p=0.02 and 0.008 respectively, but did not reach the normal. Children fed on pumpkin-millet porridge had only their mean serum retinol levels significantly increased from 0.58-0.78 µmol/l at p=0.005, but still did not reach the normal. Children fed on F-100 milk had neither their haemoglobin nor the other micronutrients significantly increased.

Table 5. 5: Effect of moringa and pumpkin improved millet porridges on haemoglobin, serum iron, zinc and vitamin A levels

Micronutrient status	F-100 milk N=25	Moringa improved (N=26)	Pumpkin improved (N=25)
Hb(Normal=11g/dl)			
Baseline	9.78±0.33	9.57±0.28	9.47±0.236
After feeding	10.0±0.29	10.19±0.30	9.68±0.26
P-value	0.374	**0.017**	0.374
Iron (Normal= 9µmol/l)			
Baseline	8.36±1.38	7.31±0.85	8.91±1.27
After feeding	6.91±1.06	8.98±1.20	7.22±0.87
P-value	0.35	0.14	0.17
Zinc (Normal=10µmol/l)			
Baseline	9.20±0.4	9.06±0.65	9.16±0.89
After feeding	9.52±1.3	9.16± 1.02	9.48±1.27
P-value	0.80	0.3	0.8
Retinol (Normal=0.8 µmol/l)			
Baseline	0.67±0.04	0.55±0.04	0.58±0.04
After feeding	0.77±0.06	0.69±0.06	0.78±0.09
P-value	0.14	**0.008**	**0.005**

Hb= Haemoglobin. P-value (Determined by paired t-test); Baseline = before feeding trials

5.4.5 Disease incidences during the study period

Table 5.6 below shows the prevailing sicknesses among children during the rehabilitation period. Although fever was slightly more frequent than other sicknesses, there was no significant difference in morbidity experienced between children fed on F-100 milk and those fed on moringa and pumpkin millet porridges. Children in all the three groups were free from unhealthy clinical condition at the time of discharge.

Table 5. 6: Disease incidences during study period

Illness	F-100 milk	Pumpkin	Moringa	P-value
Diarrhoea	8% (2)	4% (1)	3.8% (1)	NS
Respiratory infections	8% (2)	8% (2)	3.8% (1)	NS
Fever	12% (3)	12% (3)	7.6% (2)	NS

NS= Not significantly different ($p>0.05$)

5.4.6 Nutritional status of study children per rehabilitation feed

Table 5.7 shows percentage of study children who progressed from severe to moderate and normal states and those who remained in severe states of malnutrition within the seven days of rehabilitation. After 5-6 days of rehabilitation, 20.8% of children fed on F-100 milk were able to improve from severe states to moderate malnutrition, 23.1% to normal and 56.1% remained severely malnourished. The percentage improvement of children fed on moringa and pumpkin millet porridges compared to those fed on F-100 milk was 81 and 80% respectively.

The mean WHZ scores improved from -3.2±0.46 to -2.28±0.26 ($p=0.048$) for children fed on F-100 milk while for those fed on moringa - millet and pumpkin - millet porridge it improved from -3.4±0.43 to -2.02±0.57 ($p=0.054$) and from -3.4±0.69 to -2.0±0.28 ($p=0.057$) respectively. Children who were still severely malnourished were given Ready to Use Therapeutic Feeds (RUTF) at discharge and required to come after two weeks for follow up in the Outpatient clinic (OTC). It is therefore clear that moringa and pumpkin millet porridges were equally effective in the rehabilitation of children with SAM since there was no significant difference in improved nutritional status when compared with the control of F-100 milk.

Table 5. 7: Nutritional status of study children per rehabilitation group

Nutritional status	F-100 milk N = 25	Moringa-millet N = 26	Pumpkin-millet N = 25
Baseline			
Severe (<-3 Z score)	100	100	100
End			
Moderate (≤-2Z≥-3 Z score)	20.8	24.0	24.0
Normal (≥-2Zscores)	23.1	11.6	11.5
Severe (<-3 Z score)	56.1	64.4	64.5

Baseline = before feeding trials; End = after feeding trials

5.4.7 Discharge rate for children during rehabilitation period

Figure 5.3 shows the rate of discharge of children during rehabilitation. Majority of the children were discharged after six days of rehabilitation. By day six, all children fed on F-100 milk were discharged while only 97 and 92% of children fed on moringa and pumpkin millet porridges respectively were discharged. The rate of convalscence for the sick is critical and significant in assessing efficacy of a therapeutic treatment. Accordingly it can be deduced that experimental porridges had 92-97% efficacy compared F-100 milk, the hospital preparation.

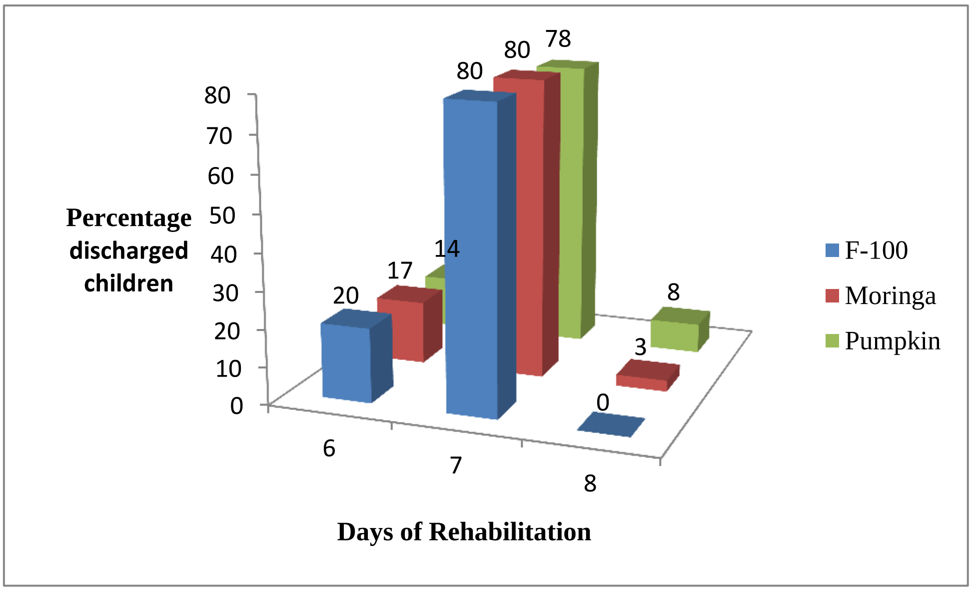

Figure 5. 3: Discharge rate from the Nutrition Rehabilitation Unit

5.5 Discussions

5.5.1 Feed intake among study children

Intakes for pumpkin and moringa millet porridges were significantly higher than for F-100 milk. This can be attributed to familiarity with the products and palatability due to a sweet sour taste from lactic fermentation and the sweetening. Given the acceptability of the porridges by severely malnourished children, they can therefore be easily adopted as complementary feeds to avoid relapse of malnutrition conditions after children are discharged from rehabilitation units. This could help reduce on rehabilitation costs and the inconviniences experienced by families due to separation from their homes while attending to children during rehabitation in nutrition units. Feed intake for children fed on pumpkin millet porridge increased at a slightly higher rate than for other feeds and this promoted recovery.

5.5.2 Nutrient intake among study children

All groups received adequate amounts of energy basing on WHO recommendations of a daily energy intake of 150-220 kcal /kg body weight. The daily protein intake of 4.7g and 4g for children fed on moringa and pumpkin millet porridges was significantly lower than for children fed on F-100 mil,k but met WHO's recommendations of 4-6g of daily protein intake per kg body /day for severely malnourished children undergoing rehabilitation (Ashworth, 2003). The daily protein intake derived from the improved millet porridges in this study were higher than for a study using tempeh-yellow maize porridge and milk yellow maize porridge for rehabilitation of malnourished children, where the mean daily protein per kilogram/ body weight was 3.4g and 3.9 respectively (Kalavi et al., 1996)

5.5.3 Effect of moringa and pumpkin millet porridges on nutritional status of children

Though the average daily feed intake for F-100 milk was lower compared to the improved millet porridges, the average weight gain /kg body weight increased drastically for children fed on F-100 milk compared with the experimental groups.

The high feed intakes for moringa and pumpkin millet porridges did not translate to quick recovery as measured by weight gain when compared to F-100 milk. F-100 milk was therefore better for recovery, when the body's deficit for energy and nutrients is high. Moringa millet porridges performed better than pumpkin millet porridges. This was because of increased solid matter in moringa millet porridges compared to pumpkin millet porridges. This occurred after the porridges were adjusted to the acceptable viscosity.

The weight gain/kg body weight/day in all groups was within World Health Organisation recommendations of 10-20g/kg body weght (Ashworth, 2003). Apart from improved protein, vitamin A, iron and zinc content in moringa and pumpkin millet porridges, significant improvements in weight among these childen could also be attributed to the reported enhanced digestibility of starch and protein as a result of lactic acid fermentation (Onyango et al., 2005, Thierry et al., 2013). Use of moringa powders in millet could also have promoted protein utilisation in the body system of these malnourished children since digestibility of proteins in moringa powder is reported to be close to 60% (Zongo et al., 2013).

Fermented yellow maize and millet, supplemented with moringa powder have also been reported to improve the nutritional status of preschool children (Arise et al., 2014). An interventional study among severely malnourished children with moringa as a supplement in porridge registered a weight gain of 8.9±4.3g/kg body weight /day in 36±16.54 days compared with the control which had no moringa supplement, where the weight gain /kg body weight/day was 5.7±2.7g (Zongo et al., 2013). These results support the the use of moringa powders in the fight against malnutrition (Yang et al., 2006).

5.5.4 Effect of moringa and pumpkin improved millet porridges on serum zinc, retinol, iron and haemoglobin levels

Mean serum zinc, retinol, iron and haemoglobin levels for the children fed on moringa and pumpkin porridges and F-100 milk were below normal even after the feeding trials. This was because of the short time frame. However children feeding on moringa and pumpkin millet porridge significantly improved in their serum retinol levels. While only children fed on moringa millet improved in their haemoglobin levels. These results compare well with those where addition of moringa leaf powders combined with lactic acid fermentation in yellow maize (*Zea mays*) and soybean (*Glycine max*) blend, improved haemoglobin levels, minerals and vitamins in infants aged 6-12 months (Odinakachukwu et al., 2014). Moringa has also been effective in improving vitamin A status in depleted rats (Thurber and Fahey, 2009). Reduction in infections could also have contributed to the improved vitamin A status since infections lower vitamin A levels (Black et al., 2008). Increased bioavailability of minerals and vitamins reported in lactic acid fermented foods could also have contributed to the increased haemoglobin levels (Thierry et al., 2013). Failure of children fed on F-100 milk to significantly increase in their serum retinol levels can be attributed to the short period of rehabilitation compared to those fed on moringa and pumpkin millet porridges.

5.5.5 Discharge rate from the rehabilitation unit

The porridges were found to be 92-97% efficacous basing on 100% for F-100 milk. This implicated both F-100 milk and moringa and pumpkin millet porridges as being effective in rehabilitating children with SAM. Such progress is attributed to the palatability of the porridges that resulted in increased protein, vitamin A, iron and zinc intake by children on improved millet porridges. Adding 7% moringa leaf powder and 17% pumpkin flesh powder combined with lactic acid fermentation promoted not only the flavour and taste but also the improved performance of millet porridges because of increased nutrient intake due to blending of foods, enhanced bioavailability due to fermentation and the antioxidant properties of moringa leaves and pumpkin flesh powders. The children were able to be rehabilitated within an interval of 5-8 days since severe acute malnutrition is sensitive to rapid changes in food supply and nutrient intake (Zongo et al., 2013).

5.6 Conclusions

Moringa and pumpkin millet porridges were palatable even among malnourished children and were able to rehabilitate children with severe acute malnutrition reasonably well when compared with the hospital ration in a cost effective manner.

5.7 Recommendations

The porridges are therefore effective in handling malnutrition and can therefore be relied upon to avoid relapses in malnutrition conditions after children are discharged from rehabilitation centres. This would reduce on the inconviniences caused by separation of caretakers from their families when attending to their children in rehabilitation units. There is however need to evaluate the the technology involved in the production of these porridges to assess how easily it can be adopted by mothers/caretakers in the communities.

CHAPTER 6: NUTRITIONAL PERFORMANCE OF IMPROVED MILLET PORRIDGES AMONG MODERATELY MALNOURISHED CHILDREN

6.1 Introduction

Moderate malnutrition has been a persistent problem in Western Uganda. Current Uganda Demographic and health Surveys indicate the Western region of Uganda as having a very high stunting rate of 45% among children under five years, only surpassed by Karamoja region at 46%. Baseline studies done also indicated wasting levels of 7.4% in Bujenje County compared to the national one of 5% among children under five years. Mothers/caretakers are disempowered to do anything about it because of lack of knowledge, skills and complementary feed technology to fight malnutrition. There is rampant use of millet porridges with their poor nutritional perfomance. Continued use of these traditional millet porridges leads to an exacerbated malnourishment condition that progress rapidly to severe acute malnutrition, necessitating hospital admission for nutritional rehabilitation.

The nutritional performance of moringa and pumpkin millet porridges among children with severe acute malnutrition in a hospital setting showed that they were 92-97% efficacious compared with F-100 the hospital ration used for their treatment. According to Ashworth and Ferguson (2009), the dietary management of moderate malnutrition should be based on the optimal use of locally available nutrient-dense foods to improve the nutritional status of children and prevent them from becoming clinically malnourished or failing to thrive (Ashworth and Ferguson, 2009).

The objective of this study was to evaluate the performance of improved millet porridges in the rehabilitation of moderately malnourished children among households in an intergrated approach in a community setting, as a prophylactic strategy for mitigating child malnutrition in Western Uganda.

6.1.1 General objective

The overall objective was to determine the rehabilitative value for moringa and pumpkin millet porridges among moderately malnourished children in a community setting on an integrated basis with mothers/caretakers

6.1.2 Specific objectives

i). Determine the effect of the improved millet porridges on wasting, underweight and stunting levels of moderately malnourished children.

ii). Determine the effect of the improved millet porridges on morbidity among malnourished children.

iii). Evaluate the technology uptake for the improved millet porridges by mothers/caretakers and its application.

6.1.3 Research questions

i). What is the effect of the improved millet porridges on wasting, underweight and stunting levels of moderately malnourished children?

ii). What is the effect of the improved millet porridges on morbidity among malnourished children?

iii). Are moringa and pumpkin improved millet porridges easily adoptable by mothers/caretakers in Western Uganda and effective as complementary feeds for children?

6.2 Literature review

6.2.1 Dietetic management of moderate malnutrition in children

There are different approaches to addressing malnutrition with prepared foods for example, improved local diets, blended food supplements, complementary food supplements, providing lipid-based nutrient supplements either a full daily dose or in a low dose as a complement to the usual diet (Lazzerini et al., 2013). WHO advocates for supplementary feeding for moderately wasted children only in emergency situations while nutrition counselling is recommended on the assumption that nutritious food is available, but also that caretakers do not have sufficient awareness on how to combine foods into appropriate diets for malnourished children or at-risk children (Annan et al., 2014). Breastfeeding promotion and support and nutritional adequacy of the diet are principles of nutritional management for malnutrition (WHO, 2012). Table 6.1 shows a selection of the proposed Recommmended Nutrient Intakes for moderately malnourished children by Golden, Schofield and Huffman (2009).

Table 6. 1: Proposed Recommended Nutrient Intake (RNI) for moderately malnourished children living in poor environments expressed as nutrient energy densities (amount of nutrient/1000 kcal)

Nutrient	Unit	Locally available foods	Specially formulated foods
Protein	g	24	26
Vitamin A	µg	960	1900
Iron	mg	9	18
Zinc	mg	13	20

6.3 Study design and methods

The design was controlled, interventional and longitudinal in nature, involving moderately malnourished children in the three villages of Bujenje County namely Ntooma, Karongo and Kiryamyongo. Children in Ntooma village were supplied with millet porridge flours as control while those in Karongo and Kiryamyongo were supplied with moringa and pumpkin millet flours respectively as experimental porridges. Choice of the feeds for villages was influenced by baseline findings concerning common raw materials and use of fermented foods.

6.3.1 Sample size determination

The sample size was calculated according to the formula $n = Z^2pq/d^{2,}$ where:

n = sample size

P = prevalence of moderate wasting among children under five years in Bujenje County at baseline = 5.4%.

q = 1-p = proportion of moderately wasted children = 94.6%

d = error of assumption = 5%

z = normal distribution at 95% confidence interval (1.96)

An attrition factor of 15% was included making the final sample size of 93 moderately wasted children.

6.3.2 Admission criteria

The inclusion criteria for selection of study children from households in the villages were:

a) Age of 7 to 23 months
b) Breastfeeding children
c) Moderately wasted with MUAC of 11.5-< 12.5 cm (Red colour)
d) Voluntary written consent from parents/guardians.
e) Absence of congenital abnormalities and other medical conditions.

6.3.3 Characteristics of study children and their households

The characteristics of study children and their household members in the rehabilitation groups are shown in Table 6.2. The characteristics were not different at $p<0.05$.

Table 6. 2: Baseline characteristics of study children and their households

Variable	Traditional millet N=32	Moringa millet N=30	Pumpkin millet N=31	P-value
Vitamin A supplementation	36.6	40.7	39.2	NS
Sex				
Male	50	59.3	38.5	NS
Female	50	40.7	61.5	
Fully immunised	12	14	12	NS
Age	17.9±1.7	19.2±1.7	18.3±1.6	NS
Nutritional status				
WAZ	-1.5±0.1	-1.7±0.2	-1.8±0.2	NS
HAZ	0.2±0.05	-0.4±0.03	-0.3±0.003	NS
WHZ	-2.3±0.09	-2.2±0.09	-2.2±0.06	NS
Maternal age	26.5±1.6	26.2±1.4	26.1±1.1	NS
Total family income	95,400± 20,250	93,900± 25,050	93,700± 28,020	NS
Number of children <5 years	2.81±0.4	2.51±0.3	2.9±0.4	NS
Mother's education				
No formal education	7.7	18.5	3.8	
Primary	80.8	70.4	88.5	NS
Secondary	11.5	11.1	7.7	
Father's occupation				
Salaried employment	7.7	3.7	2.0	
Non salaried employment	87.6	92.6	90.3	NS
Not employed	4.7	3.7	7.7	

6.3.4 Production of millet-based porridges

A month before the intervention, mothers converged in demonstration centres to be equiped with knowledge and skills for production of porridge flours, their preparation, cooking and service. Participatory demonstrations were conducted on the production of traditional millet porridge flours and moringa and pumpkin millet porridge flours. Mothers carried out the basic production processes of cleaning, cutting and slicing of pumpkins and drying of pumpkin flesh, moringa leaves and fermented flours under supervised guidance. The processes were done as indicated in Figure 4.1 apart from the drying of the porridge flours which was done by solar. Mothers prepared the porridges in groups based on the villages and their children's age. Consesus was made concerning the ratio of flour solids to water. The solid matter in all porridges also varied depending on the age of a child and the type of porridge (Table 6.3) The prepared porridges were tasted to determine acceptability by mothers and children. Hygiene during processing, cooking and serving of the porridges was encouraged by emphasizing washing of hands, cooking and serving utensils with water and soap, and drying of flours on clean mats.

After every two weeks, mothers converged in the village centres to prepare the porridge flours in supervised groups. The porridge flours produced were stored in a general pool and distributed to mothers on a one week interval. During the meetings, experiences of feeding children on these porridges were shared.

6.3.5 Feeding program for study children

Table 6.3 shows the number of servings, amount of solids in each porridge serving and the total porridge flours that were given on a weekly basis to the mother/caretaker. Children aged 7-8 months were fed 4 times while those aged 9-23 months were fed 3 times a day. The frequency of feeding was governed by WHO recommendations and mothers experiences concerning feeding children on these porridges. The amount of solid matter in the porridges varied from 15g to 40g in 150mls to 300mls feed depending on the age of the child and the type of porridge to be given. Amounts of 1000-2000g porridge flours were distributed weekly basing on

Table 6. 3: Feeding program for the study children

Variable	7-8 months	9-11 months	12-24 months
Serving			
Number of servings	4	3	3
Amount of serving	150 mls	200 mls	300 mls
Amount of solids per serving			
Traditional millet	15 g	20 g	30 g
Pumpkin- millet	18 g	25 g	35 g
Moringa- millet	20 g	30 g	40 g
Amount of flour given/week			
Traditionalmillet	1000g	1500g	2000g
Pumpkin- millet	1000g	1500g	2000g
Moringa- millet	1000g	1500g	2000g

the age and village children came from, but in all cases additional flours were given since there was bound to be sharing at home. Mothers were given standard cups for measurement. The following key points were emphasized during the meetings.

- Continued breastfeeding up to atleast two years.
- Taking children for health days.
- Reporting sicknesses to health centres.
- Giving porridges to children after breastfeeding.
- Hygienic handling of equipment for service of feeds.
- Serving children other foods in addition to the porridges.

The feed intakes and micronutrients derived from the porridges were measured and calculated.

6.3.6 Methods of assessment

6.3.6.1 Nutritional performance of millet-based porridges

Feeding trials were carried out for four months. Follow up visits were done to assess,

- Compliancy on home-based preparation of the porridges and the experience of feeding the porridges to children.
- Assessment of weight gain for the study children.
- Intakes of protein, kilocalorie, iron, zinc and vitamin A in children basing on mothers/caretakers reports on feed intake and records of feeds given to children for literate mothers.
- Disease morbidity whereby reported incidences of diseases such as malaria and diarrhoea episodes were recorded.

Mothers/caretakers visited the centres on a two weekly basis to produce more porridge flours and to have their children monitored. Children were monitored by measuring their weight, height and recording amounts of feeds given. Disease incidences and health seeking habits were also recorded (Appendix 7). Subsequent results during the intervention were compared to assess the effect of feeding on each of the porridges on the nutritional and morbidity status of children.

6.3.6.2 Anthropometric measurements

Anthropometric measurements (standing height/ length and weight) were taken using calibrated equipment and standardized techniques (Lohman et al., 1998). Age was determined basing on mothers /caretakers reports and verified using the child health clinic card. Nutritional status indices for height for age (HAZ) and weight for age (WAZ) and weight for height (WHZ) were calculated using ENA for SMART 2010 software and interpreted using WHO 2006 reference standards.

6.3.7 Data processing

Data was entered, cleaned and analyzed using SPSS (Statistical Package for Social Scientists) version 20.0 for windows (*SPSS, Inc., ChicagoIL*). Analysis of Variance (ANOVA) and chi-square tests were used to determine the effect of interventions on disease morbidity and nutritional status of children being rehabilitated. In all cases a p-value of <0.05 was considered significant.

6.3.8 Ethical clearance

The design and ethics of the study was reviewed and cleared by The Aids Support Organisation (TASO) internal review board (TASOIRC/029/13-UG-IRC-009), and then approved by the Uganda National Council of Science and Technology (HS 1315). Informed consent from children caregivers/mothers was given by signing a form (Appendix 7).

6.4 Results

6.4.1 Feed intake during the rehabilitation period

The calculated feed intakes for moringa and pumpkin millet porridges were higher than for traditional millet porridge (Figure 6.1). Moringa and pumpkin millet porridges were therefore more palatable than the traditional millet porridge.

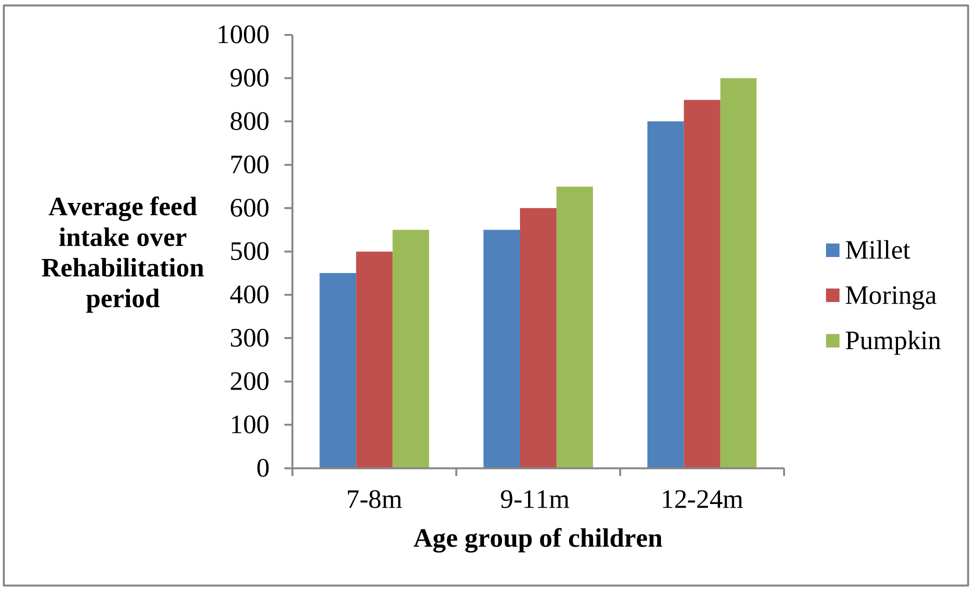

Figure 6. 1: Average porridge intakes per rehabilitation group

6.4.2 Energy, protein, vitamin A, iron and zinc intakes from porridges per rehabilitation group

Energy and protein intakes per kilogram body weight was higher among children fed on moringa and pumpkin millet porridges than those fed on traditional millet porridge (Table 6.4). The average daily kilocalorie, protein, iron, zinc and vitamin A intakes from moringa and pumpkin millet porridges were also significantly higher than for traditional millet porridges. Moringa millet porridge had the best overall nutrient intake.

Table 6. 4: Average daily nutrient intake from porridges per the rehabilitation group

Variable	7-8 months	9-12 months	13-24 months
Kilocalorie intake/kg/day			
Traditional millet	57.6	58	60.1
Pumpkin millet	71.8	73.6	75.2
Moringa millet	76.6	79	80.1
Recommended*	83	89	86
Protein (g)/kg/day			
Traditional millet	0.81	0.90	1.0
Pumpkin millet	1.75	1.85	1.86
Moringa millet	1.79	1.79	2.09
Recommended*	1	0.87	0.87
Kilocalorie			
Traditional millet	169.7 (85%)	207.4 (69%)	350.4 (64%)
Pumpkin millet	240.9 (>100%)	284.7 (95%)	394.2 (72%)
Moringa millet	250 (>100%)	300 (100%)	425.0 (77%)
Protein (g)			
Traditional millet	4.1 g (45%)	5.0 g (52%)	7.2 g (66%)
Pumpkin millet	6.6 g (73%)	7.8 g (81%)	10.8 (99%)
Moringa millet	7.0 g (78%)	8.4 g (92%)	11.9 g (>100)
Vitamin A (µg)			
Traditional millet	0 (0%)	0 (0%)	0 (0%)
Pumpkin millet	205.7(82%)	243.1 (81%)	336.6 (84%)
Moringa millet	221.5 (89%)	265.8 (89%)	376.6 (94%)
Iron (mg)			
Traditional millet	4.5 (41%)	5.5 (50%)	8 (73%)
Pumpkin millet	6.7 (61%)	7.8 (71%)	10.8 (98%)
Moringa millet	12 (>100%)	14.4 (>100%)	20.4 (>100)
Zinc (mg)			
Traditional millet	0.9 (32%)	1.1 (39%)	1.6 (57%)
Pumpkin millet	1.7 (61%)	2.0 mg (70%)	2.7 (99%)
Moringa millet	2.0 (72%)	2.4 mg	3.4 mg>100%

Iron =Assuming medium iron bioavailability (10%). Zinc = Assuming moderate bioavailability (30%)
RNI Reference: World Health Organisations Recommendations (Dewey and Brown, 2002, Ruel et al., 2004).
Numbers in brackets represent % RNI met.
Recommendation for children with normal nutritional status*: (Dalmau et al., 2015, Dewey and Brown, 2002).

Moringa and pumpkin millet porridges were able to meet >60% daily RNI for energy, protein, vitamin A, iron and zinc. Traditional millet porridges could not meet >60% RNI for vitamin A and zinc. Moringa and pumpkin millet porridges therefore have the potential of catering for the energy, protein, vitamin A, iron and zinc requirements of children aged 7-24 months unlike the traditional millet porridges.

The energy intake per body weight for all children were below the recommended for children with normal nutritional status while the protein intake per body weight in experimental groups were above the recommendations for children with normal nutritional status.

6.4.3 Morbidity status during the rehabilitation period

Table 6.5 shows disease incidences during the study period. Diarrhoea incidences were significantly less reported among children feeding on moringa and pumpkin millet porridges (p=0.006). Respiratory infections were only significantly less reported among children feeding on moringa millet porridge (p=0.003). The health seeking habbits of all rehabilitation groups were not significantly different.

Table 6. 5: Morbidity statusduring the rehabilitation period

Disease condition	Millet porridge	Moringa-millet porridge	Pumpkin-millet porridge	P-value
Diarrhoea	5.9±0.93	3.08±0.56	2.9±0.61	**0.006**
Malaria	4.0±0.80	3.8±0.61	4.8±0.80	0.646
Respiratory infections	5.5±0.53	3.6±0.38	6.0±0.54	**0.003**

Children fed on moringa and pumpkin millet porridges therefore had less reported incidences of diarrhoea while only those fed on moringa millet porridge had less reported incidences of respiratory infections

6.4.4 Percentage prevalence of wasting during the feeding trials

Figure 6.2 shows the percentage of wasted children from the time of recruitment to the end of the rehabilitation period. All children recruited were moderately wasted at the beginning. Wasting levels reduced very fast in the first 2 weeks. The change was significantly higher among children fed on moringa and pumpkin millet porridges compared to children fed on traditional millet porridge. By the 6th week, none of the children feeding on moringa and pumpkin millet porridges was wasted, while 26% of the children fed on traditional millet porridges were still wasted. By the end of the feeding trials, 7.2% of the children fed on the traditional millet porridges were still wasted while none of those fed on moringa and pumpkin millet porridge was wasted.

There was no significant difference in the changes in wasting among children fed on moringa and pumpkin millet porridge.

Moringa and pumpkin millet porridges are therefore more effective in addressing wasting among children compared to the traditional millet porridges.

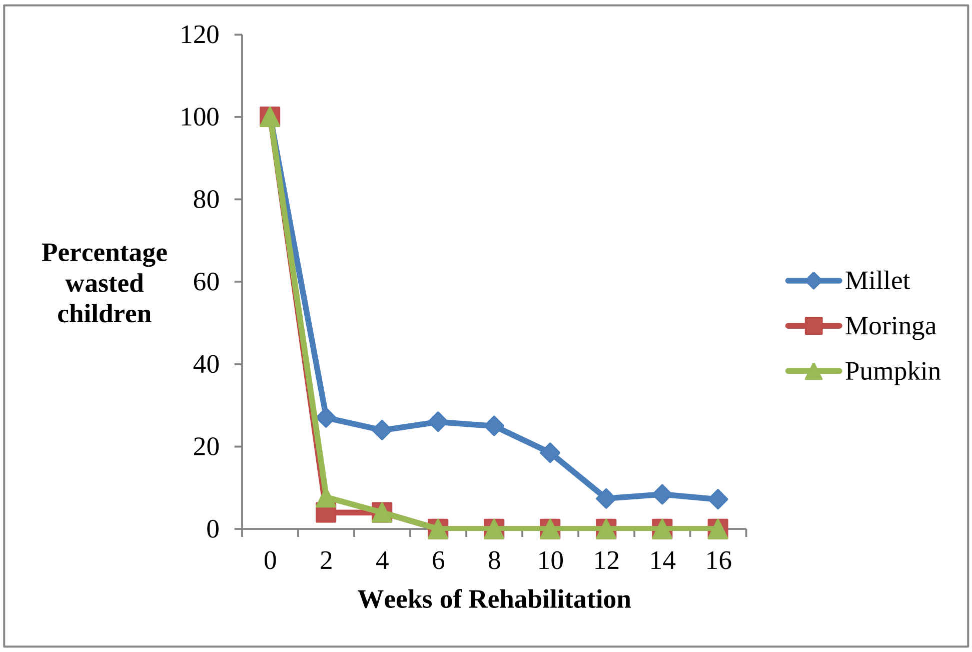

Figure 6. 2: Percentage prevalence of wasting during the rehabilitation period

6.4.5 Trends in underweight during the rehabilitation period

The percentage of children who were underweight from the start to the end of the study are shown in Figure 6.2. Fifty percent of children fed on moringa and pumpkin millet porridges and 40% of children fed on the traditional millet porridge were underweight at the beginning of rehabilitation. The percentage of underweight children in all feeding groups reduced very fast in the first four weeks. It continued reducing among children fed on moringa and pumpkin millet porridge until week 12 when it was no more existent.

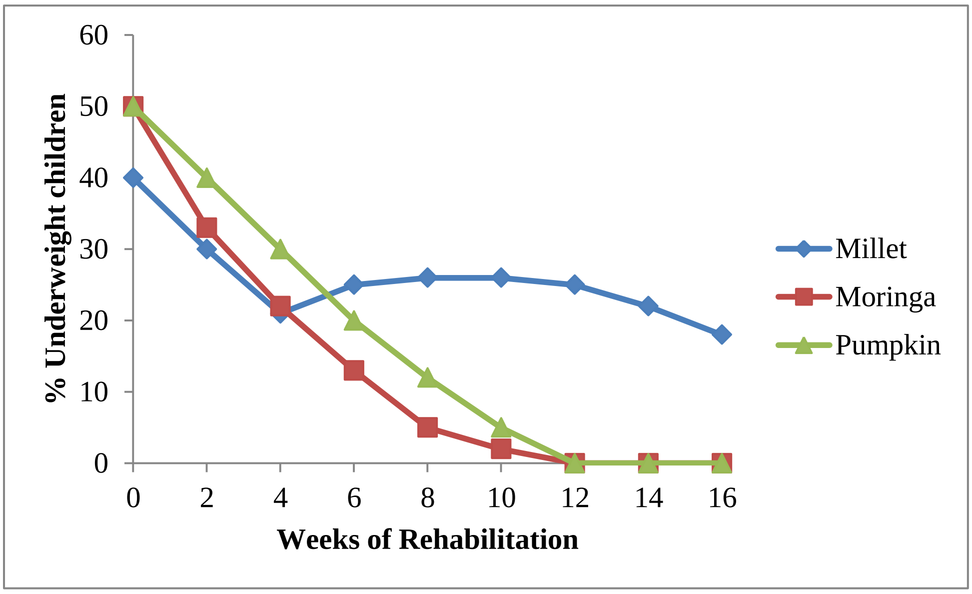

Figure 6. 3: Percentage prevalence of underweight during rehabilitation period

There was no significant difference between % changes in underweight among children fed on moringa and pumpkin millet porridge. Though the prevalence of underweight among children fed on the traditional millet porridge reduced very first in the beginning, it stablised gradually after the 4thweek. After the 12th week, it began to decline slowly up to the end. By the 12th week, none of the children fed on moringa and pumpkin millet porridges was underweight while 25% of the children fed on the traditional millet porridge were still underweight. About 20% of the children fed on the traditional millet porridge were still underweight at the end of the rehabilitation period. Children fed on moringa and pumpkin millet porridges consistently improved in underweight levels unlike those fed on the traditional millet porridge. Moringa and pumpkin porridges were therefore able to improve the nutritional status of the moderately malnourished children on the basis of their underweight status.

6.4.6 Changes in HAZ scores during the rehabilitation period

Figure 6.3 shows the stunting levels of children from the time of recruitment to the end of the rehabilitation period. At the beginning of rehabilitation, all recruited children had normal HAZ scores though very low. The mean HAZ scores for children fed on the traditional millet porridge, moringa and pumpkin millet porridge at the beginning were -0.2, -0.4 and -0.3 respectively but not significantly different. Mean HAZ scores for children fed on moringa and pumpkin porridges gradually improved up to 1.4 and 1.0 HAZ scores respectively. HAZ scores for children fed on the traditional millet porridges, gradually stabilised up to -0.6 and they still remained within in the normal range.

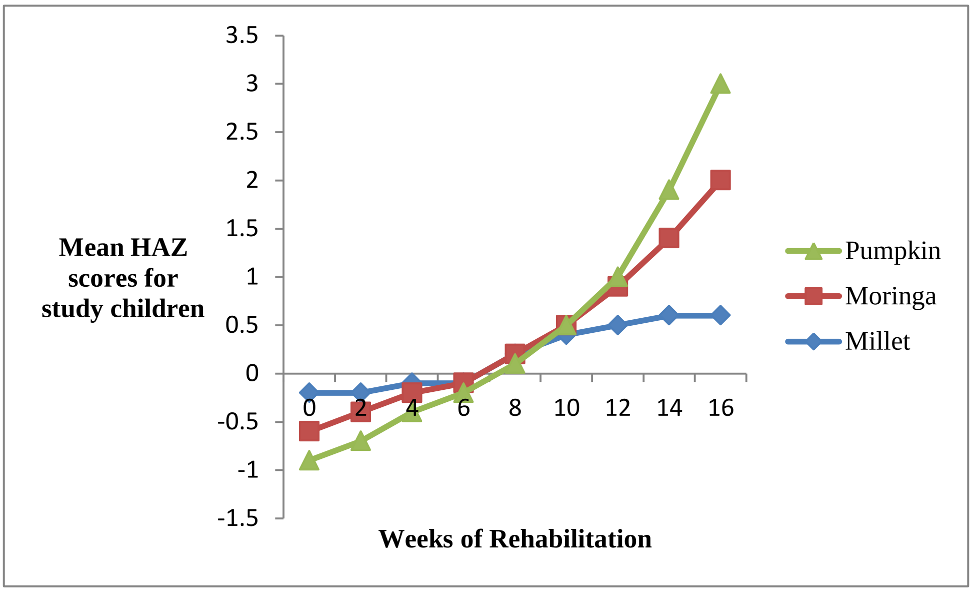

Figure 6. 4:Changes in HAZ scores during rehabilitation period

By the end of the rehabilitation period, children fed on moringa and pumpkin millet porridges had better HAZ scores compared to children fed on the traditional millet porridges. Moringa and pumpkin millet porridges can therefore prevent stunting among children.

6.5 Discussions

6.5.1 Feed intake among study children

There was higher consumption of moringa and pumpkin millet porridges compared to traditional millet porridges. Palatability of moringa and pumpkin millet porridges is due to the flavour and taste contributed by fermentation (Lei, 2006). Such increased intakes resulted in a higher percentage nutrient intake for energy, protein, iron, vitamin A and zinc being met, thus reducing any deficit in nutrient intake among children compared to those who fed traditional millet porridges. Pumpkin millet porridge registered the highest intake possibly because of being a common food in the area compared to moringa which was associated mainly with herbal medicine. Such high intakes resulted in comparable energy, protein, vitamin A, iron and zinc intakes to those of children fed on moringa millet porridges. The nutrient intake of children fed on the traditional millet porridge was quite low compared to those fed on moringa and pumpkin millet porridges. This was because millet porridge is a bulky food. The reduced palatability of traditional millet porridges when compared to moringa and pumpkin millet porridges could also account for the gaps in nutrient intake. Improving millet flour with 17% pumpkin flesh powder and 7% moringa leaf powder combined with fermentation resulted in not only improved palatability but also increased nutrient intake and this impacted the health and nutritional status of these children. The kilocalorie intakes per body weight were slightly less than the recommended for children with normal nutritional status but fulfilled the study design target of atleast 60% RNI. The protein intake per body weight for children fed on moringa and pumpkin millet porridges were higher than the recommmended for normal children (with >-2 z score). This is quite a positive achievement given the increased need for body repair and buiding up of immunity during this state of malnutrition.

Children fed on the traditional millet porridges had big gaps in meeting their protein and micronutrient requirements. The biggest gaps were among children aged 7-12 months. This was because of high nutrient requirements and yet millet porridge is a bulky food. Deficiences in protein, vitamin A, iron and zinc among children fed on traditional millet porridges even with supervised feeding, pose a challenge of inability of millet porridges to serve as a complementary food for children especially during this critical stage of growth and development. Deficiencies in these micronutrients have serious health implications in children in the long run and must be addressed.

6.5.2 Effect of improved millet porridges on nutritional status of rehabilitated children

Reduction in wasting and underweight, and improvements in HAZ scores after feeding with moringa and pumpkin millet porridge demonstrates how simple technologies like fermentation combined with biofortification with nutrient rich locally available local food materials can improve child nutritional status.Wasting levels reduced earlier since wasting is normally caused by current inadequacies in food intake and or diseases causing loss of weight and onset of malnutrition within few days and it responds very fast to treatment (Zongo et al., 2013). Underweight takes into account both chronic and acute forms and responded after a slightly longer time compared to wasting. The percentage prevalence of underweight among children fed on the traditional millet porridge kept on flunctuating and this was influenced by frequent infections especially diarrhoea.

This research finding is comparable to a study in South Africa by Glatthaar et al. (1986), where underweight levels in children failed to improve when moderately wasted children were fed for 3 months on porridges which were thickened, and sugar and oil added. Diarrhoea in Uganda is associated with a decrease in dietary intake of 40-50% lower for energy and protein intakes and impacts weight negatively (FANTA-2, 2010). High prevalence of diarrhoea could also partly explain the worsening HAZ scores among children fed on the traditional millet porridge. Such high diarrhoea incidences cannot allow linear growth to recover.

Both lactic acid fermentation and moringa leaf powder have been shown to be effective in the fight against malnutrition. Fermented yellow maize and millet supplemented with moringa oleifera powder have been shown to have the potential of improving the nutritional status by curbing PEM (Arise et al., 2014). Addition of moringa *oleifera* leaf powders combined with lactic acid fermentation in yellow maize (Zea mays) and soybean (Glycine max) blend has been reported to improve weight and length in infants aged 6-12 months by Odinakachukwu et al. (2014).

6.5.3 Effect of improved millet porridges on morbidity status of rehabilitated children

Incidences of diarrhoea and respiratory infections were common among children feeding on the traditional millet porridge compared to those fed on moringa and pumpkin millet porridges. This was because of the vulnerability of this age group to infections especially dirrhoea. Antimicrobial properties against *E.coli*, *S. aureus, S. shiga* and *S. Typhi* detected in the moringa and pumpkin millet porridges could have played a role in the prevention of diarrhoea among children feeding on these porridges. *Moringa oleifera* and pumpkin have been reported to have antioxidant properties and such a property could be antimicrobial and help the body to resist infections (Compaore et al., 2011, Fahey, 2005, Usha et al., 2010). The results can also be compared to an interventional study in Burkina Faso using 10g *Moringa oleifera* leaves powder as a supplement in porridges that resulted in low diarrhoea episodes of 7.8% against the control of 80.3% without moringa supplement (Zongo et al., 2013). Results in this rehabilitation study support the fact that functional foods with good amounts of micronutrients and phytochemical compounds can be developed with beneficial impact on health and mitigate against malnutrition among children (Yang et al., 2006).

6.5.4 Technology uptake by mothers/caretakers

The raw materials for these porridge flours were locally available and this motivated mothers in learning about the technology. Mothers/caretakers were involved in the processing of their own porridges and feeding them to their children. This promoted understanding of the improved millet porridges technology and ensure a sustainable solution for mitigation of malnutrition in Western Uganda. However, there was a challenge in drying the porridge flours which would have to be addressed.

6.6 Conclusions

Moringa and pumpkin millet porridges were able to rehabilitate moderately malnourished children by reducing on diarrhoea incidences and improving nutritional status as determined by wasting, underweight and stunting within a period of 4 months. Through involvement of mothers/caretakers, the technology for the production of the improved millet porridges were transferred to women as part of the feeding practices of children in Bujenje County of Western Uganda. The improved millet porridges can therefore be adopted by mothers/caretakers as proved appropriate complementary feeds in Western Uganda. This could provide a sustainable solution to the child malnutrition problem that has been attributed to diarrhoea and common use of traditional millet porridges in Western Uganda.

6.7 Recommendations

There is need to design locally friendly ways of drying the porridge flours to avoid the uncertainities of relying on the sunshine.

CHAPTER 7: GENERAL DISCUSSIONS

7.1 Factors responsible for malnutrition among children in Bujenje County

Persistently high stunting levels reported in Western Uganda necessitated a survey to find out the causes of child malnutrition in this area. Research findings in Bujenje County of Western Uganda indicated that percentage prevalence of stunting, underweight and wasting was unacceptably high. Diarrhoea, low levels of maternal education, use of millet porridges, health care practices and low household income were the factors that contributed to the poor nutritional status in Bujenje County. Diarrhoea contributed to stunting and underweight especially among infants. The porridges in this community were kept prepared for the whole day and such a practice could have promoted infections like diarrhoea. Infections affect dietary intake and utilization. Diarrhoea in Uganda is associated with 80 % weight faltering due to a decrease of about 40-50 % lower intake for energy and protein among children (FANTA-2, 2010).

Millet porridge contributed to underweight and stunting in children. The porridges were watery and introduced quite early to majority of children because of being affordable and available. Most malnutrition set in as soon as children were introduced to these porridges reflecting the inability of millet porridges in handling the nutrient requirements of children in this age group. Millet porridges have low nutrient density, limited amino acids and vitamin A content (Singh and Raghuvanshi, 2012) and unable to meet the high nutrient requirements for children with rapid growth and development (WHO, 2012). The digestibility of protein and starch and bioavailability of iron and zinc are reported to be affected by the high contents of phytates and tannins in millet (Onyango et al., 2005). The limited gastric capacity in children together with the shortcomings of millet porridges call for development of appropriate children's meals to meet their recommended nutrient intakes.

Lower levels of maternal education influenced the care given to children resulting in underweight and stunting. According to Girma and Ganebo (2002), educated women can utilise available resources for improving their children's feeding and health resulting in sound nutritional status. In this study, women with secondary education significantly immunised, de-wormed and gave vitamin A supplements to their children compared to those with lower levels of education. They also had better dietary practices like meeting the recommended dietary diversity score and meal frequency. This calls for nutrition education if children's health and nutritional status is to be improved. Association of wasting and underweight with children of low socio-economic class observed in this study has also been reported in other studies (UBOS and ICF, 2012, Teshome et al., 2009). Good income helps you to afford nutritious foods, supplements and medicare care which are key to good nutritional status especially in early childhood.

Households had limited maternal education, income and access to animal products and supplements. Their children were caught up in a vicious cycle of malnutrition since caretakers were disempowered and could not do anything about their condition. This calls for an intervention to avoid the irreversible effects of malnutrition at such an early age.

7.2 Improving the nutritional value of traditional millet porridges

Traditional millet porridges had to be improved to serve as a suitable complementary food in Bujenje County. The nutritional value and safety of traditional finger millet porridges was improved with 7% *Moringa oleifera* leaf powder and 17% pumpkin *(Curcurbita maxima)* flesh powder and lactic acid fermentation. The target was to cater for atleast 60% RNI for protein, iron and zinc while maximizing vitamin A in 150-300mls of prepared porridges taken per day since traditional millet porridges lacked vitamin A. Moringa and pumpkin flesh flours had a negative impact on gelatisation of millet porridges. Such a property promoted use of more flours to improve on the viscosity of the porridges while promoting nutrient content. The property was especially vital for households in Bujenje County where low calorie and protein intake in children was attributed to dilution of finger millet porridges. Moringa improved millet porridges had the highest amounts of energy, protein, iron, vitamin A and zinc compared to pumpkin and traditional millet porridges due to its better nutrient content and viscosity properties. The porridges were more palatable than traditional millet porridges since lactic acid fermentation is reported to enhance flavour and taste in foods (Blandino et al., 2003, Lei, 2006). This was especially highly noticed in pumpkin millet porridges and could promote uptake.

Moringa and pumpkin millet porridges inhibited growth of *E. Coli*, *S.* t*yphi, S. aureus and S. shiga*. Lactic acid fermentation is reported to produce bacteriocins, hydrogen peroxide, carbon dioxide, ethanol and antibiotic like substances that inhibit growth of bacteria (Gabriel-Ajobiewe et al., 2014, Lei, 2006). Moringa leaf powder is reported to contain phytochemical compounds such as kaempferol and rutin that have antioxidant and antibiotic properties (Patel et al., 2011, Fuglie, 2005). These could also minimise growth of bacteria in the porridge. Apart from fermentation, bacteria inhibition in pumpkin improved porridges could also have been promoted by the reported phytochemicals in pumpkin (Dhiman et al., 2009). These antimicrobial properties of the moringa and pumpkin porridges justify them for use in communities like Bujenje County where high infection rate and long keeping of children's feeds have been reported (Ring and Develo, 2009). Perhaps this would reduce on the high levels of diarrhoea infections that are common during the weaning period not only in Western Uganda but also regionally as the information would be disseminated.

Increased digestibility of starch and protein and bioavailability of iron and zinc are some of the benefits of lactic fermentation that have been reported in millet and moringa fermented products (Lei, 2006, Onyango et al., 2005, Thierry et al., 2013). Moringa and pumpkin millet porridges had the potential of meeting the target point of $\geq$60% RNI for energy, protein, vitamin A, iron and zinc in children. The porridges were designed to be intergrated in the feeding practices of children aged 7-24 months and therefore could reduce child malnutrition in Western Uganda. However aspects of digestibility of macronutrients and bio-availability of vitamins and minerals in these porridges need further investigation before the porridges can be adopted as complementary feeds in Western Uganda.

7.3 Rehabilitative performance of moringa and pumpkin improved millet porridges among children with severe acute malnutrition in a hospital setting

Feed intake was high among children taking moringa and pumpkin millet porridges compared with those fed on F-100 milk. This was because the porridges were familiar to the children and the sweet sour taste from lactic acid fermentation improved their palatability. Though there was increased intake of moringa and pumpkin millet porridges compared to F-100 milk, the weight gain per kg body weight in these children was lower compared with the children fed on F-100 milk. Equally the energy and protein intake per kg body weight per day among children fed on moringa and pumpkin was lower than for those fed on F-100 milk. However they were both within WHO's recommendations of 150-220 kcal and 4-5g protein per kg body weight (WHO, 1999). F-100 milk has been specially formulated for severely malnourished children and is better for catch up growth at the onset of nutrition rehabilitation when the body's deficit for energy and nutrients is high (WHO, 1999). Moringa improved millet porridges perfomed better than pumpkin improved millet porridges because of increased solid matter in millet porridges after the porridges were adjusted in consistency. However, both groups were able to achieve WHO recommended weight gain of 10-20g per kg body weight per day (Ashworth, 2003). Moringa and pumpkin millet porridges were able to rehabilitate severely malnourished children within an interval of 5-8 days and were 92-97% efficient compared to the hospital ration of F-100 milk. This was because of increased intakes due to palatability of porridges. Mean serum zinc, retinol, iron and haemoglobin levels for the three test groups were below normal even after the feeding trials. This was because of the short time frame for the rehabilitation. Moringa and pumpkin millet porridges can therefore prevent relapses in malnutrition conditions that occur in Bujenje County after children are discharged from rehabilitation centres since they wer 92-97% effective when compared to the hospital ration (F-100 milk) used for rehabiitation.

7.4 Perfomance of moringa and pumpkin millet porridges among moderately malnourished children in Bujenje County

Moringa and pumpkin millet porridges were evaluated as complementary foods among moderately malnourished children in Western Uganda. This was meant to gauge their potential in rehabilitating moderately malnourished children in communities and the ease by which the technology involved can be intergrated into communities in Western Uganda. The porridges registered high intakes among children compared to traditional millet porridges. Such increased intakes resulted in a higher percentage RNI for energy protein, iron, vitamin A and zinc being met among children fed on these improved millet porridges compared to those fed on traditional millet porridge. Significant reductions in the percentages of wasted and underweight children and improvements in HAZ scores after feeding on moringa and pumpkin millet porridges reflect the ability of these porridges to serve as better complementary feeds compared to traditional millet porridges. Diarrhoea incidences were common among children feeding on traditional millet porridges because of the vulnerability of this age group to infections especially diarrhoea. Antimicrobial properties in the improved millet porridges contributed to the reduced diarrhoea infections among children fed on moringa and pumpkin millet porridges. This is comparable to an interventional study in Burkina Faso where supplementation with 10g moringa leaves powder resulted in comparative diarrhoea frequency of 7.8 % compared with the control of 80.3 % without moringa supplement (Zongo et al., 2013). There are also reports of antioxidants in pumpkin and moringa and these could help the body resist infections (Thierry et al., 2013, Usha et al., 2010). Mothers/caretakers were able to adopt the technology for improved millet porridges by utilising locally available resources of moringa, pumpkin and fermentation to process and feed their children porridges that resulted in reduced malnutrition levels and diarrhoea incidences.

CHAPTER 8: GENERAL CONCLUSIONS AND RECOMMENDATIONS

8.1 General conclusions

The factors contributing to the persistent problem of child malnutrition in Western Uganda were diarrhoea, low levels of maternal education, use of millet porridges, health care practices and low household income. Low levels of maternal education limited caretakers/mothers from tapping the limited available resources for promotion of their children's nutritional status and health.

Addition of 7% moringa *oleifera* leaf powder and 17% pumpkin *(Curcurbita maxima)* flesh powder in finger millet porridges combined with fermentation, and biofortification with nutrient-rich locally available materials improved the nutritional functionality and safety of millet porridges without negatively influencing their organoleptic properties and cost.

The porridges were palatable and efficacous and rehabilitated children with severe acute malnutrition well compared with the hospital ration. They were also effectively intergrated among households of Bujenje county as complementary feeds where they improved the the nutritional status of children and reduced diarrhoea incidences.

8.2 General recommendations

The porridges can be adopted for complementary feeding among children aged 7-24 months. They should also be evaluated for bioavailability of their iron and zinc and digestibility of their protein and starch. More user friendly ways of drying fermented porridge flours should be investigated to make the technology sustainable.

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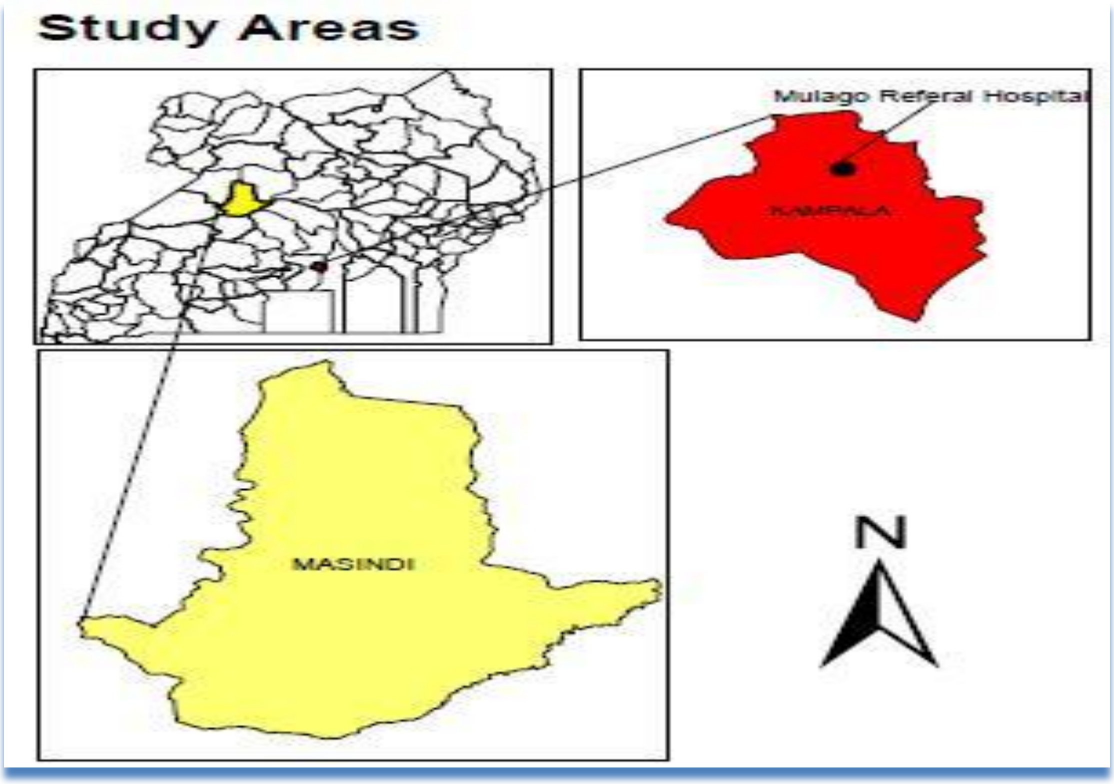
10.0 APPENDICES

Appendix 1: Study areas



Appendix 2: Factors responsible for poor nutritional status in Bujenje County of Western Uganda (Baseline questionaire)

Introduction and consent

Hello. My name is Barugahara Evyline Isingoma. I am a student at the University of Nairobi. I am carrying out a baseline survey on the nutritional status of children aged 7-36 months. You are requested to voluntarily answer the questions below and allow me to take body measurements of your child. Be assured that the data will be treated with confidentiality.

Consent form (English)

Title of the study:

Empowerment of households in Western Uganda with improved traditional millet porridges as complementary food.

Telephone: (+256) 782673038....................... ……………… **(Researcher)**

Study purpose:

Improvement of millet porridges to address nutritional and health status of preschool children in Western Uganda using moringa, pumpkin and lactic acid fermentation.

Study procedures:

On agreeing to participate in the study, I will be asked to complete an interview with a trained interviewer on the socio-economic and demographic characteristics of my household members. I will also be asked about the feeding of my child and anthropometric (body measurements) of my child will be taken. All this information will be kept confidential.

Benefits:

I will benefit from the study by obtaining some information about the nutritional status of my child. I will not be paid for participating in the study.

Risks:

No risks will be posed to my life, household members and my study child as a result of this study. I will be asked to give up 20-30 minutes while being interviewed and this may cause some inconvenience. My study child will be also be measured (height/length, weight and mid upper arm circumference) and may experience some anxiety or discomfort by taking these body measurements.

Rights to refusal or withdrawal:

My participation is entirely voluntary and I am free to take part or withdraw at any time. I may also choose to answer some or all of the questions posed.

Confidentiality:

The results of this study will be kept strictly confidential, and used only for research purposes. My name and that of my child will not appear anywhere on the coded forms with the information.

Statement of Consent/Assent

.... has described to me what is going to be done, the risks, the benefits involved and my rights regarding this study. I understand that my decision to participate in this study is voluntary. In the use of this information, my identity will be concealed. I am aware that I may withdraw at anytime. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy of this form will be provided to me.

Signature of parent or guardian ……………… Date ………………

Signature of Interviewer …………………… Date……………….

Questionnaire No………… Name of the interviewer………………...

- Date of the interview ……..
- Give information about each member of the household beginning with the head of the family

No	Sex	Age*	Marital status	Religion	Education	Occupation	Relation to the child
1							
2							
3							
4							

***Age for children should be in months**

- Mother's age……Weight (kg)…….. Height……Family residential area………. Division/zone/……. Village……………
- Mother's education: 1= No formal education, 2=some primary education 3 = Completed primary education,4 = some secondary education 5 = completed secondary education, 6 = some tertially education7 = University, 8= others (specify)
- Occupation (mother)1= Civil servant, 2= Business, 3= Casual labourer,

4=Unemployed, 5=Farming, 6=Student, 7=Not applicable 8 = others (specify)

- Education level (Father) 1= No formal education, 2=some primary education 3 = Completed primary education,4 = some secondary education

5 = completed secondary education, 6 = some tertially education

7 = University, 8= others (specify)

- Occupation (Father) 1= Civil servant, 2= Business, 3= Casual labourer,

4=Unemployed, 5=Farming, 6=Student, 7=Not applicable 8 = others (specify)

- Who takes care of the child?

1 = Mother, 2 = Father, 3= Grandparent, 4 = Uncle/aunt

5 = Sibling, 6= Cousin, 7= others (specify)

Social economic status of the family

- What is the father's average income per month?……………...
- What is the mother's average income per months?……………………….

- What is the care taker's average income (if not mother)?......................
  Circle the correct Answer
- Do you own any of the following?
  01) Radio 02) Bicycle 03) Car

- What is the type of your house roof?
  01) Grass 02) Iron sheet 03) Asbestos 04) Tiles

- What is the main source of household income? ....(**can have multiple response)**
  01) = Sales from farm produce 02) = Casual labour 03 = Formal employment
  04) =Business 05) = others (specify)……

Immunisation status

Tick corresponding box
Has your child received the following vaccines?

BCG	OPV0	DPT 1	OPV 1	DPT 2	OPV 2	DPT 3	OPV 3	Measles

Circle the corresponding answer
- Has the child ever received vitamin A supplements?
  i) Yes ii) No
- Has the child received vitamin A supplements in the last 6 months?
  i) Yes ii) No

- Has the child been de-wormed in the last 3 months? i)Yes ii) No

Disease morbidity (Circle the corresponding answer)

1. Has the child been sick in the last month? 1. Yes 2. No
2. If yes, is the treatment card available? 1. Yes 2. No
3. Has the child been breast feeding? 1. Yes 2. No

Morbidity Recall (Fill in the right answer)

Type of illness	**Number of episodes**	**Duration of illness (days)**	**Symptom**	**Source of treatment**
Malaria				
Diarrhoea				
Common cold				
Cough				
Pneumonia				
Others(specify)				

Code for symptoms and source of treatment

Symptom (multiple choices allowed)		Action taken	
1	Fever	1	Went to health facility
2	Vomiting	2	Herbal treatment
3	Running nose	3	Self medication
4	Loss of appetite	4	Faith healing
5	Weight loss	5	Others (specify)
6	Cough		
7	Wheezing		
8	Blood in the stool		
9	Difficulty in breathing		
10	Loose stool		
11	Others (specify)		

Dietary practices (Circle/Fill in the corresponding answer)

- Did you ever breastfeed? 1. Yes 2. No
- How long after birth did you put the child on the breast

1). Immediately 2).Hours 3). Days

- In the first 3days after delivery, was the child given anything to drink other than breast milk? 1.Yes 2.No
- What was the child given to drink………..
- Are you still breastfeeding? 1.Yes 2.No
- How many months did you breastfeed…..?
- How many months did you breast feed without giving anything else? (Exclusive breastfeeding)…..

- At what age did you introduce anything other than breast milk….
- Have you ever heard of fermentation? 1. Yes 2. No
- If yes, do you ferment your child's flour for porridge? 1. Yes 2. No

24-Hour child dietary diversity
Establish whether the previous day and night was normal for the child. If not select another day.

Food group consumed: What foods did the child consume in the past 24-hours (from this time yesterday to now?). Include any snacks consumed	1=yes 0=no
Type of Food	**Number**
A) Cereals and cereal products (e.g. maize, millet, spaghetti,rice,bread)	
B) Milk and milk products (e.g. cow/goat milk, fermented milk, milk powder, yoghurt)	
C) Sugar and Honey	
D) Oils/ fats (e.g. cooking fat or oil, margarine, cheese, ghee, butter)	
E) Meat, poultry,offal (e.g. goat, beef; chicken or their products)	
F) Pulses,legumes, nuts(e.g. beans, peas, sesame, groundnuts)	
G) Roots, tubers & plantain (e.g. sweet potatoes, Irish potatoes, cassava, yams, matooke)	
H) Vegetables (e.g. green leafy vegetables, tomatoes, carrots, onions)	
I) Fruits (e.g. water melons, mangoes, grapes, sweet bananas, lemons)	
J) Eggs	
K) Fish and sea foods (e.g. mukene, nkejje, nileperch tilapia, fish fillet	
L) Miscellaneous (e.g. spices, chocolates, sweets, beverages)	
TOTAL OF FOOD GROUPS	

How many feeds has the child had in the last 24 hours (from this time yesterday to now?....................

Nutritional status data
Record of the child's anthropometric data Date………….
Age (Months)…… Date of birth………………. Sex

Reg no	Weight (kg)	Weight (kg)	**Average**	Height (cm)	Height (cm)	**Average**	**MUAC**
1							
2							
3							

24- Hour recall food intake record sheet

Time	Dish	Ingred	Amount in HH Measure	volume of dish prepared	volume of food served	Amount left over	Food consumed

(Take the household measures: teaspoon, table spoon, cups, mugs, measuring jugs and the food ingredients used in the household to show the exact amounts, sizes and units used in food preparations, Request to see the measures, sizes, foods and ingredients in order to practically measure and weigh the used levels)

Appendix 3:Linear regressions

Coefficients [a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	-15.297	3.085		-4.959	.002
Millet porridge	1.498	.509	.882	2.944	.022
Did the child have diarrhoea in the last months?	4.091	1.116	1.319	3.666	.008
Education level of caretaker	1.000	.394	.765	2.538	.039
What is your income	-9.331E-6	.000	-.429	-1.568	.161
Source of treatment	.474	.345	.331	1.373	.212
Occupation of caretaker	-.352	.233	-.326	-1.507	.175
Time of complementation	1.153	.543	.457	2.122	.071
For how long did you breastfeed your child?	-.188	.071	-.896	-2.657	.033
If yes do you ferment any of yourchild's food?	2.687	.863	.905	3.115	.017

a. Dependent Variable: height for age of child

Coefficients [a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	1.881	1.365		1.378	.198
What is your income?	-7.905E-6	.000	.501	-2.344	.041
Did the child have diarrhoea in the last months?	-.692	.479	-.308	-1.444	.179
Source of treatment	-.608	.219	.586	-2.774	.020
For how long did you breastfeed your child?	.005	.031	.030	.148	.885
Millet porridge	-.070	.274	-.057	-.255	.804
Education level of caretaker	.027	.234	.029	.117	.909

a. Dependent Variable: weight for height of child

Coefficients [a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-7.321	2.081		-3.519	.010
	For how long did you breastfeed your child?	-.122	.048	-1.001	-2.557	.038
	Time of complementation	.819	.366	.559	2.235	.061
	Millet porridge	.842	.343	.853	2.452	.044
	Education level of caretaker	.675	.266	.889	2.541	.039
	Source of treatment	-.136	.233	-.164	-.585	.577
	Occupation of caretaker	-.452	.157	-.721	-2.872	.024
	Has thechild had any diarrhoea in the lastmonths?	2.174	.753	1.206	2.889	.023
	If yes do you ferment any of yourchild's food?	1.578	.582	.915	2.712	.030
	Family income	1.208E-5	.000	-.955	-3.010	.020

a. Dependent Variable: weight for age of child

Appendix 4:Product development (Sensory evaluation questionnaire)

1. Sensory evaluation of the porridges using a seven point hedonic scale
Type of porridge…………………………………………………………

Variable	Colour	Consistency	Flavour	Taste	Overall acceptability
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					

2. Proximate composition, vitamin A, zinc and iron content of millet,pumpkin and moringa

Variable	Pumpkin seeds	Pumpkin pulp	Moringa fruit	Moringa leaf	Millet
Moisture content					
Crude fat					
Crude fibre					
Crude protein					
Total mineral (ash)					
Carbohydrates					
Calorific value					
Iron					
Zinc					
Vitamin A					

3. Antimicrobial properties

Bacteria	Fermented pumpkin -millet porridge	Fermented moringa-millet porridge	Fermented millet porridge
E. coli			
Staphylococcus aureus			
Salmonella typhi			
Shigella shiga			

Appendix 5: Panellist effect on formulated porridges

Variable	ss	df	Ms	F	P value	F Crit
Colour	97.39	21	4.64	4.72	1.51	1.68
Consistency	52.40	21	2.50	3.38	3.74	1.68
Flavour	71.60	21	3.41	1.51	0.09	1.68
Taste	57.42	21	2.73	1.11	0.36	1.68
Overall acceptability	25.46	21	1.21	0.97	0.51	1.68

Appendix 6:Hospital based questionnaire

Introduction and consent
Hello. My name is Barugahara Evyline Isingoma. I am a student at the University of Nairobi. I am carrying out an intervention research in children aged 7-24 months. The study will involve monitoring weight, feeding and taking blood to determine the iron, zinc and vitamin A status of your child. You are requested to voluntarily participate in this study. The information you provide will be treated with maximum confidentiality.

Consent form

Title of the study:
Empowering households in Western Uganda with improved traditional millet porridges as complementary food for mitigation of child malnutrition.
Telephone: (+256) 782673038...................... ……………………………… **(Researcher)**

Study purpose:
Addressing the nutritional and health status of preschool in Western Uganda by empowering households with technologies for improving millet porridge.

Study procedures:
On agreeing to participate in the study, I will be asked to complete an interview with a trained interviewer. I understand that the interview will ask about the demographic and socio-economic characteristics of my household members. Information also be got about the feeding of my child and anthropometric (body measurements) of my child taken. Also, more information about my study child will be obtained from the medical records if necessary. All this information will be kept confidential. About 5mls blood samples will be taken from my child at the beginning and at the end of the study.

Benefits:
I will benefit from the study by obtaining some information about the nutritional status of my child and the haemoglobin, serum zinc, serum vitamin A and serum iron levels. I will not be paid for participating in the study.

Risks:
No risks will be posed to my life and my child as a result of this study. Blood samples will be taken from my child and this may cause some discomfort and anxiety to my child. I will also be asked to give up 20-30 minutes for an interview and may experience some anxiety or discomfort while being interviewed.

Rights to refusal or withdrawal:
My participation is entirely voluntary and I am free to take part or withdraw at any time without my medical supplies or treatment being withdrawn from my child. I may also choose to answer some or all of the questions posed.

Confidentiality:
The results of this study will be kept strictly confidential, and used only for research purposes. My identity will be concealed in as far as the law allows. My name will not appear anywhere on the coded forms with the information. The interviewer has discussed this

information with me and offered to answer my questions. For any further questions, I may contact Tel:(+256) 414541288 or the Chairperson, TASO Institutional Review Board or Uganda National Council of Sciences and Technology. Tel: (+**256)-41-250431**

Statement of Consent/Assent

.... has described to me what is going to be done, the risks, the benefits involved and my rights regarding this study. I understand that my decision to participate in this study will not alter my usual medical care. In the use of this information, my identity will be concealed. I am aware that I may withdraw at anytime. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy of this form will be provided to me.

Signature of parent/Caretaker ……………… Date ………………

Signature of Interviewer ………………… Date ………………………..

Questionnaire

English version

Date…… Pediatric Unit/Ward…… Name of the interviewer…………

Parents' information

1. Mother's age…… ….. (Years) Weight (kg)…….. Height…… (cm)

MUAC……. (If pregnant)

2. Family residential area………. Division/zone/ village………………….....

3. Mother's education:

a) = Completed primary education b) = some primary education

c) = Completed O' level d) = some secondary education

g) University education e) = Completed tertially education f) = Never went to school

4. Pregnancy status: a) Pregnant Yes…No….

b) Number of pregnancies…… c) Number of children alive……

5 a) Breastfeeding status ……….. 1. = Breastfeeding 2. = Not breastfeeding

b) Length of breastfeeding ……………… (months)

6a). Mother's occupation:……………………

a) Housewife only b) Housewife and farmer

c) Salaried employment (Teacher, clerk, nurse, etc) d) Casual labourer

e) Self employed/business/Hawking/Saloon f) Unemployed

6b). Fathers' occupation……………………..

a) Farmer b) Salaried employment (Teacher, clerk, nurse, etc)c) Self employed/business/Hawking/Saloon d) Casual labourer e) Unemployed

6c). Family size a) Number of children ………..

b) Number of children under five years; i) In the household…………….. ii) For the mother……………

7. a) What is the mother's average income per month.......................?

b) What is the caretaker's average income?(if not mother)…………….

8. What is the father's average income per month...?

9. Mother' marital status:……………….

a) Single b) Married c) Widowed d) Divorced e) Separated

10. Father's age……..

11. Father's education: a) = Completed primary education b) = some primary education c) = Completed O' level d) = some secondary education e) = Completed tertially education g) University education f) = Never

Child's information

1. Date of admission……….. . Date of birth…/…/…
Age in months…………… Sex of the child a) = Male b) = Female
4. Birth order……….. 5. Weight (kgs)……. .

7. Type of PEM: a) Oedematous b) Non oedematous kwashiorkor

8. Cause of admission a)………… b)……… c)…………...

9. Immunisation status: Has your child been immunised against the following;

BCG	OPV0	DPT 1	OPV 1	DPT 2	OPV 2	DPT 3	OPV 3	Measles

Tick corresponding box

10. Has the child ever received vitamin A supplements? i) Yes ii) No

11. Has the child received vitamin A supplements in the last 6 months? i) Yes ii) No

12 Has the child been de-wormed in the last three months? Yes… No……….

Child's feeding pattern

1. Is the child still breastfeeding i) Yes………….. ii) No……………
2. If not breastfeeding at what age was the child stopped ………..
3. How long did the child breastfeed ……………… (Months)
4. How many months did you breast feed without giving anything else (exclusive breastfeeding)…………..
5. At what age did you introduce anything other than breast milk………
6. What foods did you commonly feed your child on before admission to the hospital? (List in order of importance under staples and relishes

	Common Relishes	**Common Staples**
1		
2		
3		
4		
5		

Record of children's biochemical indices

a) Laboratory request form

Name of analyzing institution………… Name of Analyst…………………...

b) **Biochemical indices:** A = Baseline B = After intervention

No	Hb		Serum iron		Serum zinc		Serum vitamin A	
1	A	B	A	B	A	B	A	B
2								

Food record form

Serial Number…. Date……………… Ward Number…………….

Kitobero ingredients

Weight Container	Ingredient Description	Amount (g)	Total food + container (g)	Total food (g)

Weight of cooked food + container (g)
Weight of cooked food (g)

Food service record

Meal	Weight of plate (g)	Plate + food (g)	Plate + extra food (g)	Plate + food left (g)	Food eaten (g)

F-100 milk, moringa and pumpkin improved millet porridge feeding record

Time	Feed	Amount served	Amount left (ml/g)	Amount taken ml/g

Appendix 7: Community based questionnaire

Consent form

Title of the study:
Empowering households in Western Uganda with improved traditional millet porridges as complementary food for mitigation of child malnutrition.
Telephone: (+256) 782673038....................... ……………… **(Researcher)**
Study purpose:
Addressing the nutritional and health status of preschool in Western Uganda by empowering households with technologies for improving millet porridge.
Study procedures:
On agreeing to participate in the study, I will be asked to complete an interview with a trained interviewer. I understand that the interview will ask about the demographic and socio-economic characteristics of my household.
Also, more information will be got about the feeding of my child and anthropometric (body measurements) of my child taken. All this information will be kept confidential.

Benefits:
I will benefit from the study by obtaining some information about the nutritional status of my child. Parents/caretakers of children will be taught how to prepare millet based fermented porridges (interventional products). I will not be paid for participating in the study.
Risks:
No risks will be posed to my life, household members and my study child as a result of this study. No samples will be taken from any of my household members. However, I will be asked to give up 20-30 minutes and may experience some anxiety or discomfort while being interviewed. My study child will be also be measured (weight) and may be inconvenienced by taking these body measurements. Millet based porridge will be fed to my child.
Rights to refusal or withdrawal:
My participation is entirely voluntary and I am free to take part or withdraw at any time. I may also choose to answer some or all of the questions posed.

Confidentiality:
The results of this study will be kept strictly confidential, and used only for research purposes. My identity will be concealed in as far as the law allows. My name will not appear anywhere on the coded forms with the information. The interviewer has discussed this information with me and offered to answer my questions. For any further questions, I may contact ……………………….. Tel:(+256) 414541288 or the Chairperson, TASO Institutional Review Board or Uganda National Council of Sciences and Technology. Tel: **(+256)-41-250431**

Statement of Consent/Assent
.... has described to me what is going to be done, the risks, the benefits involved and my rights regarding this study. I understand that my decision to participate in this study is voluntary. In the use of this information, my identity will be concealed. I am aware that I may withdraw at anytime. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy

of this form will be provided to me.
Signature of parent or guardian …………… Date ………………
Signature of Interviewer …………………… Date……………….

Questionnaire No………… Name of the interviewer………………...

- Date of the interview ……..
- Give information about each member of the household beginning with the head of the family

No	Name	Sex	Age*	Marital status	Religion	Education level	Occupation	Relation to the child
1								
2								
3								
4								

Codes

- Sex: 1= Male, 2 = Female
- Age: Record in years for adult; Record in months for <5years
- Current marital status: 1= Never married/Never lived together,

2= Married/Living together (monogamous) 3 = Married/Living together (polygamous); 4 = divorced/Separated, 5= Widowed; 6= Not applicable)

- Religion: 1 = Catholic, 2= Protestant, 3= Moslem, 4= SDA

5= Pentecostal, 6= Traditionalist, 7= others (specify)

1. Mother's age……Weight (kg)…….. Height……
2. Family residential area………. Division/zone/ village……………….....

Circle the correct Answer

3. Mother's education: 1= No formal education, 2=some primary education 3 = Completed primary education4 = some secondary education 5 = completed secondary education, 6 = some tertially education 7 = University,

8= others (specify)

- Occupation (mother) 1= Civil servant, 2= Business, 3= Casual labourer,

4=Unemployed, 5=Farming, 6=Student, 7=Not applicable 8 = others (specify)

- Education level (Father) 1= No formal education, 2=some primary education 3 = Completed primary education,4 = some secondary education

5 = completed secondary education, 6 = some tertially education
7 = University, 8= others (specify)

- Occupation (Father) 1= Civil servant, 2= Business, 3= Casual labourer,4=Unemployed, 5=Farming, 6=Student, 7= others (specify)
- Who takes care of the child?1 = Mother, 2 = Father, 3= Grand parent,

4 = Uncle/aunt5 = Sibling, 6= Cousin, 7= others (specify)

Social economic status of the family (Circle the correct answer)

- What is the father's average income per month?……………...
- What is the mother's average income per months?……………………….
- What is the care taker's average income (if not mother)?.....................
- Do you own any of the following?
  01) Radio 02) Bicycle 03) Car

- What is the type of your house roof?
  01) Grass 02) Iron sheet 03) Asbestos 04) Tiles

- What is the main source of household income? ....(**can have multiple response)**
  01= Sales from farm produce 02) = Casual labour 03 = Formal employment 04 =Business 5= others (specify)……

Immunisation status

Tick corresponding box. Has your child been immunised against the following

BCG	OPV0	DPT 1	OPV 1	DPT 2	OPV 2	DPT 3	OPV 3	Measles

- Has the child ever received vitamin A supplements? i) Yes ii) No
- Has the child received vitamin A supplements in the last 6 months? i)Yes ii) No
- Has the child been de-wormed in the last three months? i) Yes ii) No

Disease morbidity (To be taken after every month)

Circle the correct answer

1. Has the child been sick in the last month? 1.Yes2. No

2. If yes, is the treatment card available?
1. Yes 2. No
3. Has the child been breast feeding?
1. Yes 2. No
4. Did the child share the flour with other members of the family?
1. Yes 2. No

Morbidity Recall (Done after every 2 weeks)

Registration Number…………………..

Type of illness	Number of episodes	Duration of illness (days)	Symptom	Source of treatment
Malaria				
Diarrhoea				
Common cold				
Cough				
Pneumonia				
Others(specify)				

Code for symptoms and source of treatment

Symptom (multiple choices allowed)		Action taken	
1	Fever	1	Went to health facility
2	Vomiting	2	Herbal treatment
3	Running nose	3	Self medication
4	Loss of appetite	4	Faith healing
5	Weight loss	5	Others (specify)
6	Cough		
7	Wheezing		
8	Blood in the stool		
9	Difficulty in breathing		
10	Loose stool		
11	Others (specify)		

Dietary practices (Circle the correct answer)

- Did you ever breastfeed? 1.Yes 2.No
- How long after birth did you put the child on the breast
  1. Immediately 2. Hours 3. Days
- In the first 3days after delivery, was the child given anything to drink other than breast milk1.Yes 2). No
- What was the child given to drink….
- Are you still breastfeeding? 1.Yes 2.No
- How many months did you breastfeed…..?
- How many months did you breast feed without giving anything else? (Exclusive breastfeeding)…..
- At what age did you introduce anything other than breast milk….
- Have you ever heard of fermentation 1.yes 2. No

Nutritional status data (To be taken every after 2 weeks)

Record of the child's anthropometric data after every 2 weeks
Date…………………………. Sex……..
Age (Months)…… Registration No……………. Date of birth……………….

	Weight (kg)	Weight (kg)	**Average**	Height (cm)	Height (cm)	**Average**	**MUAC**
1							
2							
3							
4							
5							
6							
7							
8							
9							

Dietary data (Taken after every 2 weeks)

How many feeds has the child had in the last 24 hours (from this time yesterday to now? **(Record amounts).**

24- Hour recall food intake record sheet

Time	Dish	Ingred	Amount in HH Measure	volume of dish prepared	volume of food served	Amount left over	Food consumed

(Take the household measures: teaspoon, table spoon, cups, mugs, measuring jugs and the food ingredients used in the household to show the exact amounts, sizes and units used in food preparations, Request to see the measures, sizes, foods and ingredients in order to practically measure and weigh the used levels)

Appendix 8: Photographic presentation of the most inhibited microorganism

Staphylococcus inhibition by pumpkin millet porridges

Appendix 9: Photographs on community interventions with millet-based porridges

Community demonstrations on processing of pumpkin millet porridges

Community demonstrations on processing of moringa millet porridges

Children fed on pumpkin millet porridges after 10 weeks of rehabilitation.