

**SUBSTITUTION OF MILK WITH HIGH-ENERGY HIGH-PROTEIN  
LACTIC FERMENTED MAIZE- BEAN MIXTURE IN REHABILITATION  
OF SEVERELY MALNOURISHED CHILDREN A**

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Human Nutrition

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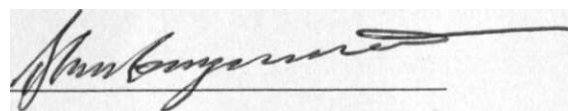
## DECLARATION

I Faith Mayanja Namavengo hereby declare that this thesis is my original work and has never been presented for a degree in any other University

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The thesis has been submitted for examination with our approval as  
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## DEDICATION

This work is dedicated to my husband John Khafu-Muvonga and to our  
daughter Kharobo-Atiila

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## ABBREVIATIONS AND SYMBOLS

<b>WHO</b>	World Health Organisation
<b>UNICEF</b>	United Nations International Children Education Fund
<b>GOK</b>	Government of Kenya
<b>UDHS</b>	Uganda Demographic and Health Survey
<b>HEP</b>	High-Energy Porridge
<b>HEM</b>	High-Energy Milk
<b>OP</b>	Ordinary Porridge
<b>GURT</b>	Government of the United Republic of Tanzania
<b>ml</b>	Millilitres
<b>FAO</b>	Food and Agricultural Organisation
<b>SD</b>	Standard Deviation
<b>NS</b>	Not Significant
<b>g/gm</b>	Grams
<b>Kg</b>	Kilogram
<b>Bwt</b>	Body weight
<b>PEM</b>	Protein Energy Malnutrition

## DEFINITIONS OF TERMS:

1. **Diarrhoea:** The passage of stools with an unusual consistency from the one normally observed by the mother/caretaker, more than three times a day.
2. **Rehabilitation phase:** The time when two out of the seven meals of the malnourished children at the Mwanamugimu Nutrition Unit are composed of Kitobero (a mixture of local foods) and the rest of the meals are composed of High Energy Milk (HEM).
3. **Dietary bulk:** The concept of dietary<sup>7</sup> bulk refers to the factors in the food that make it difficult to for an individual to consume that food in sufficient amount to cover the energy and nutrient requirements. The energy content/nutrient density and the consistency of the diet are the two characteristics identified as dietary bulk factors.
4. **Energy Density:** The energy value per unit weight/volume of food. It is usually expressed as Kcal/gram or Kcal/ml.
5. **Food Consumption/food - intake:** This is food and drink ingested in grams which is finally used to determine energy and nutrient intake.
6. **Kitobero:** A multimix of foods containing two good sources of protein and one staple food.

## ABSTRACT

High-energy milk (HEM) consisting of cow's milk, oil and sugar is used in the rehabilitation diet of children at the Mwanamugimu Nutrition Unit. In this study a mixture of lactic fermented maize and beans was, used as a substitute for the HEM, in a bid to reduce rehabilitation costs. The maize-bean flour containing 14.6 % protein was used to prepare a high-energy high-protein porridge (HEP), containing 15% total solids. This was liquefied using of Millet Amylase Rich Flour (ARF). The energy and protein density for the HEP was found to be 0.9 kcal/ml and 0.027g / ml respectively. This compares well with 1.0 kcal/ml and 0.0355 g protein /ml for HEM. It is however higher than the protein and caloric content of Ordinary porridge, (OP), which is commonly used by mothers as a complementary food in Uganda.

The performance of HEP, as substitute for HEM in feeding severely malnourished children at the unit, was then investigated. HEM was substituted by HEP in the diet of some of the children in the rehabilitation phase at the unit. This was referred to as the HEP group of children. The comparison group (HEM group) remained on HEM. For both groups other foods that are normally given to children at the unit were fed.

The HEP group consisted of 39 children while the HEM group had 43 children. The food intake, children's weights as well as the occurrence of diarrhoea and other illnesses were monitored during the study period. The socio-economic and demographic characteristics of the study children and those of their parents and families were obtained using a questionnaire interview.

No significant difference was observed in the sensory acceptability between HEP and OP, by mothers. 70% of the children who were given HEP accepted it.

The caloric intakes (per kg body weight/day) were  $168 \pm 38.1$  and  $153.7 \pm 36.9$  for the HEP and HEM groups respectively. The protein intakes (g/kg Bwt/day) were  $6 \pm 2$  and  $5.6 \pm 2.5$  for the HEP and HEM groups respectively. The caloric and protein intakes showed no statistical difference ( $P > 0.05$ ). Both groups took levels of calories and protein adequate for the treatment of protein energy malnutrition.

Growth rates in the first seven days of stay in the study were 10 and 7 grams/kg body weight/day, for the HEP and HEM groups respectively. These were statistically different ( $p < 0.05$ ). However, the overall growth rates, for the entire period of stay in the study (8 and 7 grams/kg body weight/day for the HEP and HEM groups respectively), were not statistically different. Growth that is adequate in the treatment of PEM was achieved in both study groups. It can be concluded that HEP is a better media for catch-up growth during the first seven days of rehabilitation phase, when the body's deficit for energy and other nutrients is high. After the deficit is cleared growth continues at more or less the same rate on both HEM and HEP. Study results indicated no difference in the experience of diarrhoea and other illnesses between the study groups.

Both groups of study children came from families of low socio-economic status.

It was also concluded that a protein and energy dense porridge (HEP), could be produced from a lactic fermented kidney beans-maize mixture by incorporation of millet ARF. It is a suitable substitute for milk in the rehabilitation diet for severely malnourished children. In addition, its caloric and protein content make it a suitable complementary food, for healthy children. It is inexpensive and has a potential for acceptability by mothers, and children, making it ideal for use in the rural and peri-urban areas of Uganda and other countries where prevalence of malnutrition is high.

## 1. INTRODUCTION

Protein energy malnutrition (PEM) is widely spread in developing countries. PEM prevalence in Uganda is very high. It has been reported that approximately 2% of all deaths of children under 5 years of age in Uganda are directly due to malnutrition (Burton and Wamai, 1994). Stunting, underweight, kwashiorkor and marasmus are wide spread (UNFNC, 1996; Kikafunda et al., 1998).

The high incidence of PEM in Uganda has been linked to the low energy and nutrient densities of banana and cereal based foods given to pre-school children. Maize gruels commonly given to children contain 6.3- 7.7 % (w/w) flour and a mean energy density of 0.25 Kcal / ml (Nakubulwa, 1997). It is not possible for children above 6 months of age to ingest adequate amounts of such food preparations to fulfill their daily energy requirements, because of the small capacity of their stomachs. Over time, children consistently feeding on these low energy and nutrient density preparations develop PEM.

The addition of milk to maize gruels may be used to enrich porridge with proteins and other nutrients. However, milk is expensive and unaffordable to many families. Many mothers therefore do not add milk to maize gruels and those who do so, use it only sparingly. In nutrition rehabilitation centers in many developing countries milk is used

in diets of malnourished children. At the Mwanamugimu Nutrition Unit, at Mulago hospital Kampala, High Energy Milk (HEM), containing cows milk, sugar and vegetable oil is the sole food given to children in the resuscitation phase. During the rehabilitation phase the children are fed on maize Porridge mixed with HEM, alongside *kitobero*, a menu consisting of animal protein (egg, beef or fish), or plant protein sources (groundnuts or beans) and a staple (usually matooke, maize flour, rice, Irish potatoes, potatoes or cassava). Although milk is widely used in nutrition rehabilitation, it is expensive and its' consumption cannot be sustained by low-income families. It cannot provide a sustainable solution to PEM in underdeveloped countries, particularly beyond the nutrition rehabilitation centers, because of the high cost of milk and because many people are poor. Church (1991) cautioned against the use of expensive foods in nutrition rehabilitation, as it is not sustainable. Indeed there is need for an inexpensive substitute for milk at the center, which is affordable to rural households, for use in follow-up feeding, upon discharge from the rehabilitation center.

There have been efforts to find low cost readily available foods to be used as substitutes to milk. *JIKO*, a combination of groundnut, simsim and sugar, was tried out in the past at Mwanamugimu Nutrition Unit. This was however abandoned, because of the limited supply of simsim and groundnuts. Cereals and legumes notably beans, maize and millet are widely produced in the country. They are inexpensive and cereal-legume combinations are of high nutritional value (Cameroon and Hofvander, 1983).

Their amino acid profile is comparable to that of milk proteins. They give higher energy and nutrient density gruels than gruels made from cereals alone.

Legumes however, contain a number of anti-nutritional factors, which cause flatulence and limit protein bioavailability (Liener and Kakade, 1980; Cameron and Hofvander, 1983; Wolf and Cohen, 1971). These factors may be destroyed using fermentation (Gustofsson and Sandberg, 1995), malting or/and heat treatment (Chitra et al., 1996). In addition to destroying anti-nutrients, fermentation improves flavour and taste (Muroki, 1990) and reduces the frequency and duration of diarrhoea (Kalavi, et al., 1996; Mensal et al., 1991). It generally enhances the nutritional quality (Svanberg and Sandberg, 1988) and safety of foods (Nout et al., 1989).

Malting of legumes, cereals and tubers leads to reduction in dietary bulk (Darling et al., 1995). Use of Amylase rich flours (ARF) from germinating cereal grains enables preparation of porridge with a higher energy density than conventional weaning foods. In this study, ARF was used in combination with fermentation to produce high-energy gruels from beans and maize. The gruels were used to feed malnourished children.



## 1.1. OBJECTIVES OF THE STUDY

### 1.1.1 General objective of the study

This study was aimed at developing a high energy high protein porridge from lactic acid bacteria fermented kidney beans -maize flour mixture and assessing the suitability of the developed formulation as a substitute for milk in the rehabilitation diet for severely malnourished children.

### 1.1.2 Specific Objectives

The specific objectives of the study were to:

1. Formulate a high-protein, high-energy fermented maize/bean flour (**HEP** flour), for preparation of high-protein, high-energy porridge (**HEP**).
2. Determine and compare the sensory acceptability of **HEP** to that of ordinary maize porridge (**OP**), by mothers.
3. To determine the sensory acceptability of **HEP** by children.
4. Determine and compare the energy and protein intakes of children whose diet is supplemented with high energy milk (**HEM**) with that for whom some of the **HEM** is substituted with **HEP**.
5. Determine and compare the energy and protein content of **HEM**, **HEP** and **OP**
6. Compare the growth rates of children on the two diets.

7. Determine and compare the diarrhoea and Illness experience of the two groups of children.

## 1.2. *EXPECTED BENEFITS OF THE STUDY*

The study results may be a basis for the following:

1. Prevention and alleviation of malnutrition among children especially among poor families which cannot afford sufficient amounts of milk
2. Reduction of the cost of nutrition rehabilitation at the Mwanamugimu Nutrition Unit.
3. Nutrition security among farm families which do not raise milk animals.
4. Promotion of fermented weaning foods in Uganda.
5. Self-sufficiency and increase in utilisation of beans and maize in Uganda.

## 1.3. *HYPOTHESES*

- I. There is no difference in sensory acceptability of HEP and OP by mothers .

- II. There is no difference in energy and protein intakes of children whose diet is supplemented with HEM to those for whom some of the HEM has been substituted with HEP.
- III. There is no difference in the growth rates of children whose diet is supplemented with HEM and those for whom some of the HEM has been substituted with HEP.

## **2. LITREATURE REVIEW**

### *2.1. OVERVIEW OF MALNUTRITION*

Malnutrition is a worldwide problem affecting over 226 million children. The problem is worse in developing countries where out of all the annual childhood mortality, 14 million are related to severe malnutrition (UNICEF, 1998). Protein energy malnutrition (PEM) characterized by kwashiorkor and marasmus is wide spread. It affects mostly children under five years of age because of their relatively high nutritional requirements (Ljungqvist et al., 1981; Parkin and Stanfield, 1991; Taba, 1970). Nutrition problems constitute a major public health problem in the tropical and subtropical regions of the world. The prevalence of chronic malnutrition in Uganda is very high. Approximately 38% of the children below the age of three years are stunted, 26% under weight and 5% wasted (UNFNC, 1996). About 2% of all deaths of children under 5 years of age in Uganda are directly due to malnutrition (Burton and Wamai, 1994). In Mubende District, central Uganda, prevalence of Kwashiorkor, marasmus, stunting, underweight and low Mid-Upper Arm circumference (MUAC) are approximately 3.8%, 5.7%, 23.8%, 24.1% and 23.8% respectively (Kikafunda et al., 1998). These statistics give a grim picture of the devastating state of malnutrition. The high prevalence of malnutrition has a heavy toll on life. It also imposes severe handicaps on survivors. There is evidence to suggest that PEM has lasting effects on growth and development (Parkin and Stanfield, 1991).

There is thus an urgent need to provide ways of preventing malnutrition and to develop foods for nutritional rehabilitation of malnourished children.

## 2.2. CAUSES OF MALNUTRITION

Although nutritional deficiency diseases are primarily due to inadequate diets, they are closely related to the poor socio-economic and environmental conditions. In Uganda the risk factors for marasmus and underweight include poor health, the use of unprotected water supplies and lack of milk consumption. The risk factors for stunting include age of the child, poor health, prolonged breast feeding, low socio-economic status of the family, low education of mothers, consumption of small meals and consumption of food of low energy density. The risk factors for low Mid Upper Arm Circumference (MUAC) are poor health, lack of meat and cows milk consumption, low intake of energy from fat and less educated and older mothers (Kikafunda et al., 1998). PEM is often associated with infections. Respiratory infections and diarrhoea are the most common diseases that precipitate severe PEM and death (Ljungqvist et al., 1981).

PEM is particularly serious post weaning (Parkin and Stanfield, 1991). In East Africa during the weaning period breast milk is substituted with diluted cow's milk or starchy low protein gruels. In areas where milk has to be purchased it is given in diluted form, and is handled in unhygienic ways causing gastro intestinal problems. The result is

often malnutrition resulting in high child morbidity and mortality. Nutritional marasmus is common in children in urban and peri-urban areas and has been associated with stopping of breastfeeding early and inadequate supplementation (Taba, 1970).

### **2.2.1. Dietary bulk and PEM**

Nutrient density and consistency are the most important factors influencing the extent to which a child can cover its needs for energy and other nutrients in the diet (Hellstrom et al.,1981).

In most developing countries traditional complementary foods are based on local staples, usually starchy foods such as cereals and tubers. The traditional staple foods tend to be low in fat and high in starch such that when cooked they are low in energy density.

During the cooking process the starch granules swell and bind a large amount of water, resulting in gruels of high viscosity. A gruel of satisfactory feeding consistency will usually contain a great deal of water and large volumes with relatively little starch solids, thus contributing to high dietary bulk and low energy density. If the concentration is raised to increase the nutrient and energy density, the gruel will be too viscous for a small child to eat easily (Mosha and Svanberg, **1983**). The complementary diets with low energy density because of high dietary bulk, have been implicated in the

etiology of malnutrition (Mosha, and Svanberg; 1983; Ljungqvist et al., 1981). The high dietary bulk and low energy density of a food makes it difficult for an individual to consume enough to meet nutritional requirements (Ljungqvist et al., 1981; Cameron and Hofvander, 1983). The appropriate volume of starch based foods required to cover the energy requirements of pre-school children is 900-1050 ml. For cereal-based diets this can be achieved by taking 4 meals a day (Ljungqvist et al., 1981). Few caretakers in developing countries give 4 or more meals a day to their children .

Young children usually, are not able to feed on solid foods but only on liquid foods. Many mothers therefore attempt to liquefy thick gruels by addition of water. In this way the energy density is lowered (Ljungqvist et., 1981). In areas where starchy staples are prevalent and PEM abounds, dietary bulk is a major issue (Ljungqvist et al, 1981; Cameron and Hofvander, 1983; Church 1991).

Consumption of food with a low energy density is a risk factor for stunting in Uganda (Kikafunda et al., 1998). It also leads to inadequate energy intake. Insufficient energy intake leads to poor utilization of dietary proteins, which are usually of marginal or sub optimal supply (Ljungqvist et al., 1981). Rutshauser and Whitehead (1972) reported energy intakes of Uganda children to be 70kcal/kg Bwt/day, which is 70% of the recommended levels. This was in spite the fact that the actual quantity of food consumed was greater than their European counterparts. A study carried in Uganda by Rutshauser and Froot (1973) showed that even when children were fed 5 times

daily, on the traditional home diet, only 50% had energy intakes of over 418 KJ and 2 grams of protein/Kg Bwt/day. They compared the caloric and protein intakes of these children to those on a milk-based diet and found the protein and energy intakes of children on the home diet to be significantly lower than those on the milk based diet. They concluded that intakes of food were limited by the type of diet and not by physiological requirements.

### **2.2.2. Cost of weaning foods**

High quality weaning foods such as Cerelac are expensive and unaffordable for many Ugandan families. Animal milk is also beyond the reach of many people. As a result, many families rely on the cheaper cereal gruels. To address the problem of children malnutrition, it is necessary to avail high protein supplements at the lowest possible-unit cost (Taba, 1970). The use of expensive foods in nutrition rehabilitation is not sustainable (Church, 1991). Vegetable protein diets are the inevitable choice for the supply of protein to the ever expanding world population, especially to the low-income communities (Liener, 1980).



### 2.2.3. Malnutrition, Infections and diarrhoea

The struggle for survival of children in the developing countries begins at birth, as they are often underweight, deficient in protective antibodies and are exposed to a heavy dose of infectious agents. The common ailments include chest, skin and gastrointestinal infections. Diarrhoea, along with anorexia, mal-absorption and a high helminthic load compounds malnutrition. Tuberculosis is very common in both children and adults of deprived communities (Parkin and Stanfield, 1991). Round worm infestation is wide spread in many parts of the world (UNICEF, 1998).

There is a serious interaction between diarrhoea and malnutrition (Cutting, 1991).

The issue of diarrhoea and malnutrition requires great attention as these two factors constitute a vicious cycle i.e. act to reinforce each other and thus greatly affect the health of a child (Lorri and Svanberg, 1995).

Diarrhoea associated with malnutrition is one of the major factors contributing to high morbidity among children in developing countries (UNICEF, 1988). Diarrhoea can precipitate clinical malnutrition and repeated episodes may increase the severity of the condition. Malnourished children suffer longer and more severe attacks of diarrhoea which are more frequent than for the adequately nourished ones (Cutting, 1991). Weanling diarrhoea is common among children between 6 and 18 months of age many

in rural and urban poor societies. This is probably because during this period children become very active, mobile and test items they handle by putting them in the mouth. The risks of developing diarrhoea are greater if standards of environmental and food hygiene are poor (Cutting, 1991)

Contaminated complementary foods are a major cause of infant diarrhoea. The unhygienic conditions of any rural or urban poor community in a developing country make it very difficult to avoid microbial contamination during child feeding by dirty utensils and improper personal hygiene. Foods become contaminated with diarrhoeal pathogens from faeces when there is lack of clean and safe water (Lorri and Svanberg, 1995). If food is served immediately after proper cooking, there is less danger of microbial food poisoning, as the microorganisms present at this stage are too few to cause harm. Storing food in warm conditions allows germs to breed and multiply increasing the risk of diarrhoea. Health workers have therefore advised mothers to prepare fresh food for every meal. This is not always practical because the fuel, time for cooking, and even the food itself are usually limited. The infant foods are often therefore stored and used for several meals (Mensal et al., 1990).

According to Cutting (1991), breast fed babies suffer less episodes of diarrhoea than those who are not breastfed. This is because breast milk is sterile, with minimal chances of getting contaminated. In addition antibodies in the mothers milk protect the child from infections.

### 2.3. NUTRITION REHABILITATION

This is a process that involves integration of nutrition education with treatment in the management of childhood malnutrition. It involves a thorough functional analysis of the background of childhood malnutrition, with regard to socio-economic, cultural and clinical factors. In nutrition rehabilitation both a community and clinical problem diagnosis are made (Church, 1991). Nutrition rehabilitation centers have the role of rehabilitating the child and educating the mother. If well supervised, they play a vital role in preventing recurrence in malnourished children, as well as occurrence of new cases in other siblings. Mothers are assigned in turns to assist in the care of the child and in buying and preparing the food. Mothers are also taught about nutrients, feeding of children and the recovery process. No medicines are used except in emergency, to make mothers realize that drugs are not required for nutrition rehabilitation (Taba, 1970). This is the practice at the Mwanamugimu Nutrition Unit. Malnourished children are carefully selected to include children whose condition is likely to be cured with appropriate feeding. Mothers are fully involved in preparation of food and the feeding of their children. This ensures that mothers are trained and can continue feeding their children well after discharge.

Mothers are given nutrition and health education which prepares them for successful weaning of any later children (Church, 1991). During the teaching sessions local

materials and real things e.g. foods and plants, rather than pictures of them are used.

Proverbs, stories, songs and plays are used to suit the level of education of the mothers.

The education package includes the following:

1. The need for a child to have their own identified food container.
2. The use of home and locally suitable measuring methods, such as handfuls and cupfuls (Church, 1991). At the Unit the palm is used as the measure. A palm roughly weighs 90g (Young, 1999).
3. Foods need to be prepared so that when cooked they can easily be mashed and will be smooth enough for the toddlers e.g. beans should be ground into flour or soaked and peeled.
4. Foods should wherever possible be handled and mixed before cooking so that the mashing process after cooking requires minimal handling, reducing the risk of contamination. The whole process is integrated with existing cooking practices.
5. Available local foods are mixed and mashed in suitable proportions. Basing on recommendations by Church (1991) expensive foods are discouraged.

At the center milk is an important component of the resuscitation and rehabilitation diet. On admission to the center, children are fed 7 meals of High Energy Milk (HEM) which is produced from cows milk vegetable oil and sugar. These are reduced to five as the child's condition improves. Milk is an expensive food item in Uganda and its use at the center is un-sustainable. The center at times also gets cases of lactose

intolerance in the children. Cereals and legumes are foods that are locally produced and readily available in Uganda and which have a potential for use in Nutrition rehabilitation. They are cheap, do not contain lactose and can thus be used to feed children with lactose Intolerance. Their limitations and advantages are discussed In the next section.

#### *2.4. THE POTENTIAL OF LEGUMES AND CEREALS IN NUTRITION*

Legumes and cereals grow in a wide range of climatic conditions. They are relatively cheap, easy to store and handle and form part of the diet for many poor families in most parts of the world. This greatly simplifies efforts to increase, their consumption in such countries (NRC, 1979). Both maize and beans are widely grown in Uganda and are consumed in virtually all regions of the country. Uganda's annual production of cereals, pulses and oil seeds is approximately 2 million, 0.5 million and 0.5 MT respectively (FAO, 1997). The abundance and low cost of maize and beans make them good choices for use as supplementary foods.

When combined in correct proportions, cereals and legumes provide adequate quality proteins, energy and substantial levels of micronutrients. Such, all-vegetable diets have been successfully used in child feeding programs, and have been shown to combat kwashiorkor (Liener, 1980). Oil seeds and pulses contain 20-50% protein. From a

quantitative point of view legumes are good sources of proteins, but their proteins are deficient qualitatively. They are low in the amino acids methionine and cysteine (Augustin and Klein, 1989). Since every protein is consumed to the level of the most limiting amino acid, this is a big problem. They also contain protease inhibitors, which limit protein bioavailability (Bressani et al., 1984; Augustin and Klein, 1989). Legumes are relatively high in the flatulence causing sugars raffinose and starchyose. Flatulence is caused by the fact that humans lack the enzyme  $\alpha$ -galactosidase necessary for the digestion of these sugars. These compounds remain undigested and undergo anaerobic fermentation in the large intestine resulting in gas formation and flatulence (Augustin and Klein, 1989). The red kidney beans have high levels of minerals (Dzudie and Hardy, 1996).

Maize (*Zea mays*) is an important staple in many parts of the world, especially Africa where the flour is made up into a porridge or gruel (Kent, 1983). In Uganda maize is one of the popular cereals eaten by adults and infants. It is eaten in large quantities and is a main source of both major and minor nutrients. It can be prepared as gruel and used to feed infants (Nakubulwa, 1997). Maize contains 9.72-9.8% protein, 4.3-4.9% fat, 63.6-72.61% carbohydrates and 1538.32-1660 kJ/100g energy (Kakuramatsi-Kikafunda, 1998; Chavam and Kadam, 1989).

Compared to legumes and oilseeds, cereal grains are low in total protein content. Lysine is the most limiting amino acid, in all cereal grains. Corn proteins are also

limiting in tryptophan (Chavam and Kadam, 1989; Phillips, 1997). Leucine and threonine are also limiting when compared with FAO/WHO reference protein. However cereal proteins are rich in the sulfur-containing amino acids, cysteine and methionine (Phillips, 1997).

The protein digestibility of cereals ranges from 77-99%, biological value (BV) from 55 to 77.7%, and net protein utilization (NPU) from 50 to 73% in different cereal diets. The lower BV and NPU of cereals are mainly due to deficiencies of certain amino acids, like lysine, threonine and tryptophan and low protein availability. The amount of B-group vitamins, and minerals such as Iron and zinc are low in cereals. The Iron and zinc availability is low (Chavam and Kadam 1989).

Cereal, legumes and their products are often inferior in both nutritional and sensory quality when compared to animal foods. However the amino acid profiles of cereals and legumes complement each other (Chavam and Kadam 1989; De Lumen et al., 1997).

The complementing of amino acids of one protein by those of another is an economical and practical way of improving protein quality and quantity. The complementary effect of cereal-legume mixtures has been exploited in the making of traditional fermented foods. The protein value of cereal-legume mixtures is superior to either one, used alone. A weaning gruel from defatted winged bean flour, and corn had a

nutritional value equivalent to that of milk. The gruel has been successfully used in the feeding of children suffering from kwashiorkor (Narayana, 1984). Foods made from cereal-legume mixtures do have an important role to play in the nutrition of those people whose protein intake is largely vegetarian (Wang & Hesselstine, 1981). Table 2.3 gives the protein quality of some cereal legume mixtures.

**Table 2.1: Protein Quality of Cereal-Legume Mixtures**

<b>Protein Source in diet</b>		
<b>Cereal (%)</b>	<b>Legume (%)</b>	<b>PER</b>
100 rice	0 Black gram	2.3.8
0 rice	100 black gram	0.98
90 rice	10 black bean	2.60
100 corn	0 black bean	1.4
90 corn	10 black bean	1.78
100 sorghum	0 black bean	0.53
90 sorghum	10 black bean	1.22
100 wheat	0 soy bean	1.28
0 wheat	100 soybean	2.17
50 wheat	50 soybean	2.4

*Source: Wang and Hesselstine (1981)*



The use of legumes for human nutrition is however impeded by anti-nutritional factors in their seeds. These include trypsin inhibitor, phytic acid, tannins and oxalate which inhibit protein bioavailability (Liener and Kakade, 1980; Apata and Ologhobo, 1997); hemagglutinins or lectins which adversely affect the absorption of nutrients from the intestinal tract (Jaffe, 1980). They also have flavanoids, alkaloids, non-protein amino acids, and uncommon proteins (Liener and Kakade, 1980). To maximise the nutritional value of legumes, elimination or inactivation of these un-desirable substances is required.

These antinutritional factors may be destroyed by different processing methods. Trypsin inhibitor is destroyed by heat treatments (Liener, 1989). Apata and Ologhobo (1997) observed that cooking leads to complete destruction of trypsin inhibitor, while autoclaving leads to an 88-96% reduction. Cooking and autoclaving completely eliminates haemagglutinins, while roasting substantially reduces its activity. All heat processing treatments have little effect on phytic acid activity. Cooking reduces but only slowly the oxalate content (19.5-39.3%), while autoclaving and roasting are less effective. These technologies have been applied in production of weaning foods from cereals and legumes (Apata and Ologhobo, 1997).

## 2.5. FERMENTATION

Fermentation is one of the many technologies that have been developed to address the problems of legume and cereal utilisation. Fermentation of food ingredients has played an important role in food processing for a long time. There are many indigenous fermented foods based on cereals alone and from cereal-legume mixtures. In most of these cases fermentation is natural and spontaneous, involving mixed cultures of bacteria and yeast. Fermentation with natural micro flora or pure cultures is beneficial in improving the quality of cereal-based foods. It may be the most simple and economical way to improve the quality and utilisation of cereals (Chavan and Kadam, 1989). In the use of cereal legume combinations, careful attention should be paid to blend formulation as it is a major determinant of nutrient density, while the processing method is a major determinant of weaning food viscosity (Griffith et al., 1998). In the study a 30:70 Kidney bean maize blend was used to optimise nutrient density, in the high energy high protein porridge (HEP), fermentation was used to lower levels of anti-nutrients and millet Amylase rich flour was used to increase the energy density.

The common fermenting bacteria are the species of *Leuconoctoc*, *Lactobacillus*, *Streptococcus*, *Pediococcus*, *Micrococcus*, and *Bacillus* (Chavan and Kadam, 1989).

Fermentation has many advantages. It enhances nutritive value, improves the appearance and taste of some foods. It is also a method of preservation of food products.

It reduces the volume of material to be transported and destroys antinutritional and toxic constituents in foods. It may be used to salvage materials otherwise not usable for human consumption, to reduce energy required for cooking, and to make microbiologically safe products (Chavan and Kadam 1989; Wang and Hesseltine, 1981).

The role of fermentation in legumes include rendering the products more palatable by hydrolysis of proteins to amino acids, masking the beany flavour and overcoming the poor cooking qualities (Harper, 1973). In both cereals and legumes fermentation lowers the levels of tannins and phytates (Chavan and Kadam, 1989; Svanberg and Sandberg, 1988).

Fermented porridges have found wide application in infant feeding. In farming communities fermented porridges have the advantage that they can be prepared in the morning and served to children whenever required as they can be kept for relatively long periods. Children in these communities like the taste of such porridges (Lorri and Svanberg, 1990).

Soaking and heating which are common pre-treatments before fermentation have been shown to reduce levels of phytates (Svanberg and Sandberg, 1988). They also reduce *in-situ* microbial contaminants, especially the non-sporulating bacteria and moulds (Wang & Hesselstine, 1981).

Trypsin inhibitor and raffinose sugars may also be reduced by legume fermentation (Zamora and Fields, 1979). The enzymes produced by microorganisms may be responsible for destruction and removal of anti-nutritional factors (Hesselstine, 1989).

Other advantages of fermentation include the improvement of protein efficiency ratio (PER) and digestibility. The fermentation process usually does not significantly change the content and amino acid composition of the substrate. The amount of microbial protein present in fermented products is not high enough to alter greatly the amino acid composition of the substrate. However, an increase in PER values and growth response may be obtained due to improvement in availability of amino acids particularly lysine by fermentation. Fermentation further increases the PER to values approximately equal to that those of casein (Wang and Hesselstine, 1981; Shekib. 1994). All legume fermentations involve the action of proteolytic and lipolytic enzymes with the result that the final products are more digestible (Hesselstine, 1989). The proteins are partially hydrolyzed and hence made more soluble and bioavailable (Pederson, 1971). Fermentation in a traditional Ghanaian corn meal has been shown to improve protein quality and to increase *in vitro* protein digestibility (Addo et al., 1996).

Barampama and Simard (1995) observed an improvement in protein nutritive value on fermentation of common beans.

A study with rats showed improvement in PER, digestibility and biological value on fermentation of pearl millet. The rats fed on fermented product had higher weight gains than controls fed on un-fermented millet (Kheterpaul and Chauhan, 1991). Shekib (1994) reported an improvement in *in vitro* digestibility of cereal and legume products due to fermentation. There was however little improvement in the amount of protein, although the amounts of methionine and cysteine increased in the legumes. The lysine content of the cereals also increased.

Mbugua et al. (1992) observed a decrease in extractable tannins in fermented *Uji* (a product prepared by boiling sorghum flour and fermented with 3-9% *Lactobacillus Plantarum* for 24 hours at 25°C. Fermentation also led to an improvement in *in vitro* protein digestibility, but did not affect the amino acid profile. They observed a decrease in the Nitrogen Free Extract. The decrease was attributed to formation of volatile compounds. Fermentation had no effect on PER values. However fermentation followed by drum drying led a considerable improvement in the PER values (2.34 as compared to 2.5, the international standard of casein). Sharma and Khetarpaul (1997) reported an improvement in protein and starch digestibilities of rice-legume and whey blends, on fermentation.

Fermentation may or may not alter the vitamin content of the substrate. Hesseltine, (1989) observed an increase in Vitamins such as riboflavin and vitamin B12. Asiedu (1993) observed no change in vitamins in fermented maize. According to Wang and Hesseltine (1981), some microbes are unable to synthesize some or all of their vitamins. They utilise the vitamins in the substrate with the overall effect of reducing the vitamin content. Table 2.4 gives data on the vitamin content of cereals and legumes before and after fermentation.

**Table 2.2: Vitamin content of legume and cereal foods before and after fermentation.**

Food	Niacin ( $\mu\text{g/g}$ ).		Riboflavin( $\mu\text{g/g}$ )		Thiamin ( $\mu\text{g/s}$ )	
	Before	After	Before	After	Before	After
Soybean Tempe	9.0	60	3.0	7.0	10.0	4.0
Wheat Tempe	46.0	135	0.4	3.2	3.2	3.0
Idii	.	.	2.5	5.4	2.1	5.8
Eudorian Rice	.	.	0.15	0.32	.	.

Source: Wang and Hesseltine, 1981.

Mensah et al (1990) reviewed the anti-microbial effects of fermentation during weaning food preparation. They reported the inhibitory effect of fermented milk against various bacteria including *E. Coli*. Fermentation of fish silage inhibited *Salmonella*, *Staphylococcus* and *Coliform* bacteria. The fermentation of Soybean by *Rhizopus*

*oligosporus* resulted in a product that inhibited *S. aureus*, *Bacillus subtilis*, and *Klebsiella pneumoniae*. They concluded that fermentation of foods could produce an environment that is inhibitory to a variety of bacteria, and could be important in the reduction of the high levels of faecal bacteria in weaning foods in developing countries.

Fermentation increases the shelf life of cooked cereals and legumes by inactivation of spoilage and pathogenic microorganisms and reduction of pH. There is generally no need to refrigerate fermented products (Wang and Hesseltine, 1981; Van Veen and Steinkraus, 1970).

Fermented weaning porridges are reported to keep for 1-2 days after preparation. Beyond this period the product may be too sour and may give off an unpleasant odor, especially when kept at ambient temperature due to uncontrolled increase in acidity (Lorri and Svanberg, 1990). Mensal et al (1990) reported that fermentation makes food more acid, which reduces or prevents the growth of diarrhoeal pathogens. They observed that porridge samples had low levels of coliforms and other pathogens immediately after cooking. Mbugua and Njenga (1992) observed a decline in the common *diarrhoeal* pathogens during *Uji* fermentation and storage. They suggested that the inhibition mechanism could be due to both acid production and bactericidal substances present in the fermented product. According to Adams and Hall (1988), undissociated acid is the active antimicrobial substance in fermented systems. Plusani et al (1979) showed the anti-microbial effects of the common *Lactic acid* bacteria against

the common pathogenic microorganisms. *Leuconostocs*, which are common in *Idli* fermentation, have been shown to have anti-microbial properties (Branen et al., 1975). *Idli* is a *Lactic acid* bacteria fermented cereal-legume product from South Asia.

Nout et al (1989) observed a reduction of the pathogenic load in fermented weaning foods made from sorghum. They reported that the reduction of pH during lactic acid fermentation of cereal preparations is associated with reduced contamination with diarrhoea causing pathogens.

Lorri (1983) observed that young children fed on lactic acid bacteria fermented cereal gruels had a lower prevalence of diarrhoea than children fed on non fermented gruels. Lactic fermented weaning foods have anti-diarrhoeal properties (Mensal et al., 1990). Fermented high nutrient density foods have been successfully used in the rehydration of children with diarrhoea (Mensah et al., 1995).

## 2.6. REDUCTION OF DIETARY BULK IN WEANING GRUELS

Governmental and non-governmental organisations, as well as commercial enterprises have made many efforts to prepare low cost, nutrient dense weaning and toddler foods, from locally available food commodities, by use of culturally acceptable and traditional home processing technologies.



Germination/malting, fermentation, precooking, toasting, puffing and extrusion processing are examples of technologies that have been tried (Khin et al, 1995; Akpapunam and Sefa-Dedeh 1995; Hellstrom et al 1981). However, technologies like toasting, puffing and extrusion are not culturally acceptable and/or are technically unsuitable for the rural population. Germination/malting and fermentation are some of the simple and easily adaptable methods that have the potential of reducing dietary bulk in weaning porridges (Khin et al, 1995; Akpapunam and Sefa-Dedeh, 1995).

Germination of cereals and legumes alone or on combination is effective in reducing the dietary bulk of weaning formulations and increase nutrient density. This is because it allows increase in the amount of flour needed before the desired consistency of 3,000cps (a free flowing gruel) is attained (Marero et al., 1988; Chandrasekhar et al., 1988; Khin et al., 1995). The reduction in viscosity of germinated flours is a result of starch degradation caused by the action of  $\alpha$  and  $\beta$ -amylases elaborated during germination (Mosha and Svanberg, 1983). Malting has been found to be generally effective in viscosity reduction of weaning gruel (Mosha and Svanberg, 1983. Gopaldas et al., 1988; Marero et al., 1988; Hansen et al., 1989; John and Golpadas, 1988; Gimbi et al., 1997). Malting is used to liquefy gruels produced from cereal and plantain flours, which are usually bulky and inadequate in energy.

Many studies have shown that addition of small amounts of Amylase rich flours (ARF) to gruel of un-germinated cereal reduces viscosity. Thick porridges can be liquefied

this way and their energy densities increased while an acceptable viscosity is maintained. ARF levels of 1-16% have been reported (Svanberg, 1987., Gimbi et al., 1997; Golpadas et al., 1986; Wahed et al., 1994; Hansen et al., 1989). Mensah et al (1995) used ARF levels of between 1-5g % to prepare a lactic fermented high nutrient density weaning formula.

Hansen et al (1989) found that it was possible to obtain a gruel with a consistency considered acceptable for small children by adding 1 % germinated barley to thick un-germinated barley gruel at varying levels of total solids.

Mosha and Svanberg (1983) reported a reduction in gruel viscosity from 9,000 - 16,000 cp. to <1,000 cp. for precooked un-germinated sorghum following addition of 5%-germinated flour at 20 - 30°C. The amylase enzyme gets inactivated at 90°C, but if the microbiological quality of the added flour is questionable, the gruel should be reheated to boiling temperature after allowing time for enzyme activity. Addition of the germinated flours before cooking the gruel leads to no viscosity reduction. When germinated and un-germinated flours were soaked overnight, a reduction in viscosity was observed at 40°C. A child can meet its daily energy requirement by consuming half the amount of porridge they would need if no ARF were used in porridge preparation.

Asiedu et al (1993) studied the effect sprouting on the nutrient composition of maize. They found sprouted maize to have higher energy than the un-sprouted. This is because during sprouting the complex carbohydrates are broken down into simpler sugars. This in addition to the fact that they have decreased viscosity makes them ideal in infant feeding. Simple sugars are easily available for absorption and the amount of energy and overall nutrient density obtained for a unit volume of porridge is increased. This is beneficial to infants who have limited digestive capacities and who cannot eat enough to meet their nutritional requirements.

Blending of materials is another method that has been tried in the viscosity reduction of weaning gruels. Addition of milk and groundnuts to maize based weaning gruels leads to reduction in viscosity (Kikafunda et al., 1998; Kikafunda et al., 1997). These also increase energy density because of the high fat content of groundnuts and milk. Viscosity reduction can be attributed to the formation of insoluble complexes with the polysaccharide chains and/or formation of a fat layer around the starch granules. These reduce the water absorption capacity of the starch granules during the cooking process.

The addition of fat also leads to viscosity reduction. However, fat has the problem of oxidative rancidity (Hellstrom et al 1981).

When starchy materials are heated prior to or during drying, the physico-chemical properties of starch are modified due to pre-gelatinisation. Pre-gelatinisation may be used to reduce viscosity of starchy gruels. Adeyeni et al (1989) observed that pre-gelatinisation of maize lead to production of instant weaning foods with low viscosity.

### 3. METHODOLOGY

#### 3.1. FORMULATION, PRODUCTION AND EVALUATION OF HIGH-ENERGY HIGH- PROTEIN PORRIDGE (HEP)

The steps followed in preparation of HEP are shown in Figure 1. The details of the process are explained in the subsequent sections.

##### 3.1.1. Raw Materials

The *Ni/ai/o* variety of the Kidney bean *Phaseolus vulgaris* was used in the study. Dry beans were purchased from *Gikomba* market, Nairobi, while millet (*Eleusine comcana*) and maize were obtained from *Kangemi market*. Commercial malted barley was used in the trials with barley malt.

##### 3.1.2. Preparation of dehulled kidney bean flour

Beans (1kg) were sorted to remove extraneous material and dirt. This was then added to 3 litres of boiling water. To this, three tea spoonfuls of baking soda were added to facilitate the removal of the hull. Boiling was continued for five minutes or until the hulls could be easily removed by rubbing the beans between the hands. The

beans were then cooled under tap water and dehulled by rubbing the beans between the hands. The wet beans were dried in a smoking cabinet (Type 11200, Wilhelm Fessman, Switzerland) at 50-60°C for 16hrs. The dried product was then milled using a Condux (6450x 3.5 Horse power) hammer mill and stored in 250 gauge polyethylene bags.

### **3.1.3. Preparation of Maize Flour**

The maize was first sorted to remove extraneous material, dirt, and discolored grains. It was then milled in a Condux (6450X 3.4 Horse power) grinder and sieved to pass through a 500 $\mu$ m mesh. It was then packed and stored.

**Sorted Kidney Beans**

**Sorted Maize**

Dehulled

Milled

Dried

Maize Flour (1kg)

Milled

+ Beans Flour (1.3kg)

Water (2l)

Mixed Slurry

Addition of Uji Culture

Ferment & Dry

Fermented Maize-Beans Flour (2kg)

Unfermented Maize Flour (1.3Kg)

**HEP\*Flour**

Water added & mixture boiled to make ~ 13% solids porridge. 15% ARF added after cooling to 70 C. Boiled again & 6.8 % sugar added

**HEF**

Figure 1: Schematic diagram showing steps followed in preparation of High energy high protein porridge (HEP)

### **3.1.4. Determination of appropriate type and amount of ARF**

Barley ARF (1%) was added to a 15% total solid gruel at 70°C as reported by Hansen et al (1989) while millet was added at the level of 15% as reported by Golpadas et al. (1986). After adding ARF, the gruel was maintained at this temperature for five minutes with constant stirring, until thinning occurred. Both were effective in thinning the porridge but barley had the disadvantage of leaving a bitter after taste on swallowing the porridge. Millet was thus chosen as the ARF source for use in the study, as it has the additional nutritional advantage of being a good source of readily available protein, has a good level of minerals, and is locally produced and available in Uganda.

### **3.1.5. Preparation of Germinated Millet Flour**

The Finger millet was threshed and winnowed to remove extraneous material and dirt. The millet was steeped in an equal weight of water for 24 hrs. It was then washed and floating extraneous material removed. After steeping, the millet was spread on a clean surface and covered with a black cloth. Germination occurred 24 hours after the steeping. The millet was washed after 24, 48 and 72 Hrs respectively and then dried at 60°C for 14 hrs in an air-circulating oven. Millet ARF flour was produced by milling



the dry pre-germinated millet in a kitchen grinder. The process was based on the methodology by Gimbi et al., 1997.

### **3.1.6. Preparation of fermented maize-bean flour mix**

#### *3.1.6.1. Selection of culture*

Two types of culture were tried out in the study, for the fermentation of the porridge ingredients. These are the *Idli* culture and the *Uji* culture, which are both *lactic acid* bacteria cultures commonly used in cereal-legume fermentations. The trials were done as follows:

*Idli* batter from the Central Food Technological Research Institute (CFTRI) canteen, Mysore, India was freeze dried to retain its activity during transportation and storage. The *idli* culture was reactivated using a 1:1 maize -bean combination, to which an equal volume of water added. The reactivated culture was added to a 1:1 maize -bean combination, with an equal volume of water was added, and the mixture left to stand at room temperature for 24hours. After 24 hrs of fermentation the pH was determined. The presence of the beany flavour assessed by presenting the fermented product to 10 untrained panelists. They were asked to indicate whether they were detecting the beany flavour or not.

The pH after 24 hrs of fermentation was 6.1 and the panelists indicated that the beany flavour was detectable in the fermented product.

Uji culture was obtained from the Department of Food Technology and Nutrition, Microbiology section. It is a mixed lactic acid bacteria culture in which *Lactobacillus plantarum* dominates. With this culture, it was possible to attain a pH of 4.5 after 24 hours of fermentation. The product was found to have a nice fermented flavour, a sweet-sour taste and had no detectable beany flavour when presented to 10 untrained pannelists. Because of these advantages the *Uji* culture was chosen over the *Idli* culture.

#### 3.1.6.2. *Formulation of and fermentation of the maize-bean mixture*

A high protein flour containing approximately 14.6% protein as recommended by Hofvander and Underwood (1987), was prepared by mixing dehulled beans (-24%protein) and maize flour (-9% protein) in the 30:70 ratio respectively.

A 1:1 maize and bean combination was slurred with an equal volume of water. This was then inoculated with *Uji* culture (5%) and fermented for 24 Hrs. The fermented slurry was then dried in a smoking cabinet (Type 11200, Wilhelm Fessman, Switzerland) for 14Hrs. The fermented flour contained 47% of the targeted amount of maize. The remaining fraction (53%) was added as un-fermented flour to the fermented formulation to tone down the sour taste of the final product. The fermented maize-bean mixture and the un-fermented maize were mixed by together at the porridge preparation stage.

#### 3.1.6.3 Chemical Analysis of the Formulation

The proximate composition of the final flour was determined using the methods of the Association of Official Analytical Chemists (AOAC, 1980). Crude Protein was determined using the micro-Kjeldah method. Crude protein was calculated as  $N \times 6.25$ . Fat was determined using the sox let method. Crude fiber was extracted using strong acid and strong alkali. Carbohydrates were derived by difference.

The energy content was determined by calculation using the Atwater factors (4 x protein, 9 x fat, and 4 x carbohydrate). The moisture content was determined using the AOAC (1980) air oven method.

### 3.1.7 Determination of the caloric and protein density of HEP, HEM, and OP

The energy density of the Ordinary porridge, High Energy milk and High-energy high-protein porridge were determined by calculation using the Atwater factors which were 9, 4, and 4 calories per gram of fat, proteins and carbohydrates respectively. The proximate composition of HEP flour in Table 4.1 was used in the determination of the caloric and protein density of the High-energy high-protein porridge. In the calculation the caloric supply from sugar amylase rich flour was also included. This was based on the proximate composition of millet as given by West et al (1988). The determination of the protein and caloric density of HEM was based on the proximate composition that is given by the manufacturers of the milk that was used in the production of HEM (Uganda Dairy Corporation). This composition is given below:

#### The proximate composition of 100g of Dairy Corporation milk

Fat=3.3g

Protein =3.3g

Carbohydrates= 4.6

Calcium= 0.10

Vitamin A =0.15mg

Vitamin B = 0.40mg

In the above calculation the caloric supply from sugar and vegetable oil was also put into consideration.

The caloric and protein density of ordinary porridge was determined as follows:

The amounts of maize flour used by mothers on the Pediatrics Ward to prepare porridge for their children were observed and recorded. The average flour percentage was found to be 7% and this was used as the basis for the calculation. The proximate composition of maize as given by West et al (1988), was used. The caloric supply from the added sugar (6% by volume) was also included in the calculation.

### 3.1.8. Costing the products

The Cost of feeding a child on a litre of High energy high protein porridge (HEP) and on a litre of HEM was determined. The computation for the HEP Included the following:

1. The cost of raw materials used in the production of HEP flour (the beans and maize)
2. The cost of labour and fuel used in the processing of HEP flour.
- \ The cost of the labour and fuel used in the preparation of the porridge.
- 4 The cost of production of amylase rich flour.

The computation for the cost of feeding a child on a litre of high energy milk was based on the on the cost price of a litre of milk, the cost of the added vegetable oil and sugar.

## **3.2. REHABILITATION STUDY**

### **3.2.1. Study site and study population**

This part of the study was conducted at the Mwanamugimu Nutrition Unit, Mulago Hospital Kampala, Uganda. This is a nutrition rehabilitation center for children with malnutrition. The majority of the children are admitted with clinical manifestations of kwashiorkor, marasmic-kwashiorkor and marasmus. On admission they are first treated for all ailments before the nutrition rehabilitation phase. Readiness to enter the rehabilitation phase is manifested by the return of the appetite, usually after one week of admission and treatment. In addition to the above requirements, kwashiorkor children are admitted to rehabilitation phase after losing oedema.

### **3.2.2. Study Design**

A prospective Study was carried out in which children aged 6-59 months in the rehabilitation phase were followed up. The study was interventional in nature. The procedure entailed determination of nutrition rehabilitation effects of substituting some of the milk (HEM) in the diet of the children in the HEP group with the HEP, while the HEM group remained on the usual Mwanamugimu Nutrition Unit Rehabilitation diet.

The caloric and protein intake, growth rate, and morbidity experiences of the study children were monitored.

### **3.2.3. Admission Criteria into the Study**

Criteria for admission into the study were as follows:

- a) Child is aged 6- 59 months.
- b) No clinical manifestation of **HIV/AIDS**.
- c) Diagnosis of manifestation of PEM i.e. kwashiorkor, marasmic-kwashiorkor, and marasmus according to the Wellcome classification in the Table 3.1.
- d) Willingness of the mother to participate in the study as indicated by informed consent basis.

**Table 3.1 The Wellcome classification of malnourished children**

WFA as a percentage of the median	<u>Oedema present</u>	
	No	Yes
60-80%	Underweight	Kwashiorkor
Below 60%	Marasmus	Marasmic- Kwashiorkor

WFA= weight for Age

*Source:* (Young, 1999)

### **3.2.4. Sampling Procedure and Sample Size**

The rehabilitation center where the study was carried out was purposively chosen, as it is the largest center with institutionalized PEM children, in Uganda. This increased the chances of getting the desired sample size. Admission of children into the study groups was also purposively done. All children in the rehabilitation phase were eligible to enter the study. The children's medical records were then studied with the aid of a clinician for exclusion parameters. On advice from the clinicians children with clinical manifestation of HIV/Aids were excluded from the study. Children with TB, but on treatment were admitted to the study, as experience at the center showed that such children do gain weight. The child's weight form was studied; those children on



anti-T.B drugs and having no major complications who gained weight consistently, were enlisted for consideration to join the study. The mothers of the children were then told about the study, its advantages to the Unit and the whole country at large. Mothers were then asked whether they were ready to have their children in the study, for consent.

There were two methods used to allocate children into the study groups. The first criteria, was based on acceptance of HEP. During the pre-testing of HEP it was found that not all children readily consumed it. In a bid to determine HEP acceptance by the children all eligible children were served HEP three times on the same day. Children who took at least three-quarters of the HEP served to them on the three different occasions (on the same day) were included in the HEP group. Those who took less than three-quarters of HEP served to them were allocated to the HEM group. In the second method of allocation, children who entered the rehabilitation phase when the study had the maximum number of children it could handle on HEP were allocated to the HEM group.

In determining the sample size reliability of results was taken into consideration. The sample size was 39 and 43 for the HEP and HEM groups respectively. These numbers allowed statistical comparison of the groups and fitted into the research budget. The minimum number of days spent by all the children included in the results analysis was 7 days and the average length for the children was 11 days, for both study groups.

### 3.2.5 Characteristics of the Study Children and their families

Mothers/caretakers were interviewed (Questionnaire in Appendix 1) to determine demographic and socio-economic characteristics of the children and of their families.

### 3.2.6 Feeding the Children

#### 3.2.6.1 Preparation of High Energy Milk (HEM)

High Energy Milk (HEM), was prepared from the following ingredients:

- 900g Whole cow's milk.
- 20gms/ ml Vegetable oil
- 50g Sugar

The milk was boiled, and while still hot, sugar and oil were added and stirred into the milk.

#### 3.2.6.2 Kitobero Preparation and Service

Each morning the mothers/caretakers prepared *kitobero* for the midday and 6 o'clock feed for the children. The constituents of *Kitobero* varied from child to child from day to day.

Generally each child is required to take two good sources of protein in any of the following combinations:

- Two-plant protein sources. A combination of beans and groundnuts is commonly used.
- A plant protein source and an animal product for example a combination of eggs and groundnuts were usually prepared.
- Two animal foods e.g. eggs and meat together.

The first two combinations were more commonly used than the last one, as mothers were encouraged to use the inexpensive and readily available plant foods.

To any of the above food combinations a carbohydrate source was added. These included, either matoke, irish potatoes, sweet potatoes, maize flour or rice. Every child had its own food container. Water was added to the measured food items in aluminium containers. Food was cooked by steaming the different aluminium containers in a common pot for 3 hours. At lunch time the food was mashed and mothers served their children as much food as they could consume. A portion was left in the container and put over the fire, for the child's 6 O'clock meal.

### *3.2.6.3 Porridge Preparation and Service*

All porridge was prepared in a common pot. A litre of porridge containing approximately 15% total solids was prepared as follows:

60g of un-fermented maize flour were mixed with 90g fermented flour.

This was mixed in 300mls of cold water and poured into 550mls of boiling water, with constant stirring. The porridge was then kept over the fire for 30 minutes with constant stirring. It was then put off the fire to lower the temperature, for 5-10 minutes. Millet ARF 22.5g (15% of the flour used) was added, while stirring until thinning occurred. The porridge was then reheated for another 30 minutes. Amounts served were based on the criteria used for HEM, at the unit. A marasmic child was allowed 100Kcal/kg body weight /day and a kwashiorkor child, 150kcal/kg body weight /day. The child's daily caloric requirements were distributed over 7 feeds/day. The amounts served a child were determined basing on the caloric density of the HEP.

#### 3.2.6.4. Service of meals and record of intakes

Table 3.2 gives the feeding regime of the study children.

The children in the HEM group took high Energy milk at 6:00 am, 9:a.m 3:00 pm 9:00 pm and at midnight. They took two meals of *kitobero* at noon and at 6:00pm.

Those in the HEP group took high energy high protein porridge at 6:00a.m, 9:00a.m and at 9:00pm. They also took HEM and *kitobero* twice; at 3:00pm and midnight, and at midday and 6:00pm respectively.

**Table 3.2 Feeding Regime for the Study Children**

<b>Time</b>	<b>HEM group</b>	<b>HEP group</b>
6:00 am.	HEM	HEP
9:00 am	HEM + OP	HEP
12:00 noon	<i>Kitobero</i>	<i>Kitobero</i>
3:00 pm	HEM	HEM
6:00 pm	<i>Kitobero</i>	<i>Kitobero</i>
9:00 pm	HEM	HEP
12:00 midnight	HEM	HEM

HEM= High Energy milk

HEP= High energy high protein porridge

OP= Ordinary Porridge

Amounts of HEM and HEP served to the children were 150kcal/kg body weight /day for a marasmic child and 100kcal/kg body weight /day, for a kwashiorkor child, as is the practice at Mwanamugimu.

The total caloric requirements were distributed over seven feeds/day, as shown in Table 3.3. The *Kitobero*, High-energy milk (HEM), High-energy porridge (HEP), ordinary porridge and snacks supplied the daily caloric and protein intakes. Amounts served (of the different feeds) and amounts left were recorded to determine intakes.

The daily caloric and protein intakes of the study children were computed basing on food composition table values (West et al., 1988)

### **3.2.7. Sensory Evaluation**

The acceptability of ordinary porridge (OP) and HEP by mothers was assessed using a 5 point hedonic scale, with 1 to 5 corresponding to the following perceptions:

1 -Dislike very much

2 -Dislike

3 - Neither like nor dislike

4- Like

5 - Like very much

The respondents used were selected from among the female caretakers of children in the Pediatrics Ward of Mulago Hospital. A list of those willing to participate was compiled and 30 were randomly selected for the evaluation.

In order to determine the acceptability of HEP by the children, children were served porridge on three different occasions on the same day. Amounts served and amounts left after feeding were recorded and used in the determination of acceptability.

Child porridge acceptability was determined as follows:

Volume of Porridge served - Amount of porridge after feeding x100

Volume of Porridge served

A child was put in the category of children who accepted HEP, when they took more than two thirds of the porridge served to them, on the three different occasions on the same day.

### 3.2.8. Measurements of growth

Children weights were taken daily before the 9:00 a.m feed. Weight measurements were taken to the nearest 0.1Kg using a standardised 25 Kg Salter Spring Balance (Salter weight-tronix Ltd., West Bromwich, West Midlands, UK). Weights were taken using procedures recommended by United Nations (1986). Growth in the study was based on changes in weight. This was done for the mandatory seven days the children had to spend in the study and for the average overall period of stay in the study (11 days). The weight gain during the first seven days of stay in the study was determined as follows:

$$\text{-Weight gain in first seven days (g) = } W^{\text{Weight after seven days}} - \text{weight on first day in study}$$

The weight gain over the overall period of stay in the study (11 days) was determined as follows:

Weight gain in overall period of stay in study = weight on admission into study-final weight.

The growth rates during the first seven days of stay in the study and during the overall period of stay in the study were computed as follows:

$$\text{- Growth rate in first seven days} = \frac{\text{Weight gain in first seven days (g)}}{\text{Weight on first day} \times 7.}$$

$$\text{-Overall Growth Rate} = \frac{\text{Final Weight-Initial Weight}}{\text{Initial weight} \times \text{Total Days in the study}}$$

### 3.2.9. Morbidity experience

Each day, mothers/ caretakers of the children were asked whether the child was suffering from any ailment. They were specifically asked whether the child had diarrhoea. This was recorded on a Weight and Diarrhoea Record Form (Appendix 3). Morbidity experience was defined as the number of times a child was reported to have a disease condition during the study period.



### **3.2.10 Characteristics of study children and their families**

The mothers and caretakers of the children were interviewed (Questionnaire in Appendix 6) to determine the demographic and socio-economic characteristics of the study children and their families

### **3.3 RELIABILITY AND VALIDITY OF DATA**

To ensure completeness and validity of the data collected, all study records were reviewed daily. Weighing scales were periodically standardized using known weights, to reduce instrumental errors.

### **3.4. DATA ANALYSIS**

Data for food intake, weight, infection and diarrhoea experience for the 2 groups were compared by student's t-test using the SPSS (1998) programme. The T- test and Chi-square t( ts were used to determine if children and family characteristics could have been confounding factors in the study.

## 4. RESULTS AND DISCUSSION

### 4.1. *NUTRITIONAL COMPOSITION OF HIGH-ENERGY HIGH-PROTEIN PORRIDGE, HIGH ENERGY MILK AND ORDINARY PORRIDGE*

The nutritional composition of High-energy high-protein porridge (HEP), HEP flour, High Energy Milk (HEM) and Ordinary Porridge (OP) are given in Table 4.1 and Table 4.2. The protein content (about 14.6%) and fiber content (5%) of HEP flour meets the recommendations by Hofvander and Underwood (1987). The calcium and Phosphorus content of HEP flour was 300 and 400mg /100g of product, respectively. Consumption of two meals of HEP (250mls @) therefore meets the recommended daily allowances for children (Passmore and Eastwood, 1986)

The energy density of HEP (0.9Kcal/ml) was comparable to that of HEM (1 Kcal/ml) that is presently used at the Mwanamugimu Nutrition Unit. The high energy density of HEP was achieved by the use of millet ARF. This allowed increase of the amount of flour used to twice the amount that is ordinarily used (15% Vs 7%). This is in agreement with earlier studies (Mosha and Svanberg, 1983; Golpadas et al., 1988; Marero et al., 1988; Hansen et al., 1989; Gimbi et al., 1997). According to Svanberg (1983) the energy density of weaning foods should exceed 0.7 kcal/gram and preferably be about 1.0 kcal per gram. The increase in the energy density of the maize-based gruel by addition of millet ARF gives such foods an advantage over those to which no malt is added.

HEP had a higher level of protein than ordinary porridge. This is attributed to the inclusion of beans, which are good sources of protein. Beans and other legumes are inexpensive sources of protein, which are good in supplementing other food proteins, notably the cereals (Cameron and Hofvander, 1983; Augustin and Klein, 1989).

**Table 4.1: The proximate composition of HEP flour**

<u>Component</u>	<u>Amount (%)</u>
Moisture content	<b>11</b>
Ash	2.6
Fat	4.6
Protein	14.6
Fiber	4.1
NFE	74
Ca	0.03
P	0.04
Fe	0.04

\* All components except moisture expressed on dry weight basis.

NFE= Nitrogen Free Extract

**Table 4.2: Protein and Caloric Content of HEP, HEM and OP**

<u>Food</u>	<u>Protein (g/ml)</u>	<u>Calories/ml</u>
HEM	0.0355	1
HEP	0.021	0.9
OP	0.0072	0.25

HEM= High Energy Milk

HEP= High-energy high-protein porridge OP= Ordinary Porridge

FAO/WHO/UNU (1985) recommends a caloric intake of 1200Kcal/day for a child of 1-2 years. Children of this age consume on average 250 mis of porridge at a sitting. It would be necessary to take HEP/HEM 5 times compared to OP 18 times to satisfy their caloric requirements, if the diet was composed of porridge alone. In many developing countries, children have four meals / day implying that a child would cover 40% of the daily caloric requirement, from consumption of two meals of HEP (Ljungqvist et al., 1981).

#### **4.2. SENSORY ACCEPTABILITY OF OP AND HEP**

The average acceptability scores for OP and HEP by mothers were not different (3.6 and 3.9 respectively). These scores imply that the mothers liked the porridge acceptable (see Appendix 2). All mothers indicated that they would give both OP and HEP to their children. The fact that mothers would be willing to give HEP (an unfamiliar product) to their children is encouraging. It suggests success in the introduction of HEP in communities, as mothers are important in the adoption of new weaning foods.

70% of the children tried on HEP accepted it, while the rest rejected It. This means HEP has potential for acceptability more or so in a community setting, with healthy children as in the present study to convalescent children were used and they took the porridge.

#### **4.3. Demographic, socio-economic and anthropometric characteristics of parents and families of study children**

The nutritional deficiency diseases in developing countries are primarily due to inadequate diets. They are also closely related to the poor socio-economic and environmental conditions prevailing in these areas. The populations are usually of low socio-economic status, which is determined by socio-demographic characteristics such as large family sizes, high birth rates, low formal education, lack of health and nutrition education and poor environmental sanitation. The deficiency diseases mainly affect children under five years of age because of their high nutritional requirements (Ljungqvist et al., 1981; Parkin and Stanfield, 1991; Taba 1969). These characteristics can also influence the acceptance and success of nutrition rehabilitation of children. The demographic and socioeconomic characteristics of families and parents of children in the study are presented in Tables 4.3a and 4.3b.

Both groups had similar family sizes (6 and 5.8 for HEP and HEM groups respectively). The average number of underfives in the households where the children came from was 2.3. About a third of the fathers in both groups had completed secondary education (34.4% and 31.3% for the HEP and HEM groups, respectively). The average age of the fathers was 30 years and the majority, were self-employed. There was no difference in the characteristics of fathers of children in both study groups.

Mothers in the two categories had similar characteristics apart from pregnancy status. The HEP group had more pregnant mothers/female caretakers than the HEM group. However this could not affect study results as the study group dealt with institutionalised children, cared for by hospital staff. The average age of the mothers was 25, with an average of 2 children and 3 pregnancies. This number is high for the average age of mothers recorded (Burton and Wamai, 1994). The majority, were from peri-urban Kampala. The average BMI was 22 indicating that the mothers were well-nourished (King and Burgess, 1992).

**Table 4.3a: Demographic, Socioeconomic and Anthropometric Characteristics of Mothers of Study Children**

	<b>HEP group N=39</b>	<b>HEM group N=43</b>	<b>Statistical Significance (a=0.05)</b>
<b>Characteristics</b>			
Mother's Age (Yr.)	25.8	24.6	NS
Mother's Weight (Kg)	56.4	53.8	NS
Mother's Height (cm)	162.1	162.2	NS
Mother's Education			NS
No Education	12.5%	14.3%	
Some Primary Educ	45%	33.3%	
Completed Primary Educ	22.4%	26.2%	
Some Secondary Education	12.6%	21.4%	
Completed Secondary Education	7.5%	4.8%	
Pregnancy Status			S
Pregnant	30%	11.9%	
Not Pregnant	70%	88.1%	
Number of Pregnancies	2.8	3.0	NS
Number of Children Alive	2.4	2.5	NS
Breast Feeding Status			NS
Breast Feeding	15%	26.89%	
Not Breast Feeding	85%	73.2%	
Breast Feeding Duration (Mths)	11.6	10.6	NS
Mother's Occupation			NS
House Wife only	42.5%	34.1%	
House wife & Farmer	15%	22%	
Salaried employee	5%	4.9%	
Self employed	20%	24.4%	
Casual laborer	0%	2.4%	
Unemployed	17.5%	12.2%	
Mother's Marital Status			NS
Single	22.5%	30.2%	
Married	65%	65.1%	
Widowed	5%	0%	
Divorced	2.5%	0%	
Separated	5%	4.7%	

S= Significantly different    NS = Not Significantly different

**Table 4.3b: Demographic and Socioeconomic Characteristics of Fathers and Families of Study Children**

Characteristic	HEP group N=39	HEM group (N=43)	Statistical Significance (a=0.05)
Father's Education			NS
No Education	3.1%	9.4%	
Some Primary Education	12.5%	25%	
Completed Primary Educ	28.1%	15.6%	
Some Secondary Education	21.9%	21.9%	
Completed Secondary Education	34.4%	31.3%	
Father's Age (Yr.)	29.6	30.1	NS
Father's Occupation			NS
Farmer	14.8%	11.8%	
Salaried employee	22.2%	17.6%	
Self employed	37%	50%	
Casual laborer	7.4%	14.7%	
Unemployed	18.5%	5.8%	
<b>Family Characteristics</b>			
Family Size	6	5.8	NS
Number of Children	3.05	3.09	NS
Number of Children Underfive in House Hold	2.4	2.2	NS
Number of Underfives for 2 Mother	2	2	NS

5= Significantly different      NS= Not significantly different

There were more breastfeeding mothers in the HEM group than in the HEP group (26.9% and 15% respectively). However, the difference was not statistically significant ( $P>0.05$ ).

As far as employment status is concerned most of the mothers in both groups were in the category of housewives (42.5% and 34.1% for the HEP and HEM groups respectively). The proportion of mothers who were unemployed (and not housewives),



was however higher for the HEP group (17.5%) than for the HEM group (12.2%). The difference was not statistically significant ( $P < 0.05$ ).

The majority of the mothers in both groups indicated that they were married (65% for both groups). When mothers were categorised basing on education status it was found that the biggest percentage of the mothers in both groups (45% and 33.3% for the HEP and HEM groups respectively) had attended, but not completed primary education.

#### **4.4 CHILDREN CHARACTERISTICS**

The anthropometric and socio-economic characteristics of children in the study are given in table 4.3c.

The anthropometric and socio-economic characteristics of children in the study did not differ apart from the distribution of children by sex. The HEP group had a higher percentage of males than the HEM group. However, there was no adjustment to variables in consideration because for practically all characteristics of the children there was no difference. Further-more, growth rates and food intake which are the emphasis of the study, are not affected by sex in children under five years of age (Kalberg et al., 1994).

**Table 4.3c. Anthropometric and Socio-economic Characteristics of the study children**

Characteristic	HEP group N=39	HEM group N=43	Statistical Significance ( $\alpha=0.05$ )
Child age (Mths)	20.1	18.3	NS
Sex			S
Male	70%	37.2%	
Female	30%	62.8%	
Child Weight (Kg)	7.2	6.5	NS
Child Height (cm)	71.9	69.8	NS
Birth Order	2.65	2.67	NS
Type of PEM			NS
Kwashiorkor	42.5%	47.6%	
Marasmus	45%	33.3%	
Marasmic-Kwashiorkor	12.5%	19%	
Immunisation status:			NS
Fully Immunised	62.5%	44.2%	
Partially immunised	35 %	51.2%	
Never Immunised	2.5%	4.6%	
Vit. A supplementation:			NS
No. received	85%	79.1 %	
No. not received	15%	20.9%	

S = Significantly different

NS = Not significantly different

The average age of the children, in the HEP and HEM groups were 20 and 18 months respectively. The average breast-feeding period was 11 months, a figure lower than the national average of 18 months (UNFNC, 1996). The majority of children in both groups (87.1%) had stopped breastfeeding. Most of the children were of the second birth order.

No significant difference was observed in the immunisation status of the two groups. About 62.5% of the children in the HEP group and 44.2% of those in the HEM group had been fully immunised, while 35% and 51.2% of the children in the HEM and HEP groups respectively were partially immunized. All children above 9 months of age were given measles immunization on admission to the center.

When the children were categorised by type of PEM it was observed that there was no significant difference in PEM distribution between the two groups ( $p>0.05$ ). There was thus no need to adjust data for this variable. The majority of the children in the HEP group (45%) had marasmus while 42.5% had kwashiorkor and 12.5% marasmic-kwashiorkor. The HEM group had slightly higher proportion of children with kwashiorkor (47.6%), while 33.3% had marasmus and 29.1% had marasmic-kwashiorkor.

The Vitamin A status is an important factor that may affect growth. It has been shown to affect the morbidity of children and is required in the maintenance of epithelial cells. This has bearing on the condition of the gastro-intestinal tract, which affects food intake, absorption and utilization (Guthrie and Picciano, 1995). According to UNICEF (1998) even mild Vitamin A deficiency impairs the immune system, reducing the children's resistance to diarrhoea, which kills 2.2 million children a year and measles which kills nearly 1 million children annually. The majority of the children in both

groups (85% and 79% for the HEP and HEM groups respectively) had received vitamin A supplements on admission to Mwanamugimu.

#### 4.5. GROWTH, MORBIDITY EXPERIENCE, AND PROTEIN AND CALORIC INTAKE OF THE CHILDREN

Infections and food intake are important factors that affect growth of children. The protein and caloric intakes of the study children and their illness experience were compared to determine if they could have had effect on the growth of children in the two study groups.

The caloric and protein requirements for catch-up growth during nutrition rehabilitation are 100-200 Kcal/Kg body weight/day and 3-5g protein/kg body weight /day respectively. Feeding children on a highly nutritious diet with milk as a component can provide such high levels of protein and energy (King and Burgess, 1992). The HEP group in the study had some of the milk in their diet substituted with High-energy high-protein porridge (HEP). This was done in a bid to reduce rehabilitation costs. It was also based on the recommendation by Reddy (1991) that a diet that provides 3-4 g protein /kg of body weight / day with at least one fourth of it derived from milk is adequate in the treatment of PEM. In the present study the HEP group had approximately 20% of their energy from milk, but also obtained animal protein from *kitobero*.

The protein and caloric intakes of the children in the two study groups are shown in Table 4.4.

**Table 4.4 Protein and Caloric Intakes of Study Children**

Group	Caloric Intake/ day	Energy (cal/kg Bwt/ day	Protein Intake per day	Protein (g/kgBwt weight/day
Test	1164±271	168±38.1	41.6±14.2	6 ±2.1
Control	1027±240	153.7±36.9	36.7±15.4	5.6±2.5
P-Value	0.018	0.09	0.14	0.38

Bwt = Body Weight

Both study groups received adequate amounts of calories, per Kg body weight per day (168±38.1 and 154±36.9 Kcal/Kg body weight/day, for the HEP and HEM groups respectively). Both groups received adequate amounts of protein (6±2.1 and 5.6±2.5 grams of protein per Kg body weight per day, for the HEP and HEM groups respectively). There was no significant difference in caloric and protein intakes per kb body weight per day between the two groups.

The HEP group obtained 39% of their daily caloric intakes from *kitobero*, 39% from HEP and 28% from HEM. The HEP group obtained 34% of their daily caloric intakes from *Kitobero* and 57% from HEM.

The high protein and energy density of HEP made it possible for children in the HEP group to achieve high intakes. The use of maize and beans, which are locally produced and readily available products in Uganda and in many developing countries makes HEP a suitable component in any rehabilitation and supplementation diets. It has an energy density of 0.9kcal/ml and is thus in the category of foods of a high energy density (Svanberg, 1983).

The feeding regime at the Mwanamugimu Nutrition Unit and the regime administered in the study gave higher caloric and protein intakes than those observed in similar studies. Kalavi et al (1996) observed mean daily protein and caloric consumption (per Kg body weight / day) of 3.4g and 83 calories, respectively for the yellow-maize milk porridge (YMMP) group and 3.9 grams of protein and 101 calories for the *Tempe* Yellow Maize Porridge (TYMP) group.

Since the protein and caloric intakes of the children in the two study groups compare, it would be expected that they would have similar growth rates.

In the first seven days of the study it was observed that the children in the HEP group had similar percentage of children who gained weight (83.8%) than the HEM group (80%) as shown in Table 4.5.

**Table 4.5 Distribution of Study Children according to Weight Change**

Category of Weight gain	<u>HEM group</u>		<u>HEP group</u>	
	<u>First 7 Days in study</u>	<u>Overall period</u>	<u>First 7 Days in study</u>	<u>Overall period</u>
Children gaining (%)	80.0	90.7	83.8	91.9
Children losing (%)	11.6	9.3	13.5	5.4
No change in weight (%)	8.4	0.0	2.7	2.7

**Table 4.6: Growth of Study Children in Different Groups.**

Group	Weight change in first 7 days	Growth rate in first 7 days (s/KgBwt/day)	Overall growth rate (g/KgBwt/day)
HEP group	497±325	10.14±5.95	8.24±4.95
HEM group	348±272	7.01±4.75	7.28±5.75
p-value	0.05	0.025	0.45

Table 4.6 gives the growth rates of the study children, during their first seven days of stay in the study and during the overall period of stay in the study while Figure 2. gives the changes in average weight for all children in the two groups over time. The rate of weight gain in the first seven days were higher in the HEP group than the HEM group (10 and 7 g/kg body weight/ day for the HEP and HEM groups respectively ( $p < 0.05$ ). It can be deduced that HEP is better medium for catch-up growth at the onset of nutrition rehabilitation, when the body's deficit for energy and nutrients is high.

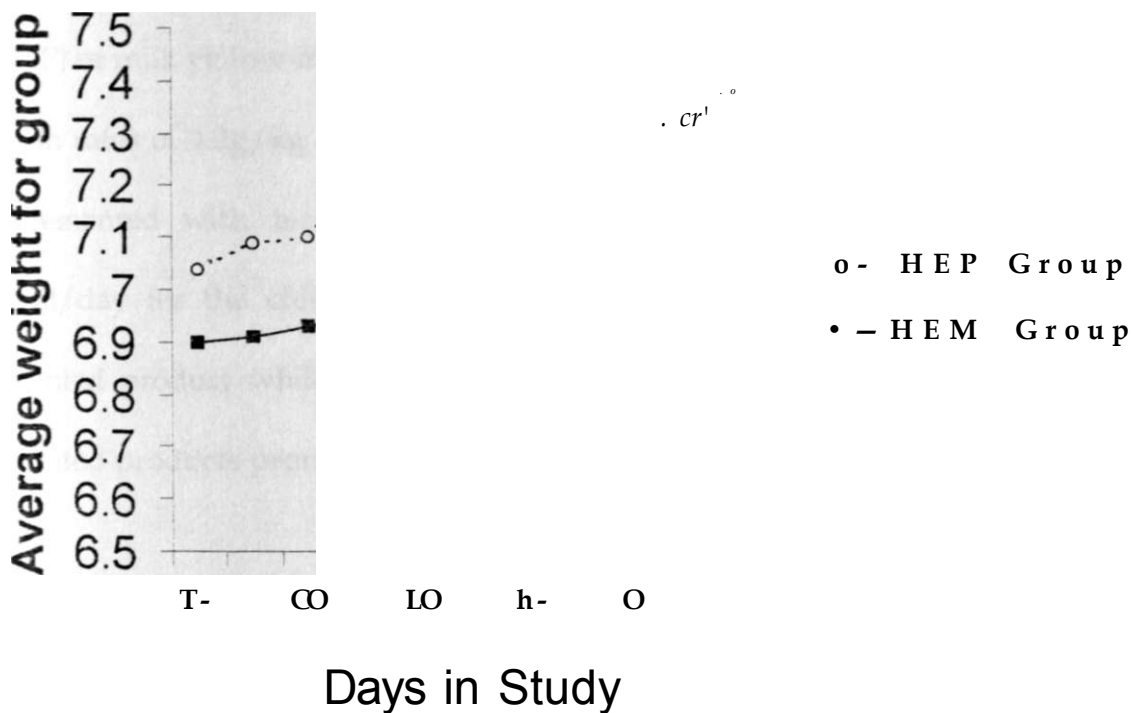


Figure 2. Change in average weight for the two study groups

After the deficit is reduced or cleared, growth continues at about the same rate for children on both diets.

However, growth rates during overall period of stay in the study (11 days) did not differ (8 and 7 g/kg body weight/day for the HEP and HEM groups respectively

( $P > 0.05$ ) The weight gain, in the first seven days for both groups were higher than set targets for the unit (250 g weight gain in seven days).

The growth rates (g/kg body weight/day) observed in the study are higher than those observed in similar studies. Kalavi et al (1996) observed growth rates of 5.2 g/kg body weight/day and 2.2g/kg Body weight/ day, respectively, when the diets of severely



malnourished children were supplemented with either tempeh-yellow maize porridge (TYMP) or milk yellow-maize porridge respectively (MYMP). Wachira (1996) observed growth rates of 4.2g/kg Body weight/day when diets of malnourished children were supplemented with tempeh-white maize porridge and a rate of 1.4g/kg Body weight/day for the children on the usual rehabilitation diet. Tempe is a mould-fermented product while HEP was lactic fermented. It may be deduced that lactic fermented products promote growth faster than mould-fermented products.

The good performance of children on HEP can be attributed to the nutritional advantages of fermented cereal- legume mixtures. This is in agreement with other studies. Cereal-legume mixtures have been known to have numerous nutritional advantages. They have large quantities of B-vitamins and minerals critical in protein biosynthesis. Narayama (1984) showed that a weaning gruel from defatted winged bean flour and corn has a nutritional value equivalent to that of milk and showed that it could be successfully used in the treatment of kwashiorkor. Cereal-legume mixtures have an added advantage if they are fermented. Many studies have assessed the effect of fermentation on the nutritional quality of cereals and legumes (alone or in combination). Improved quality was observed (Chavan and Kadam, 1989; Svanberg et al, 1993; Sharma and Kheterpaul, 1997; Shekib, 1993; Barampama and Simard, 1995; Pederson, 1971; Addo et al, 1996). This was attributed to reduction in phytates and other anti-nutritional factors and to improvement in digestibility and availability of

nutrients. Improvements in PER values due to fermentation of cereals and legumes have been observed (Wang and Hesseltine, 1981; Kheterpaul and Chauman, 1991).

Diarrhoea and infections are factors, which affect the growth of children. Further more many children with PEM are brought to hospital for treatment of associated infections, majority of which are gastroenteritis and respiratory infections (Reddy, 1991). On admission these are addressed first before the dietary management commences. The infections may recur during the dietary phase since the children's resistance to infection is still low. The occurrence of diarrhoea and other illnesses among the study children is summarised in Table 4.7 (page 70). Illnesses were a problem in the implementation of the study. Severely sick children (5 and 7 in the HEM and HEP groups respectively) were dropped from the study, as they could not afford the stress of regular weighing. In addition, such children's appetite for foods was impaired and they rejected food particularly HEP and *Kitobero*.

Table 4.7 Experience of Diarrhoea and other Illnesses among Study Children

Illness	Mean Experience (dayst SP)		P-value
	HEP group	HEM group	
Diarrhoea	0.6 ±0.9	0.3 ±0.7	0.18
Cough	2.8 ± 2.7	2.5 ± 2.4	0.59
Fever	1.1 ±1.3	1.5 ±1.6	0.32
Flu	0.9 ±3	0.6 ±1	0.55
Vomiting	0.6 ±0.8	0.4 ±0.8	0.29

The common illnesses that were reported by the mothers of the children in the study were cough, flu, fever, diarrhoea and vomiting. The diarrhoeal experience of the study children was  $0.6 \pm 0.9$  days for the HEP group and  $0.3 \pm 0.7$  days for the HEM group, which was not statistically different. There was also no difference in experience of the other illnesses between the study groups ( $P > 0.05$ ). This implies that diarrhoea and the other illnesses did not affect growth of children in the two study groups. Some authors have reported a reduction in the experience of diarrhoea when fermented foods are used (Kalavi et al., 1996; GURT and UNICEF, 1985). This was not however observed in the present study. This was probably because the study was done in controlled hospital conditions where exposure to diarrhoeal pathogens is low. In this study, cough was the most prevalent ailment, with an experience of 2.8 days and 2.5 days for the HEP and HEM groups respectively. This is not surprising as PEM children often suffer from respiratory tract diseases (Reddy, 1991).

#### **4.6 COST OF HEP AND HEM**

The approximate cost per litre of HEP was estimated at Kshs 10 (Ushs 200). The cost of HEM was Kshs 46 (Ushs. 924). Thus, feeding on HEP reduces the cost approximately four-fold. HEP was produced from maize and beans, which are generally cheap in Uganda. Cereal-legume mixtures have the advantage of being cheap and readily available. HEP is produced using low cost technologies, which are easily adapted to the rural setting in Uganda and other developing countries, where malnutrition

abounds, due to consumption of low energy and nutrient density weaning foods. HEP is thus a suitable weaning food for the low-income communities in developing countries.

## 5. CONCLUSIONS AND RECOMMENDATIONS

### 5.1 CONCLUSIONS

Below are the conclusions that were made from the study:

1. A high energy and protein dense product (HEP) can be made from lactic fermented maize-kidney bean mixture using millet ARF.
2. The HEP has a caloric and protein density that is close to that of high-energy milk (HEM) presently used at Mwanamugimu. Its caloric and protein density however exceeds that of ordinary porridge (OP) used at Mwanamugimu and in many homes in Uganda, as a weaning and complementary food.
3. HEP is a suitable substitute for milk in the diet for feeding severely malnourished children (6-59 months).
4. HEP has potential for acceptability by mothers and children in the low-income communities of the world where malnutrition abounds.
5. HEP is inexpensive and its substitution for HEM would reduce the cost of nutrition rehabilitation.

## **5.2 RECOMMENDATIONS**

Further study is needed in the following areas:

1. Optimisation of the formulations of HEP flour preparation.
2. Determination of the performance of other cereal-legume combinations.
3. Study on the amino acid profile of HEP flour and the protein bioavailability
4. The storage stability and survival of pathogens in HEP flour.
5. The performance of children on HEP in a community setting.

HEP could also be produced and used as a substitute for HEM at Mwanamugimu. The mothers can be taught how to produce HEP at the village setting, and they could be Encouraged to teach other mothers from their respective communities.

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## APPENDICES

## Appendix 1.

## QUESTIONNAIRE

Date.../... / 19...

Interviewer...

Pediatric Unit/Ward ... Q. Number...

## MOTHER'S INFORMATION.

1. Mother's Name...
2. Mother's Age ...(Yrs) Mother's Weight... (Kgs) Mother's Height...(Cm)
3. Family Residential Area:            Division/Zone...Village...
4. Mother's Education:                []
  - 1 = Completed Primary school.
  - 2 = Some Primary education
  - 3 = Completed O'Level.
  - 4 = Some secondary Education
  - 5 = Completed Tertiary Education.
  - 6 = Never went to school
- 5a Pregnancy Status                    []
  - 1 = Pregnant



5b. Number of pregnancies

5c. Number of live births

6a. Breast - Feeding Status.....[ ]

1 = Breast - Feeding

2 = Not Breast - Feeding

6b. Length of breast-feeding.....(Months)

7a Mother's Occupation                      jj

1 = House wife only

2 = House wife and farmer

3 = Salaried employment (teacher, clerk, nurse, etc)

4 = Self employed/business/Hawking/Salon

6 = Casual labourer

7 = Unemployed

7b Fathers Occupation [ ]

1= farmer

2 = Salaried-employment (teacher, clerk, nurse, etc)

3 = Self-employed/business/ Hawking/Salon

4 = Casual laborer

5 = Unemployed

8. Family size:

a. Number of children [ j

b. Number of children under 5 years (I) In household [ ] (ii) For Mother [ ]

9. Mother's Marital Status [ ]

1 = Single

2 = Married

3 = Widowed

4 = Divorced

5 = Separated

10. Father's age (Years) [ ]

11. Father's Level of Education: [ ]

1 = Completed Primary school.

2 = Some Primary education

3 = Completed "O" Level.

4 = Some secondary Education

5 = Completed Tertiary Education.

6 = Never went to school

#### CHILD'S INFORMATION.

12. Name

13. Date of Admission

14. Date of birth ... / ... / ... Age in months...

15. Sex [ ] 1 = male 2 = female

16. Birth order... [ ]

17. Weight (Kgs)... Weight for Age (WFA. ....%

18. Length/Height....(cm)...

19. Type of PEM

1 = Kwashiorkor

2 = Marasmus

3 = Marasamic - Kwashiorkor

20. Cause of admission

a)...

b)...

c)...

21. Immunisation Status:

Immunisation type	After Birth	1	2	3
BCG				
DPT				
OPV				
Measles				

Tick corresponding box

22. Has the child received Vitamin A supplements?

1. Yes  2. No

23. Did your child experience any sickness within the last two weeks?

1. Yes  2. No

24. If yes, which one (s)...

## Appendix 2

### SENSORY ANALYSIS SHEET

Mother's Name...

Age...

Years of Formal Education...

Two samples of porridge are provided. Please circle the number that corresponds to the mothers ranking for each sample.

Code...

Code...

5 Like very much (Bulungi nyo)	5 Like very much (Bulungi nyo)
4 Like (Bulungi)	4 Like (Bulungi)
3 Neither like nor dislike (Bwe Butyo)	3 Neither like nor dislike (Bwe Butyo)
2 Dislike (Bubi)	2 Dislike (Bubi)
1 Dislike very much (Bubi nyo)	1 Dislike very much (Bubi nyo)

Circle yes or no to indicate whether you would feed your child on the porridge provided.

Code ...(Yes/No)

Code ...(Yes/No)



## APPENDIX 4

## FOOD RECORD FORM

Child's Name .....S No

Date .....Ward No

Kitobero ingredients

Weight of Container	Ingredient Description	Amount (g)	Total food + Container (g)	Total weight of food (g)

Weight of cooked food + container (g)

Weight of cooked food (g)

Food service record

Meal	Wt. of Plate (g)	Plate + food (g)	Plate +extra food (g)	Plate + food left (g)	Food eaten (g)
Lunch					
Supper					

## APPENDIX 4

## FOOD RECORD FORM

Child's Name

S No.

Date

Ward No.

Kitobero ingredients

Weight of 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	Wt. of Plate (g)	Plate + food (g)	Plate +extra food (g)	Plate + food left (g)	Food eaten (g)
Lunch					
Supper					



HEP, HEM, OP and Snack Record

<b>Meal</b>	<b>Amount served</b>	<b>Amount left (ml/g)</b>	<b>Amount taken ml/g</b>	<b>Time</b>
	.			

**HEM = High-energy milk, HEP = High-energy porridge, OP = Ordinary Porridge.**