

THE USE OF SWEET POTATOES IN THE IMPROVEMENT OF THE
ENERGY CONTENT OF WEANING GRUELS IN MPIGI DISTRICT,
UGANDA.

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the degree of Master of Science in Applied Human Nutrition of the
University of Nairobi.

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1997

DECLARATION

I MARY NAKUBULWA hereby declare that this thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

This work is dedicated to my parents Mary and Charles Kasujja who have sacrificed a lot to ensuring my welfare.

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DEFINITIONS

Dietary Bulk density : The concept of dietary bulk refers to the factors in the food that make it difficult for an individual to consume that food in sufficient amount to cover the energy and nutrient requirements. The energy /nutrient density and the consistency of the diet are the two characteristics identified as dietary bulk factors.

Consistency (Viscosity): The behaviour of matter to deformation. In case of a Food indicates the ease with which it can be eaten.

Diet: All forms of food eaten/consumed including fluid.

Dish : Particular type of food prepared for a meal.

Energy density (Energy concentration): The energy value per unit weight or volume of food. It is usually expressed as Kcal/g (or Kcal/ml).

Food consumption (Synonyms; food intake; dietary intake): This is food and drink ingested. In the first stage it is expressed by type of food or drink. The measurement can be in terms of quantities or frequencies of the different types of food or drink ingested during a given time unit per individual. The ultimate expression of quantities consumed is in terms of energy and nutrients.

Food consumption survey (Synonyms dietary survey): Is a survey designed to obtain qualitative and/ or quantitative information on the food actually eaten.

24- hour recall method : Used at individual level is a procedure to find out, by means of an interview, the actual food intake of an individual during the immediate past, usually 24 hours or the preceding day.

Gruel : A cooked thin porridge made from maize meal or other cereal flour.

Malting : Germination of a cereal to increase the amylolytic enzyme content.

Meal : A combination of two or more dishes.

Nutrition Gap : Refers to the situation where national food balance sheets reveal self- sufficiency, but nutrition surveys show stunting and retardation.

Nutrition Lag : Refers to declining infant and child mortality without decline in childhood malnutrition.

Weaning : The feeding of infants with foods other than breast-milk to supplement the mother's breast- milk.

ABBREVIATIONS (ACRONYMS)

ANOVA	Analysis of variance.
ARF	Amylase Rich Food/Flour.
CIP	International Potato Centre.
FAO	Food and Agriculture Organisation.
GOU	Government of Uganda.
IDRC	International Development Research Centre.
INCAP	Institute of Nutrition for Central America and Panama.
mls	Millilitres.
PEM	Protein Energy Malnutrition.
RC	Resistance Committee/Council.
RDA	Recommended Daily/ Dietary Allowance.
UDHS	Uganda Demographic and Health Survey.
UNICEF	United Nations Children's Fund.
UNU	United Nations University.
WHO	World Health Organization.
w/w	Weight / Weight.
w/v	Weight / Volume.
g (gm)	grams.
SD	Standard deviation.

ABSTRACT

The objective of this study was to investigate the possibilities of improving energy density of maize-based weaning gruels in Mpigi District, Uganda using sweet potatoes.

A 24 -hour dietary recall was carried out to determine the types of foods used for weaning infants, the levels of intake of the foods by the infants and the contribution of the foods to the energy intake. Results indicated that maize-based gruels constituted the main food for weaning infants second only to milk. The maize gruels were fed to the infants at a consistency which permitted only an average energy density of 0.25 KCal/ml. This resulted in energy intakes between 171 Kcal to 225 Kcal; with up to five feedings at 137mls - 180mls per feeding.

Methods of preparation of the maize gruels were simulated in the laboratory. Weaning gruels were prepared and their viscosities determined as standards to develop products with the same consistency, but with higher energy densities, through liquefaction with amylolytic enzymes from sweet potatoes. Gruels with 15% and 20% maize flour were prepared and liquified accordingly with enzymes from fresh and dehydrated sweet potatoes.

It was possible to reduce the thick gruels to the viscosity desired with addition of 16.7% (w/w) of sweet potato flour, and at the same time raise the energy densities to 0.60 KCal/ml and 0.80 KCal/ml respectively. This represented 140% and 220% increment respectively, in the energy densities. Consumption of these gruels at the usual rates would contribute to the energy RDA for infants of 57% - 79%. The inclusion of sweet potato in the gruels did not alter their acceptability significantly.

The study established that maize gruels of energy densities sufficient to supply the required energy RDA for infants could be prepared from maize flour through liquefaction with amylolytic enzymes from sweet potatoes.

CHAPTER ONE

INTRODUCTION.

In the past, much emphasis was given to development of protein rich foods as shortage of these was perceived to be the most common cause of morbidity and mortality among infants and preschool children in developing countries. The current view is, however, that inadequate energy and not protein is the main aetiological factor in infantile malnutrition, because the intake of energy becomes inadequate soon after the third month and does not increase much between the ages of 7 and 30 months. Dietary protein intake though low, increases with age (Ebrahim, 1990). It has also recently been recognized that in most cases, protein needs can be reasonably met when some cereals are consumed in adequate quantities. This also prevents deficiency in energy. Energy deficiency can aggravate protein deficiency (Ebrahim, 1990 ; Scrimshaw, 1994; Ihekoronye and Ngoddy, 1985) as total dietary energy must be adequate in order for protein to be used in growth and tissue maintenance and repair rather than an energy source.

Children are mostly weaned on gruels prepared from starchy cereals, root-crops or plantains. Consumption of sufficient gruel to provide sufficient energy is therefore difficult due to the high bulk density of these foods. The gruels have to be prepared thin for easy consumption by children. This greatly lowers their energy density (King and Burgess, 1993).

The most common method of reducing bulk in cereal gruels is by germination of the cereals, whereby amylolytic enzymes are elaborated. During preparation of the gruels, these enzymes hydrolyse the starch which is the main cause of bulkiness in the gruel. In fact small quantities of flour from germinated cereal grains such as millet, sorghum, wheat and maize added to porridge during preparation has been shown to make the porridge thinner (Moshia and Svanberg, 1983), while still retaining the high energy density. Such studies have been conducted by Lorri (1993) in Tanzania, Golpadas *et al.*, (1988) in India and by Alvina *et al.*, (1990) in Chile. Pure enzyme preparations can also be used but they would be more expensive and difficult to handle by common housewives than germinated cereals.

Uganda has gap and mortality nutrition lag. Gap refers to a situation where national food balance sheets reveal self sufficiency, but nutrition surveys show stunting and retardation. Lag refers to declining infant and child mortality without decline in childhood malnutrition (Teller *et al.*, 1990). An estimated 30% of preschool children in Uganda suffer from chronic malnutrition, the majority of which is caused by inappropriate weaning practices (Sserunjogi, 1988). Moderate to severe under nutrition in children 3-35 months of age has been found to be most prevalent (Sommerfelt, 1991).

In most cultures, traditional non-milk weaning foods are based on the local staples, usually cereals, which are normally prepared as thick porridges or liquid gruels. Occasionally, the cereals for preparation of these foods could be germinated or the gruels could be fermented.

In Uganda the sweet potato is presently widely cultivated in home gardens or as field crop and constitutes one of the major staples. The crop occupies about 9% of food crops area and ranks fourth in importance after finger millet, bananas and cassava (Woolfe, 1992). Over 80% of total production is used as food and the actual quantity available for consumption per person annually is 127kg (Horton, 1988). Sweet potatoes have been said to possess high amylolytic activity (Balls, 1948). This activity could be used to increase energy density in cereal-based gruels just like germinated millet could. To date, little information exists regarding the extent to which these enzyme sources can be used to increase energy density in cereal-based gruels in East Africa. Therefore this study was carried out to try and overcome the problem of dietary bulk by adding sweet potatoes to maize gruels.

To achieve this objective the following specific objectives were formulated:

- 1.to determine the volume of gruels consumed by infants.
- 2.to determine the calorie content of maize gruels consumed by infants.
- 3.to determine the consistency (viscosity) of maize gruels consumed by infants.
- 4.to determine the appropriate levels of maize flour in the gruels required in order to meet the recommended daily dietary energy allowance for infants.
- 5.to determine the amount of fresh sweet potato to be added to the maize gruel to attain the viscosity determined of the gruels consumed by infants.
- 6.to determine the amount of dried sweet potato flour to be added to the gruels in order to increase the calorie density of the gruels to levels where their consumption help meet RDA for energy in infants.
- 7.to determine the amount of germinated finger millet flour to be added to the gruels in order to meet the RDA for energy in infants.

1.1 EXPECTED BENEFITS.

The low cost high energy maize flour formulations which will be developed will have the potential of being produced locally, adoptable for household consumption and can well be a substitute for commercial infant formulae. Being cheap and locally available this formulation will suit the purpose of low income families. Since it is a culturally acceptable food, the formulation can also be developed as income generating activity to be popularized through local women clubs.

CHAPTER TWO

LITERATURE REVIEW.

2.1. PRESENT STATE OF PROTEIN ENERGY MALNUTRITION.

Protein energy malnutrition (PEM) is the most serious nutritional problem affecting preschool children in developing countries. At any time approximately 100 million children suffer from moderate to severe forms of PEM (Ebrahim, 1990). This widespread, serious and extensively studied form of nutritional disorder manifests features which vary from one part of the world to another, due mainly to the great variation in the nutrient content of the diet, the prevalence of antecedent illness, the variability of the person, and the time over which the causative factors operate (Ebrahim, 1990). Protein Energy Malnutrition strikes hardest in the first 12 months after birth. At this stage therefore, the tiny stomach requires constant feeding (UNICEF, 1994). Two distinct clinical symptoms described as kwashiorkor and marasmus represent the severe forms of PEM (Ebrahim, 1990). In most developing countries, about 50% of all preschool children are chronically malnourished and about 7% of these are severely malnourished.

2.2 PROTEIN ENERGY MALNUTRITION IN UGANDA.

Uganda has both *gap* and mortality-nutrition *lag*. *Gap* refers to the situation where national food balance sheets reveal self-sufficiency, but nutrition surveys show stunting and retardation. Stunting represents the chronic form of PEM. *Lag* refers to declining infant and child mortality without decline in childhood malnutrition (Teller *et al.*, 1990). It has been reported that 45% of the under-fives are stunted and about 1-5% are severely malnourished (Kaijuka *et al.*, 1990 ; GOU, 1992). Moderate to severe under nutrition in children 3-35 months of age is most prevalent in Uganda at 44% (Sommerfelt, 1991). The low energy density of the diet coupled with the low frequency of feeding contribute to this condition (Kakitahi, 1981 ; Ebrahim, 1990).

Uganda is divided into three broad "food belts", namely plantain (banana)/ tuber (sweet potato, cassava) areas in the South and central, millet/ sorghum areas in the northern region and the pastoralist/ cattle keeping areas in the North Eastern. Most of the chronic form of PEM is in the predominantly plantain (banana) area, while the acute form of kwashiorkor is more common in the plantain /tuber areas in the South and central. Marasmus is prevalent in the millet/sorghum areas in the northern region, especially during the hungry season before harvest (GOU, 1992). Marasmus is also common in the pastoralists/ cattle keeping areas in the North Eastern, whenever there is a prolonged dry season.

2.3 INFANT WEANING FOODS IN UGANDA.

Traditional weaning foods in many developing countries including Uganda are non-milk family foods based on the local staple, usually a cereal, and normally made into a thick porridge or liquid gruel. Germinated and non-germinated sorghum, fermented and non-fermented cassava porridge and non-germinated maize porridge are foods commonly used to wean children. Millet porridge and millet bread, sour milk, potatoes, eggs, boiled beans, peas, fruits, and porridges soured with fruits or vegetables are identified as foods mothers would for unclear reasons avoid feeding to sick children (Sserunjogi, 1988). The practice of not including of fruits, vegetables and protein rich foods in the conventional porridges automatically deprives the infant of the essential proteins, minerals and vitamins.

The use of dishes based on cereals, tuber crops and plantains is limited by low energy and nutrient density due to their bulk (Ebrahim, 1990). For this reason, more frequent feedings, such as five meals a day, are recommended in order to achieve the energy intake required. However, simple increase in the number of meals per day will not satisfy a child's nutritional needs unless weaning foods are sufficiently dense in calories and protein. Often the nutrient levels in the basic staples are too dilute for a small child to consume adequate amounts to meet protein and energy needs (Mitzner *et al.*, 1984).

2.4 CAUSES OF PROTEIN ENERGY MALNUTRITION.

Infections and malnutrition are intimately related. It is difficult to know which precipitates the other (Martorell, 1985). Good nutrition leads to immunity and low prevalence of morbidity and mortality. The most common cause of malnutrition was in the past considered to be lack of sufficient protein in diets. It is now, however, established that malnutrition is due to low caloric consumption. Once energy requirements are met, the requirements for protein and micronutrients are also most likely satisfied. Further, energy has a sparing effect on protein (Ebrahim, 1990; Ihekoronye and Ngoddy, 1985). This means that, if a diet is low in carbohydrate more protein than usual will be used to provide energy, since energy needs have to be met first, such that less protein than consumed will be used in growth, tissue maintenance and repair, possibly resulting in manifestations of protein deficiency symptoms.

The causes of the chronic growth retardation that results in chronic stunting and wasting among preschool children are, however, more complex than energy deficiency alone (Martorell, 1985). Protein and micronutrients, as well as energy deficiency are probably together involved. In addition, high frequency of diarrhoeal and respiratory infections can result in protein energy deficiency even when the diet would seem to provide adequate nutrients (Ebrahim, 1990). On the other hand, the high frequency and severity of infectious diseases among malnourished children in

developing countries is due largely to reduced resistance to infection resulting from malnutrition (Scrimshaw, 1994).

The onset of PEM is usually after weaning. Protein energy malnutrition has been found to account for increased rate of infections and mortality due to reduced immuno status, as well as increased morbidity and mortality (Ebrahim, 1990). Problems during weaning are due to poor weaning practices such as abrupt withdrawal of child from the breast and provision of low nutrient and low energy foods (Ebrahim, 1991).

In the peasant society, parents are generally unaware of the dietary needs of children, and several customs associated with weaning are likely to give rise to nutritional deficiencies (Ebrahim, 1990). In Uganda, the Baganda understanding of *obwosi* (kwashiorkor) is that it is caused by the jealousy that the unborn fetus feels toward the suckling sibling. The foetus revenge by making the child sick. To avoid illness, as soon as the mother finds herself pregnant again, the nursing child is often separated from the mother and taken into custody of a grandmother or other relative, who frequently does not provide sufficient nutrition. Rather than serving as a prevention, this action may precipitate kwashiorkor. The inadequate diet coupled with the psychological trauma of separation from the mother often worsens the condition (Burgess and Dean, 1962; Cravioto, 1966).

The importance of ensuring that energy requirements are met was shown by INCAP researchers (Torun, 1990). The researchers demonstrated this by reducing the dietary energy intake by 10% in preschool children who had been placed in a convalescent home and were growing well on an *ad libitum* diet with adequate protein. This resulted in a decrease in their activity that compensated for their reduced energy intake, but the children continued to grow as before. When, however, energy intake was reduced by another 10%, while maintaining the same amount of dietary protein, there was further reduction in activity which was accompanied by reduced growth. These observations reveal the impact of chronic energy deficiency on millions of children in the world (Torun, 1990). When the study children were put back on the original *ad libitum* diet, they quickly made up their growth loss and resumed normal activity.

2.5 CONSEQUENCES OF MALNUTRITION.

Reduced activity of children might seem to be of little consequence as long as growth is not affected. But it is the young child's interaction with the environment, including family members, that provides the stimuli for normal cognitive development. The child is normally deprived of this important developmental aspect if adequate energy is not provided (Cravioto *et al.*, 1968 ; Cravioto and DeLicardie, 1972).

Most young children from the lower socio-economic families of Least Developed countries become stunted during the weaning period, and they are likely to remain stunted when they enter school and into adulthood. Stunted adults have reduced work capacity as has been shown in many different countries, including Colombia (Spurr *et al.*, 1977), Brazil (Desai *et al.*, 1984), Ethiopia (Areskog *et al.*, 1969), Guatemala (Martorell *et al.*, 1990) and India (Satyanarayana *et al.*, 1979).

Malnutrition at an early age affects not only the physical performance of the victims in later life but also their intellectual and social performance, a finding of tremendous significance to the future of developing countries and also the under privileged children in industrialized countries (Scrimshaw, 1994). Insufficient calorie intake can also produce stunting, brain damage, and a greater susceptibility to diseases (Morley and Harman, 1979).

In a study conducted in Uganda (Ebrahim, 1990), it was found that there is a sharp fall in the velocity of weight gain between the ages of 3 and 6 months, and a further fall between 6 and 9 months to a rate of only half of the English children. The ground lost in early period is not recovered. The growth in both weight and height is most severely affected between 3 and 12 months of age (Ebrahim, 1990).

2.6 WEANING DIETS IN DEVELOPING COUNTRIES.

Current infant feeding guidelines recommend exclusive breast feeding until the infant is about 4 months old to reduce the risk of early termination of breast feeding, undernutrition and infections (Jackson, 1992). When an infant is around 4-6 months old, the breast milk must be supplemented with energy to fill the gap.

In most developing countries gruels based on cereal flours are used as weaning foods. Infants are often undernourished during the weaning period because the gruel does not provide the necessary energy and other nutrients. Children in these countries would therefore, have to eat in the order of 1 kilogram of the foods each day, or 2-5 times as much as European children in order to ensure sufficient calorie intake (Morley and Harman, 1979).

The staple food is commonly prepared as a thick porridge for adults and older children or as a liquid gruel for young children. Prepared as a liquid gruel, a suitable consistency for feeding young children, these staple foods are diluted with water and thus become voluminous with low energy and nutrient density (Svanberg, 1988).

During cooking with water the starch swells and gelatinizes, resulting in a water retaining paste on cooling, which is very viscous and bulky. Thickness of this food prevents young children from consuming adequate quantities. The porridges have a low energy content per unit volume, necessitating frequent feedings to meet the daily energy requirements of the child. This is not practical in tribal, rural or urban slum areas where the mothers work the whole day away from home. The starch may also not be fully digested. The water in the gruel or porridge is bound in such a way that releasing it into the digestive system is not quick enough. Studies undertaken in Uganda and Papua New Guinea indicate that children fed with such starch-rich staples were not able to eat enough to fulfil their energy requirements (Mellander and Svanberg, 1984).

2.7 MEASURES TO INCREASE ENERGY DENSITY IN WEANING FOODS.

There are several methods that have been used for increasing energy density of weaning foods. These methods, which basically aim at reducing dietary bulk include the following: germination of cereal grains, fermentation with or without germination of cereals, addition of legume flours for example groundnuts to cereal flours and addition of vegetable oil and/ or sugar (Mitzner *et al.*, 1984 ; King and Burgess, 1993).

2.7.1 Use of Germinated Cereals.

In a study by Lorri (1993) in Tanzania, it was found that the same consistency of the weaning gruel could be attained by using three times as much of the germinated flour of high tannin sorghum variety as ungerminated flour. Addition of 5% germinated low tannin sorghum flour to thick ungerminated sorghum and maize gruels reduced the viscosity to acceptable weaning food consistencies (Lorri, 1993). The decrease in consistency was due to amylolytic activity, which is initiated/ elaborated by the germination process. It was established that germinated flour could be added to gruels at temperatures of 20⁰-70⁰C, and that if the germinated flour was added immediately before cooking, gruel viscosity was not reduced. A further study conducted in Tanzanian households indicated that gruels containing additions of germinated flour were acceptable and resulted in increased nutrient intake by children (Mosha and Lorri, 1987). Most women were familiar with the preparation of germinated cereals for brewing purposes, but they

were not aware of their use for thinning down thick porridges (Lorri, 1993).

The results of a laboratory based study conducted by Zambia's National Food and Nutrition Commission (Luhila and Chipulu, 1988) confirmed that germination lowers the consistency of thick gruels and increases the energy and other nutrient densities. When germinated cereal flour was added to thick porridge prepared from ungerminated flour at the rate of 10%, the dietary bulk was substantially reduced. The amylases elaborated during germination hydrolyse starch during food preparation, thereby reducing the viscosity and increasing the calorie density of the food (Chandrasekhar *et al.*, 1988 ; Desikachar, 1980).

From studies undertaken in India, it was found that incorporation of 5% malted barley could substantially reduce the viscosity of a 15% hot paste slurry of commercially available weaning foods such as Nestum, Cerelac, Balamul and Farex (Gopaldas *et al.*, 1988). Based on this finding, Gopaldas *et al.*, (1988) successfully developed an amylase-rich food (ARF) from Pennisetum typhoideum which when added at a level of 4% (w/w of total solids) to a 10% rice gruel, lowered the viscosity effectively (Gopaldas *et al.*, 1988).

Use of germination is limited by the fact that the process is time consuming, an important consideration in situations where time demands on women are already high. Another consideration is the possible side-effects of germination including the possible incidental production of mycotoxins (Mellander and Svanberg, 1984). In grains containing cyanogenic glycosides such as sorghum, germination is also likely to liberate hydrogen cyanide.

2.7.2 Use of Fermentation.

Fermentation has been used to reduce dietary bulk especially in cassava-based weaning foods. Fermented foods are thinner and provide more calories than unfermented foods. Fermentation of cereals breaks the starch structure and reduces the water binding capacity of the porridge. A study in Ghana showed that fermented maize porridge could fulfil the energy needs of a healthy child (Mensah *et al.*, 1991). Nevertheless fermented foods which have only undergone limited hours of fermentation have high concentrations of sugar which increases stool output. According to Mensah *et al.*, (1991) it is best to wait for 14 hours before offering fermented foods to infants.

By combining fermentation and addition of germinated cereal flour, it is possible to prepare liquid cereal gruels of acceptable consistency from maize, white sorghum, bulrush millet and finger millet with a 30 - 35% flour concentration (Lorri, 1993). The cereal is ground into flour, made into a slurry with water (10 -15% solids) and boiled to porridge. Germinated cereal flour and/or an old batch of fermented porridge is added to the porridge which is allowed to ferment for 12 - 24 hours to about PH 3.8 or below. The energy density of such gruels has been found to be about 1.2 Kcal/g as compared to the 0.4 Kcal/g of the non-fermented gruels prepared to the same consistency. This represents a three-fold increase in energy density (Lorri, 1993). According to Mbugua (1987), however, during lactic acid bacteria fermentation, amylolysis appears limited, thus having little effect on bulkiness of the gruel.

2.7.3 Addition of Legume Flours.

The correction of chronic dietary energy deficiency requires an appropriate balance of available protein relative to calories (Scrimshaw, 1994). Gruel viscosity was found to be reduced by the incorporation of bean and groundnut flours, with consequent increase in energy density (Mlingi, 1987). Addition of cooked legumes has also been found to decrease viscosity of gruels (Muroki, 1981). This results in increased energy and nutrient density. Although groundnuts are a rich source of energy, their use could, however, be limited by the high market price.

2.7.4 Addition of Oil Seed Flours.

Flours from oil seeds like simsim (sesame) and groundnuts can be added to cereal gruels to increase energy density (Ebrahim, 1991). At times simsim or groundnut paste can be made which can be added to the gruels. These apart from increasing the energy density, add flavour to the gruels which makes them more appealing. Unfortunately simsim is very expensive for most families. Other seeds that can be used are pumpkin and water melon seeds.

2.7.5 Addition of Vegetable Oil, Fats and / or Sugar.

Addition of vegetable oil and fats increases energy density of the food (Mitzner *et al.*, 1984; King and Burgess, 1993). The oil adds little bulk but increases greatly the energy density and also helps to soften the food for the children. This has, however, proved to be too expensive for the very poor (Morley and Harman, 1979). Further, the flavours developed by the oils and fats could be unacceptable in some peasant communities, because most of them do not use much fat in cooking. Addition of sugar increases the caloric density without increasing the bulk and imparts a sweet flavour which is desirable in gruels. Although sugar is acceptable in all communities, its use is on a decline as it is becoming expensive for low income earners.

2.7.6 Other Methods of Lowering Bulk Density.

Extrusion cooking of starch containing foods at high temperatures results in dextrinization of starch (Mosha *et al.*, 1983) and helps to reduce dietary bulk. Precooking of starch reduces the water holding capacity of the flour and results in lower water binding properties. Such preparations are expensive due to the high processing cost involved and the products therefore become unaffordable by households in the low socio-economic groups in developing countries (Jideani and Adetula, 1993).

2.7.7 Use of Sweet Potatoes.

Sweet potatoes are said to have amylolytic activity and the sweet potato flour has an energy content similar to that of cassava flour or maize meal (Table 11 Appendix VII), both of which are in common use in some countries. Sweet potato starch is easily digested (Woolfe, 1992). Apart from being a source of energy, whole experiments have indicated that the quality of sweet potato protein is moderately good (Collins, 1987) and that it has the potential to complement the proteins in other foods (Woolfe, 1992). The supplementary value of sweet potato protein for cereals has also been shown for humans. Infants obtain sufficient vitamin A from breast or animal milk, but are frequently weaned on staple foods such as rice which are totally lacking in carotene. Cultivars of sweet potato with carotene-rich roots could make a tremendous contribution to dietary vitamin A, especially in situations where animal sources of the vitamin are not available for child feeding.

Also sweet potatoes have a noticeably better Calcium content than plantains, potatoes and yams, boiled rice and cereal porridge (Table 11 Appendix VII). There is no village scale processing apart from sun-drying of root slices (McDowell, 1970) in parts of Uganda to enable storage. The dried roots are ground into flour for use in gruels, porridges and soups.

2.8 CHILD WEANING PRACTICES IN UGANDA.

In Uganda, especially among the communities along the shores of lake Victoria, the common practice is to separate the child from his mother in order to take it off the breast and to get it to eat other foods. In the traditional society, weaning is commonly abrupt and unplanned, and is brought about by the occurrence of another pregnancy in the mother. The child is introduced to mashed plantain (matooke), sweet potato or cassava accompanied by very little protein rich food, for example beans, groundnuts or fish. The weanling is sent away to live with the grandparents for a few months. The unhappiness of separation adds to the nutritional upset caused by a sudden change from a highly nutritious food to a starchy gruel made from maize flour only. That is why the onset of protein energy malnutrition has been traced to the period of weaning (Ebrahim, 1991).

In some communities, in Northern Uganda, the child is usually weaned onto non germinated sorghum gruel. Sorghum and millet are primarily used for commercial purposes, as the germinated cereals are very popular for brewing "ajono" local beers and thus, in this case, economic interests override the direct food interest. Groundnut and simsim paste normally accompany the staple, millet bread, prepared for the older family members. The weaned child eats from the same dish with all the older siblings. This practice of communal eating makes it impossible for the weanling to meet the energy and other nutrient requirements. However, groundnuts and simsim are mostly available at harvest time, after which most of the produce is sold in the major towns where the demand is high.

In West Nile, North West Uganda, fermented and non fermented cassava porridge is the major weaning food. Flour from dried sweet potatoes is added to the porridges to make them sweet.

CHAPTER THREE

STUDY SETTING

The study was set up in Mpigi district of Uganda.

3.1 GEOGRAPHICAL LOCATION OF MPIGI DISTRICT.

Mpigi is one of the biggest districts in Uganda, covering an area of 7,175 sq km (717500ha). It borders Luwero district to the North, Mubende to the North West, Mukonc to the East, Masaka to the South-West and surrounds the whole of Kampala district (Figure 3.1)

3.2 ADMINISTRATIVE SET UP OF MPIGI DISTRICT.

Mpigi district is divided into six counties, which are in turn divided into sub-counties which are further divided into parishes. The parishes are further divided into villages (zones). At each of the levels there exists an administrative set up consisting of a Resistance council (RC). The administrative set up at the various levels is as follows:

District level	—	RC V
County level	—	RC IV
Sub-county level	—	RC III
Parish level	—	RC II
Village (Zone)	—	RC I

3.3 POPULATION AND THE PEOPLE OF MPIGI DISTRICT.

According to the 1991 census, Mpigi District had a population of 905,400 distributed as follows in the six counties: Kyaddondo 271,700, Busiro 252,500, Mawokota 156,200, Gomba 119,800, Butambala 73,600, and Entebbe municipality 41,600. The total number of assessed tax payers is 76,972. The main ethnic group is the Baganda people speaking the Luganda language.

3.4 RAINFALL, CROP PRODUCTION AND LIVESTOCK IN MPIGI DISTRICT.

Mpigi receives an approximate rainfall between 1000-1500 mm per year. Food crops and livestock like cattle, goats and sheep are an integral part of the agricultural system in the area. Contrary to common perception, the main staple food in Mpigi is not green bananas (matooke) but cassava, followed by sweet potatoes. Cassava is grown on a total area of 35,040 ha. The main cash crops are coffee on 15,760 ha, cocoa on 72 ha, and sugarcane on 237 ha. Busiro county is well known for production of sweet potatoes and cassava for home consumption and for sale, while the sweet potatoes grown in Kyaddondo are mainly for home consumption. Other food crops grown in the two counties are maize, beans and coco yams.

Approximate area in Mpigi available for agriculture is 440,600 ha, but only 149,585 ha is under cultivation. The 1993 report shows that Mpigi district had a total number of 146,817 cattle, 26,873 goats, 10,252 sheep and 51,181 pigs. Fishing is mainly carried out at Katebo and Kasenyi on the shores of Lake Victoria.

3.5 THE LOCATION OF STUDY AREAS IN MPIGI DISTRICT.

The survey was carried out in three parishes namely: Bunnamwaya and Ndejje parishes in Makindye sub-county of Kyaddondo county and Bwebajja parish in Ssisa sub-county of Busiro county (Figure 3.2). Therefore the study was carried out in the two counties Kyaddondo and Busiro only.

CHAPTER FOUR

MATERIALS AND METHODS.

4.1. THE STUDY DESIGN.

The study was designed as a descriptive community survey, followed by a laboratory component. The survey sought information on the types of foods used for weaning infants based on the 24-hour recall and was intended to determine the average volume of the weaning gruels consumed by infants per sitting and per day as well as the energy intake from the gruels.

The study was carried out in two phases as described below:

Phase I- January to March 1995: A community survey to document types of foods consumed by the infants, the methods of porridge preparation and amounts consumed by infants, and energy density.

Phase II- April to June 1995: Laboratory work to :-

- determine consistency of porridges consumed by the infants.
- determine the energy density of the porridges.
- investigate the amount of maize flour and sweet potato flour to be added to obtain products with viscosity similar to that consumed by the infants.
- computation of energy content of gruels and their contribution to RDA.

4.2. STUDY POPULATION AND STUDY SUBJECTS.

The sampling frame consisted of infants 4-12 months in Kyaddondo and Busiro counties of Mpigi district, Uganda. These counties were selected because they are in the plantain (banana) /tuber (sweet potato, cassava) area where the prevalence of stunting is reported to be relatively high.

4.3. METHOD OF SAMPLING AND SAMPLE SIZE DETERMINATION.

Multistage random sampling was carried out to select villages (Zones) from the two randomly selected counties. This is shown in Figure 4.1. Sub-counties, Parishes and Zones were selected randomly in Busiro and Kyaddondo counties. The number of infants from each randomly selected village was determined on the basis of size (Appendix VI) i.e. by proportional probability. The number of mothers selected was such that they gave a plausible sample size to allow for statistical analyses. This took into account availability of funds. It was envisaged that a sample of 100 infants 4-12 months would be satisfactory.

4.4. THE SURVEY.

The pre-survey involved development of the study instrument, the questionnaire (Appendix II) which was designed to seek information on the age of the child, time of feeding, dish, ingredients, amounts served and eaten. A research permit was procured, then a visit to the research site to meet with the village resistance committee members. After explaining the objectives of the study, the researcher had to get acquainted with the secretary for women affairs in each committee. These women representatives assisted with the identification of the mothers with infants between 4 - 12 months of age. Initial preparation for the survey involved selection and training research assistants on how to take a 24-hr. dietary recall. Three research assistants were selected, one from each of the parishes selected for the study ie; Bunnamwaya, Ndejje and Bwebajja.

Securing equipment and printing the pre-testing forms was done soon after the training. This was followed by implementation of the pre-testing. For the pre-testing, 20 mothers of infants 4-12 months of age, from a village outside the three parishes selected for the study were interviewed.

4.4.1. The Field Survey.

A food consumption survey based on a 24-hour dietary recall was used to collect data on the volumes of gruels consumed by the infants. Observation of the actual preparation of the gruel was used to ascertain the consistency and therefore the energy density of the gruel.

(a) 24 hour dietary recall.

The mother (or any other person responsible for preparing the child's meals) was asked to recall the foods and amounts prepared in the course of the previous day, the ingredients used in each dish and the amount of each ingredient. The person was asked to use the same utensils used during the previous day and measure replicas of similar ingredients like the day before. A measuring cylinder was used to measure the volumes of the gruel fed to the infants. Water was used to estimate the volume on being shown by the mother the level of the ingredient used if this (ingredient) was not available. The total volume of gruel prepared, the amount served per meal was estimated by the mother who showed the level of the gruel in the cooking vessel and feeding cup. The amount consumed was obtained by subtracting from the amount served the amount which was left in the cup after feeding. The ingredients added to the gruel in the cup were also measured (Appendix II).

(b) Observation of preparation of maize weaning gruels.

Six mothers who used maize gruel for weaning were identified and requested to prepare the gruel under observation of the researcher. The volumes and/ or weights of the ingredients, the method of cooking used including the time taken to cook as well as the total volume of the final product gruel were recorded.

(c) Calculation of energy content of the gruels and their contribution to RDA.

Food consumption data were converted to energy according to the format in Appendix III and using the Food Composition Tables developed by CTA-ECSA for use in East, Central and southern African countries (West *et al.*, 1987). The levels of energy consumption were compared with the requirements by FAO/WHO/UNU, expert consultation, 1985 (Appendix I).

(d) Observation of preparation of germinated finger millet:

Germination of finger millet was preceded by observation on how it is traditionally made. Traditional method of preparation of the product is as follows:

- The grain is soaked in water overnight.
- The water is decanted and the wet (soaked) grain is spread on broad banana leaves or gunny bags and covered with the same materials. This is left for three to four days depending on the temperature. The higher the temperature the shorter the germination period.
- The germinated grain is then dried and finally milled.

4.5. MATERIALS FOR LABORATORY ANALYSES.

The study was carried out on Maize (Zea mays) gruels because the maize is affordable, locally grown and widely used among low income groups for infant feeding in the area.

Sweet potato (Ipomoea batatas) was selected as a source of amylolytic enzymes because it is also locally and widely grown.

Germinated finger millet is commonly used as a source of amylolytic enzymes in making of traditional beer and is also readily available.

The maize was bought at local markets. One variety of sweet potatoes (NEW KAWOGO) was obtained from Namulonge research station, Uganda, and another (KEMB 10) from the CIP germplasm collection at Kabete, Kenya. The finger millet was purchased at Owino market, Kampala, Uganda.

4.6. PROCESSING OF RAW MATERIALS.

4.6.1. Preparation of Sweet Potato Flour:

The sweet potato tubers were harvested and then covered with moist soil. After ten days, the sprouted tubers were peeled and then sliced into thin pieces. The slices were dried in an air circulating oven for 12 hours at 50⁰ C to a moisture content of about 10%. The dried potato chips were then milled to a fine powder in a Willey hammer mill.

4.6.2 Preparation of Germinated Finger Millet Flour.

The finger millet was cleaned to remove dust and foreign materials. The seeds were soaked in cold water and kept in the dark for 12 hours. After draining the soak water and washing once in a similar quantity of water, the seeds were spread as 1 cm layer between wet cotton cloths, then left at 25⁰ C to germinate for 72 hours. The germinated seeds were oven dried at 50⁰ C for 12 hours. The dried grain (both seeds and shoots) were ground to pass through 50 micron sieve in a laboratory mill.

4.7. LABORATORY PREPARATION OF GRUELS.

Gruels of flour concentration between 5% - 10% were prepared according to the recipe from the survey as follows: about 90% of the water was heated to boiling, the remaining water was mixed with the maize flour to make a slurry. The slurry was then poured into the boiling water slowly and stirred continuously to prevent sticking at the bottom. The gruel was boiled for 10 minutes, and then simmered at simmerstat 4 for 15 to 20 minutes. There was a 10% loss of water due to evaporation.

To prepare 20% maize gruel, 100g of maize flour was mixed with 100mls of cold water. The mixture was poured into 400mls of boiling water with constant stirring. After five minutes the heat was reduced to simmerstat 4 of the ETA 1-113 electric boiling plate. Stirring was continued for another five minutes. The pan was then covered and the gruel allowed to simmer for fifteen to twenty (15-

20) minutes. The gruel was then taken off the fire and allowed to cool for 5 - 10 minutes. The sweet potato flour or pulp was added and mixed thoroughly until it was completely dissolved in the gruel. The pan was covered and kept in a warm place, after 45 minutes the gruel was put back on the heater and boiled for 3 to 5 minutes. For faster action, after mixing the sweet potato flour in the gruel, the gruel was put back on the heater at simmerstat 1. This allowed the temperature of the gruel to be between 55° - 65° C which is well below 71° C the heat denaturation temperature of sweet potato amylase (Hasling *et al.*, 1973). For a 15% maize flour concentration 75g of maize flour were mixed with about 100mls cold water and poured in 400mls of boiling water. The final volume after cooking came to 500mls.

4.8. MEASUREMENT OF VISCOSITY.

A Post-humus Viscometer was used to measure viscosity of the gruel samples. This measured the flow which was recorded in seconds using a Fisher Scientific LCD Digital-stop watch. Gruel at 35° C was poured into the Post-humus Viscometer to the brim. The outlet at the bottom was opened as a stop watch was started. The watch was stopped when the pointer metal was exposed. The time taken by the gruel (from the survey) to flow out of the viscometer was recorded, this was used as the reference time to act as the standard for subsequent trials.

4.9. DETERMINATION OF THE AMOUNT OF GERMINATED FINGER MILLET FLOUR REQUIRED TO LIQUIFY THICK GRUELS OF 15% AND 20% MAIZE FLOUR CONCENTRATION.

The thinning effect was evaluated by adding a known quantity of the germinated finger millet flour to measured volumes of cooked gruels, while still warm (55° - 65° C) and stirring with a wooden spoon for a few minutes. Thick gruels of 15% and 20% were cooked and the viscosity reduced by addition of varying amounts of germinated finger millet flour. Trials on different amounts of finger millet flour were carried out until the recorded time taken when using the Post-humus viscometer was approximately equal to the one taken by the gruel from the recipe survey or close to it. The reference time was between 6.4 seconds and 12.0 seconds with an average of 8.8 seconds. The amount of germinated finger millet flour used and the time of flow were recorded.

4.10. DETERMINATION OF THE PERCENT MAIZE IN THE GRUEL TO INCREASE THE ENERGY DENSITY TO THE DESIRED.

The gruels from the survey had an average flour concentration of 7.5%. This concentration of flour was increased by about two and three times to give thicker gruels. Thus to increase the flour concentration two and three-fold a 15% and 20% gruel were prepared. The viscosity of these gruels which were found to be too thick to be measured by the methods used were then treated with germinated finger millet flour and sweet potato.

4.11. CALCULATION OF SWEET POTATO EQUIVALENTS.

Most sweet potatoes currently cultivated in developing countries have a dry matter content of around 30% (Woolfe, 1992) and therefore a moisture content of 70%.

100g of fresh sweet potato have $100 \times 30 / 100 = 30\text{g}$ dry matter,
After drying to a moisture content of 10%, and 90% dry matter, 30g dry matter will be equivalent to 90% of the dry sweet potato.
weight of the dry sweet potato = $100 / 90 \times 30 = 33.3\text{g}$

Therefore, 100g of fresh sweet potato are equivalent to 33.3g dried sweet potato at a moisture content of 10% .

4.12. CALCULATION OF ENERGY CONTENT OF DRY SWEET POTATO.

From the Food Composition Table, the energy content of 100g fresh sweet potato is 109 Kcal. 100g of fresh sweet potato yield 33.3g sweet potato on drying to 10% moisture content.

33.3g dry potato contain 109 Kcal

100g dry potato contain $100 / 33.3 \times 109 = 327$ Kcal

Therefore, 1g of dry sweet potato contains $327 / 100 = 3.27$ Kcal.

4.13. CALCULATION OF ENERGY DENSITY AND CONTRIBUTION TO RDA OF THE MAIZE GRUELS AFTER TREATMENT WITH SWEET POTATO.

A 15% maize gruel had an energy density of 0.5 Kcal/ml. After addition of sweet potato flour at a level of 21% (w/w of flour) the energy density was increased to 0.63 Kcal/ml calculated as follows (West et al., 1987):

15% (75g in 500ml)

$75\text{g} \times 3.34 \text{ (Kcal/g)} = 250.5 \text{ Kcal (maize)}$

$20\text{g} \times 3.27^{\text{a}} \text{ (Kcal/g)} = 65.4 \text{ Kcal (sweet potato flour)}$

$= 315.9 \text{ Kcal in 500ml which is}$

$= 315.9/500 = 0.63 \text{ Kcal/ml.}$

(a = energy content of 1g of sweet potato flour calculated as shown in section 4.12).

At an energy density of 0.63 Kcal/ml the gruel would contribute to the energy intake of infants per day as follows:

Age group	Kcal per day	RDA	percent of RDA
4-6 months,	$0.63 \times 137 \times 5 = 431.6$	700	61.7
7-9 months,	$0.63 \times 160 \times 5 = 504.0$	810	62.2
10-12 months,	$0.63 \times 180 \times 5 = 567.0$	950	59.7

N.B The Daily average energy requirements by the FAO/WHO/UNU (1985) were 700 Kcal for 4-6 months, 810 Kcal for 7-9 months and 950 Kcal for 10-12 months (Appendix I).

A 20% maize gruel had an energy density of 0.67 Kcal per ml. After addition of sweet potato flour at a level of 23% (w/w of flour), the energy density increased to 0.86 Kcal/ml, calculated to include the energy contribution of the sweet potato as follows:

20% (100g in 500ml)

100g x 3.34 (Kcal/g) = 334 Kcal (maize)

30g x 3.27 (Kcal/g) = 98.1 Kcal (sweet potato flour)

= 432.1 Kcal in 500ml which is

$432.1/500 = 0.86$ Kcal/ml

20% maize gruel liquified with 41% (w/w of fresh sweet potato pulp and maize) had an energy density of 0.82 Kcal/ml calculated as follows:

100g x 3.34 Kcal/g = 334 Kcal (maize)

70g x 1.09 Kcal/g = 76.3 Kcal (fresh sweet potato)

= 410.3 Kcal in 500 ml

= 0.82 Kcal/ml

4.14. SENSORY EVALUATION.

(a) Preparation of Maize gruel for Sensory Evaluation.

Maize gruels of flour concentration 7.5%, 15% and 20% (w/v) were prepared and given three digit random codes as follows:

Table 4.2

GRUEL COMPOSITION (in 500 mls water)

Sample designation	Maize (g)	Sweet potato flour (g)
725	37.5	-
571	75.0	15.0
503	100.0	20.0

(b) Sensory Evaluation of the Gruels.

Gruels from each of the three formulations (Table 4.2) were prepared. The gruel samples were then evaluated by 15 panellists for colour, appearance, flavour (taste), texture and overall acceptability, on a 7 point hedonic scale with 1 = dislike very much and 7 = like very much.

The sensory evaluation results were then subjected to Analysis of Variance and Duncan's Multiple Range Test (Larmond, 1970) to determine if there were significant differences in the quality parameters tested, between the samples. In order to prevent biases the samples were presented in identical sample containers, coded with 3-digit random numbers. Each sample had a different number. The sample order was randomised for each panellist. The samples were presented simultaneously as it was easier to administer and allowed panellist to re-evaluate samples if desired and make comparisons between the samples.

CHAPTER FIVE

RESULTS.

5.1. DISTRIBUTION OF THE INFANTS BY AGE AND SEX.

Most of the infants (42%) were in the age group 10-12 months, 33% were 7-9 months, while 25% were 4-6 months old (Table 5.1.). Of the total number of infants used in the study 60% were females while 40% were males.

5.2. TYPES OF WEANING FOODS FED TO INFANTS.

A variety of foods were fed to the infants. Based on the 24 hour recall, it was shown that at least four supplementary feedings per day were received by about two thirds of the infants. Meals for infants which were mainly gruels were prepared separate from those of the rest of the family. All infants were fed on liquid foods at least three times per day (Table 5.2a.), which were mainly cow's milk and cereal gruels which were fed to 92% of the infants. Up to 55% of the infants had their diets supplemented with cow's milk. It was established that the milk was fed to the infants after dilution from average caloric density of 0.79 Kcal/ml (West *et al.*, 1987) to that of 0.52 ± 0.21 Kcal/ml. The most common cereals for preparation of gruels were maize and finger millet. Similar proportions of infants (18% and 19%) were weaned on maize and millet gruels respectively. About 60% of the infants who fed on cereal gruels were in the age category 10-12 months.

It is important to note that milk was used by a relatively high proportion (68%) of the mothers of the 4-6 months infants. For gruel preparation, 8% of the mothers indicated adding a little milk. All the gruels were prepared with sugar except in 10% of the cases. Commercial baby foods namely "Baby soy", Cerelac and "Soy-maize flour" were used by only 4% of the mothers. A small percentage (4%) of infants were fed on black tea. High protein supplements (eggs and fish) and energy rich foods were given by a very small proportion.

Twenty percent of the infants received two, while 16% received three other kinds of foods in addition to the main gruel per day. These other kinds of foods are shown in Table 5.2b.

Of the total number of infants used in the study, about a half were given other foods at least once a day to supplement the gruels. These foods and the respective proportion of infants consuming them were: mashed plantain (matooke) (22%), mashed irish potato (14%), mashed sweet potato (5%), rice (4%), mashed cassava (3%), bread (2%), fish (8%), eggs (2%), beans (3%), ground nut paste (3%) and margarine (4%). The margarine was mainly mixed with mashed irish potatoes. Passion fruits, ripe bananas, pawpaw (papaya) and avocado were among the fruits given to the infants occasionally.

Table 5.1. Age distribution of infants.

Age group (months)	No. of infants	Mean age ^a (months)
4 - 6	25	5.32 ± 0.69
7 - 9	33	7.97 ± 0.85
10 - 12	42	10.86 ± 0.84

^a Mean ± SD

Table 5.2. Distribution of infants by type of food used for weaning and frequency of feeding.

(a) Foods consumed at least 3 times a day.

Weaning food	Percentage of infants being weaned
Milk (fresh)	55
Maize gruel	18
Millet gruel	19
Black tea	4
Baby soy	2
Cerelac	1
Soy maize gruel	1

(b) Foods consumed at least once a day.

Irish potato	14
Matooke (plantain)	22
Bread	2
Rice	4
Cassava	3
Sweet potato	5
Eggs	2
Fish	8
Beans	3
Groundnuts	3
Margarine	4

5.3 THE MOTHERS' RECIPE.

The maize gruel prepared by the mothers had proportions of between 6.3 - 7.7% (w/w) flour to water and was prepared as follows: about 90% of the cooking water was heated to boiling. The remaining 10% of the cold water was mixed with maize flour to make a slurry. The slurry was added slowly to the boiling water while stirring constantly to prevent formation of lumps and sticking at the bottom of the pan, until the gruel boiled. The gruel was boiled for about 10 minutes after which the heat was reduced and the gruel simmered for 15 to 20 minutes. The gruel was then cooled, before feeding the infants. Up to 90% of the mothers added sugar at a rate of 5g per serving which was about 184 mls.

5.4. PATTERN OF FEEDING AND AMOUNTS OF GRUELS SERVED AND CONTRIBUTION OF WEANING FOODS TO RDA.

Table 5.3 shows the number of feedings, the mean volume of maize and millet gruels taken per sitting and per day, the daily calorie intake and the percent energy RDA for each age group. The mean volume of gruel taken per sitting increased with age. The mean volume (681 ±347)mls of gruel taken per day by the age group 7-9 months was unexpectedly lower than that taken by the 4-6 months which was 701±565 mls, although the difference was not significant. This was due to the higher number of feedings for the former than the latter infants, so that at the end of the day the more frequent small feedings added up to a higher volume. Infants of 10-12 months were given as would be expected the highest amount, 846±439 mls. The average number of supplementary feedings to the infants were

about the same: 5 for 4-6 months, 4 for 7-9 months and 5 for 10-12 months.

Using the Requirements (FAO/WHO/UNU, 1985), of 700 Kcal for 4-6 months, 810 Kcal for 7-9 months and 950 Kcal for 10-12 months, it was established that supplementary feeding contributed only a little over 50% of RDA for energy in all the age categories of infants used in the study (ie about 51-59%). The results showed that the contribution of the supplementary foods to RDA decreased with age. It was 59.4% for age group 4-6 months, 55.5% for infants in the age group 7-9 months and 50.9% for infants within age group 10-12 months.

5.5. ENERGY DENSITY OF WEANING GRUELS.

Figure 5.1 shows the energy densities of the maize gruels prepared by mothers for feeding different age groups of infants. The average energy density of all the gruels prepared by all the mothers for their infants was low. It ranged from 0.10 to 0.39 KCal/ml with a mean of 0.25 ± 0.13 KCal/ml.

Table 5.3. Gruel and energy intake of infants.

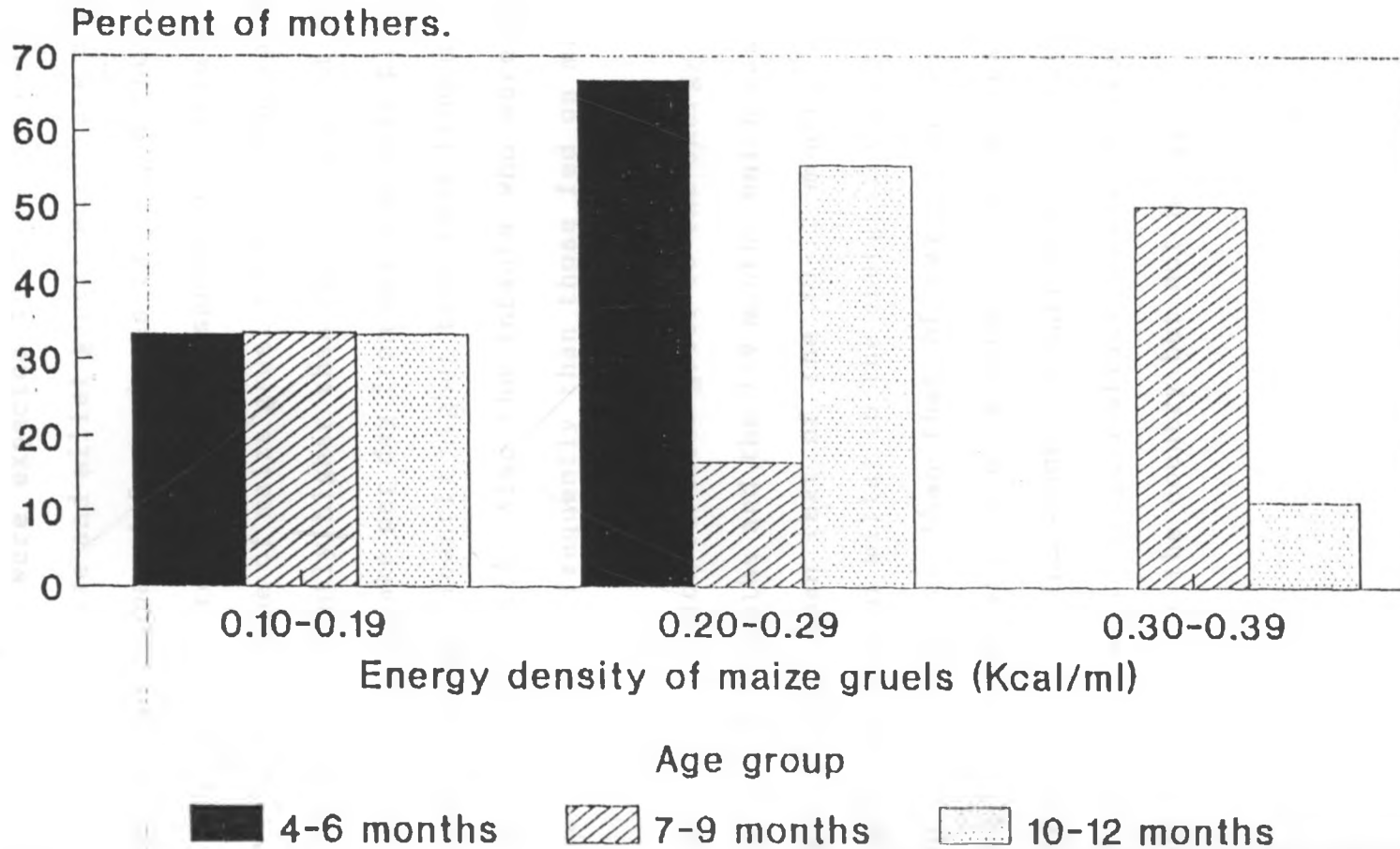
Age (months)	Average no. of feedings	Mean volume of gruel taken (mls) ^a		Mean Calorie intake Per day (KCal) ^b	%energyRDA
		per sitting	per day		
4-6	5	137 ± 62	701 ± 565	416.2 ± 345.2	59+49
7-9	4	160 ± 43	681 ± 347	450.0 ± 236.1	56+29
10-12	5	180 ± 52	846 ± 439	484.0 ± 280.8	51+29

^{a b} Mean ± SD (N = at least 25)

As Figure 5.1 shows, the caloric densities of the maize gruels prepared for feeding infants of ages between 4-6 months were rather low and did not exceed 0.29 Kcal/ml. It is important to note that about equal proportions of infants in the three age categories (33.3%) were fed low energy density gruels ranging between 0.10-0.19 Kcal/ml. Also the proportion of infants fed on the moderately high energy density gruels 0.20-0.29 Kcal/ml in the age group 10-12 months was not very different from that of the 4-6 months. Thus a very small proportion (11.1%) of the infants 10-12 months was fed relatively high energy gruel. Among the infants of age groups 7-9 months and 10-12 months, about a half and 11.1% respectively were fed on gruels with caloric densities ranging between 0.30-0.39 Kcal/ml. A third (33.3%) and half of this number (16.7%) of the ages between 4-6 and 7-9 months were fed gruels of caloric densities between 0.10-0.19 and 0.20-0.29 Kcal/ml respectively.

The average serving of maize gruel was found to be 184 mls, though 50% of the mothers served more. Using the mean energy density of 0.25 Kcal/ml of maize gruel for 4-12 months infants, and the average intake of 184 mls per serving, the infants were receiving an average of 46 Kcal at each feeding session.

Fig 5.1: Distribution of mothers by energy density of maize gruels prepared for infants of the three age categories.



Since cereals were expected to have more impact than any other foodstuff, maize and millet gruels which are commonly used in Mpigi diet were compared for volumes taken and their equivalent caloric density. The results are presented in Table 5.4. These show that the mean volume of maize gruel taken by the infants per sitting was not significantly higher than the volumes of millet gruels taken. The energy intake per day from maize gruels plus sugar (322.04 ± 113) was not significantly higher than that from millet gruel which was 281.02 ± 122 Kcals. Also the infants who were fed on maize gruels were fed more frequently than those fed on millet gruels.

The contribution of maize gruel to the energy intake of the infants of the 4-6 months and the 7-9 months which was about 40% of the RDA was higher than that of the 10-12 months which was 34.9%. The contribution of millet to the energy intake of the infants who fed on it was lower than that of maize, it was 22.63%, 31.66% and 33.24% for the 4-6 months, 7-9 months and 10-12 months respectively. The study concentrated on maize gruel since maize is locally grown in Mpigi district, unlike millet which is produced in drier parts of the country but not Mpigi.

The distribution of infants on the basis of the percent RDA of energy taken from the weaning foods is shown in Table 5.5a. Results show that only about a tenth (11%) of the infants received 100% and above of their energy RDAs from the weaning foods only. Most (85%) of the infants received less than 80% of their energy RDAs from the weaning foods only. A half of the infants received less than 50% of their energy RDA from the weaning foods only.

Table 5.5b. shows the distribution of energy intakes by infants in the age groups. A higher proportion (24%) of the younger (4-6 months) infants received a high (over 80%) RDA intake than the older infants. Rather unexpectedly the proportion of the 10-12 months old infants receiving a high caloric intake from the weaning foods (14.3%) was higher than that of the 7-9 months which was 9.1%. However, the age group 7-9 months had the least (45.5%) while the 10-12 months had the highest (54.8%) proportion of infants receiving less than 50% of their energy RDA from the weaning foods.

Table 5.4. Mean volumes of maize and millet gruels served to infants, frequency of feeding and their equivalent energy intakes.

Type of gruel	No. of feedings	Mean volume(mls) per sitting per day		Mean Energy Density KCal/ml	Daily Energy Intake KCal
Maize	5a	184 ± 48b	950 ± 401	0.25 ± 0.13	322.04 ± 113c
Millet	4a	166 ± 44b	689 ± 390	0.27 ± 0.09	281.02 ± 122c

Mean + SD (N = 18).

Note the daily energy intake includes the contribution of sugar which is 93.75 Kcal.

Figures in the column followed by different letters are significantly different at p value \leq 0.05.

Table 5.5a. Distribution of infants by proportion of RDA of energy from weaning foods.

Percent of RDA (%)	Percent of total No. of infants (%)
Above 100	11
80 - 100	4
50 - 79	35
Below 50	50

Table 5.5b. Distribution of infants within age group by percent of energy from the weaning foods.

Age group Months	No. of Infants in the group	Percent of infants achieving RDA			
		> 100%	80-100%	50-79%	<50%
4 - 6	25	20.0	4.0	28.0	48.0
7 - 9	33	6.1	3.0	45.4	45.5
10-12	42	9.5	4.8	20.9	54.8

5.6. LABORATORY IMPROVEMENT OF ENERGY DENSITY OF MAIZE GRUELS.

5.6.1. VISCOSITY AND ENERGY DENSITY OF THE MAIZE GRUELS.

The porridge/gruels from the survey had a viscosity which ranged from 6.4 seconds to 12.0 seconds with an average of 8.8 ± 2.67 seconds. Gruels with apparent viscosities close to 12.0 seconds were mainly prepared for older infants 8 to 12 months, while those gruels with viscosities close to 6.4 seconds were prepared for the young infants 4 to 6 months. The mean viscosity of 8.8 seconds represented energy densities of 0.25 Kcal/ml, while the viscosity of 6.4 seconds and 12 seconds represented average energy density of 0.21 Kcal/ml and 0.39 Kcal/ml respectively.

5.6.2. DEVELOPMENT OF HIGH ENERGY DENSITY MAIZE GRUELS.

The results on viscosity and caloric density (Section 5.6.1) were used for improvement of the energy density of the gruels. Thus an attempt was made to make gruels of viscosity close to 8.8 seconds with increased caloric density which would give at least 80% of the energy RDA to the infants.

5.7 VISCOSITY OF GRUELS AFTER TREATMENT WITH GERMINATED FINGER MILLET AND SWEET POTATO.

5.7.1. Use of Germinated Finger Millet to Reduce Viscosity of Gruels.

As more of the germinated finger millet flour was added to the 20% maize gruel the viscosity of the resulting gruel decreased making the gruel thinner (Table 5.6). The gruel with 15% maize flour required 3g of germinated finger millet flour to reduce its viscosity close to the lowest that was determined from the field samples. The viscosity of the gruel was recorded as 6.5 seconds. However, 5g of germinated millet flour were needed for 500mls of a 20% maize gruel to reduce the viscosity considerably. The time taken for the flow of the resulting gruel was 8.8 seconds.

5.7.2. Use of Sweet potato to Reduce Viscosity of Maize Gruels.

The viscosity of the gruels when the two varieties were added was more or less the same (Table 5.7b). Addition of 20g (equivalent to 16.7% w/w of flour) of sweet potato flour to a 20% maize flour gruel reduced the viscosity to 8.8 seconds for KEMB 10 and 8.5 seconds for NEW KAW (Table 5.7b). Levels of sweet potato flour less than 16.7% resulted in gruels that were too thick to have their viscosities measured by the methods used. As more of the KEMB 10 and NEW KAW sweet potato flours were added there was reduced decrease in viscosity. For the 15% maize flour gruel it was observed that addition of 16.7% (w/w of flour) did reduce the viscosity to 8.9 seconds for KEMB 10 and 8.6 seconds for NEW KAW.

Table 5.6. Viscosity of the 15% and 20% gruels from maize flour containing different amounts of germinated finger millet flour.

Concentration of maize flour (w/v) (%)	Amount of finger millet flour gm	Viscosity seconds
15	2	8.4
15	3	6.5
20	3	11.3
20	5	8.8
20	7	8.2
20	9	7.8

When more flour was added (21% w/w of flour) the viscosity decreased to 6.42 seconds for KEMB 10 and 6.1 seconds for NEW KAW. The energy density of the gruel increased by a smaller margin than did the viscosity as more sweet potato flour was added. The decrease in viscosity was found to decrease from 8.8 seconds by 12.5% and 27.27% after application of 30 and 40g of sweet potato flour respectively, but the energy density increased by 7.5% and 16.25% only.

Since it was expected that the gruel with 15% maize flour would require much less potato to lower the viscosity to the desired level, therefore only 16.7% and 21% of the potato flour and 34.8% and 40% (w/w) of the fresh potato were tested.

From Table 5.7a it can be seen that in order to get 20g, 30g, and 40g of sweet potato flour at 10% moisture content, 60g, 90g and 120g respectively of fresh sweet potato have to be dried. Upon drying to a 10% moisture content, the fresh sweet potato of 50g, 70g and 100g would yield 16.67g, 23.3g and 33.3g respectively.

Computation to convert fresh sweet potato to equivalent of flour (Section 4.11.) shows that 20g (16.7% w/w) which would give the desired viscosity is obtained from drying about 60g of fresh sweet potato (Table 5.7b). The factor used is fairly correct because on addition of 70g of fresh sweet potato to a 20% porridge the viscosity is slightly lower 8.6 seconds for KEMB 10 and 8.5 seconds for NEW KAW than that of adding 20g of flour.

Table 5.7a. Equivalent of Sweet potato (fresh and flour)

Fresh potato (70% M.C) Dry matter 30% (g)	Potato flour (10% M.C) Dry matter 90% (g)
40	13.30
50	16.67
60	20.00
70	23.30
80	26.67
90	30.00
100	33.30
110	36.67
120	40.00
130	43.30

M.C = Moisture content

Method of calculating equivalents is shown in section 4.11.

Table 5.7b. Viscosity and energy density of a 15% (0.5 Kcal/ml) and a 20% (0.67 Kcal/ml) gruels from maize flour containing different amounts of sweet potato.

Concentration of maize flour(w/v) (%)	Sweet potato flour gm (% w/w of flour)	Fresh sweet potato gm (% w/w)	Viscosity (seconds)		Energy density Kcal/ml
			KBMB 10	BBV KAV	
15	15 (16.7)	--	8.9±0.23	8.6±0.25	0.60
15	20 (21.0)	--	6.42±0.13	6.1±0.20	0.62
15	--	40 (34.8)	9.8±0.12	9.5±0.07	0.60
15	--	50 (40.0)	6.54±0.06	6.48±0.3	0.61
20	10 (9.09)	--	*	*	--
20	20 (16.7)	--	8.8±0.77	8.5±0.63	0.80
20	30 (23.0)	--	9.9±0.17	9.8±0.06	0.85
20	40 (28.6)	--	11.2±0.25	10.8±0.45	0.93
20	--	50 (33.3)	11.4±0.25	11.2±0.16	0.78
20	--	70 (41.2)	8.6±0.20	8.5±0.22	0.82
20	--	100 (50.0)	10.3±0.10	10.1±0.21	0.37

* Viscosity could not be measured.

W.B The energy density was calculated.

KBMB 10 and BBV KAV are sweet potato varieties.

BBV KAV is BBV KAVOGO from Namulonge Research Station, Uganda.

This is also evident from the observation that on adding 100g of fresh sweet potato the viscosity 10.3 seconds compares well with that of 40g which was 11.2 seconds for KEMB 10 and 10.8 for NEW KAW. The effect of adding more flour was investigated because some of the younger infants were having thicker gruels.

At lower concentrations (15%) of maize flour (substrate) lower amounts of sweet potato were required, as would be expected from enzyme kinetics. The 15g (16.7% w/w) sweet potato flour was observed to give optimal reduction in viscosity. Results showed that the 16.7%(w/w) of the sweet potato flour reduced the viscosity of the 15% maize flour gruel to a level that was practically equal to that of the 20% maize flour gruel. The increase in energy density was approximately 2/3 that of the 20% gruel.

Apparently no level of sweet potato flour can be used in the 15% maize flour gruel to raise the energy density above 0.63 Kcal/ml.

The contribution to RDA for the gruels with desired viscosities 6.4 seconds to 8.9 seconds were as would be expected, higher for the 20% maize flour gruel (Table 5.8) than for the 15% maize flour gruel.

Table 5.8. RDA contribution of different gruels at viscosity 6.4 - 8.9 seconds.

Conc. of maize (v/v)%	Amount of sweet potato		Viscosity (seconds)	Energy density (Kcal/ml)	Volume per day (mls)			Percent RDA		
	Flour (gm)	Fresh (gm)			(4-6)	7-9	10-12)	(4-6)	7-9	10-12)
20	20	--	8.8	0.80	685	800	900	78.3	79.0	75.8
20	--	70	8.6	0.82	685	800	900	80.2	81.0	77.7
15	15	--	8.9	0.60	685	800	900	58.7	59.3	55.8
15	20	--	6.42	0.63	685	800	900	61.7	62.2	59.7
15	--	50	6.54	0.61	685	800	900	59.7	60.3	57.8

(4-6 7-9 10-12) Age groups in months.

N.B The volumes given are based on a feeding frequency of five times a day and a serving volume of 137 mls, 160 mls and 180 mls for the 4-6 months, 7-9 months and 10-12 months respectively.

The contributions of the Gruels to RDA were practically similar for the three age groups. The 15% maize Gruels had RDA contributions which were approximately three quarters of the 20% maize Gruels.

5.8. SENSORY EVALUATION OF THE GRUELS.

The results of sensory evaluation of the Gruels are shown in Table 5.9. The rating decreased with the increase in concentration of the maize flour. The mean colour score of the 7.5% maize flour Gruel (6.1 ± 1.4) was significantly higher ($p < 0.05$) than the mean colour scores of the 20% maize-16.7% (w/w) sweet potato flour Gruel which was 5.5 ± 1.1 . The score of the 7.5% and 20% were not significantly different from that of the 15% maize-16.7% (w/w) sweet potato flour Gruel.

The mean score for appearance of the 20% maize flour-16.7% (w/w total flour) sweet potato flour Gruel (6.1 ± 1.2) was significantly lower ($p < 0.05$) than the mean scores of the control (7.5% maize flour) Gruel sample and the 15% maize flour-16.7% (w/w) potato flour Gruel, which were not significantly different from each other. The mean appearance score for the 7.5% maize flour Gruel was, however, slightly higher than that of the 15% maize flour-16.7% (w/w) sweet potato flour Gruel.

Table 5.9. Mean Sensory scores of the three gruel samples^a.

Attribute	7.5% maize flour only (control)	15% maize flour + 16.7% (w/w)flour	20% maize flour + 16.7% (w/w)flour
Colour	6.1 _± 1.4a	5.6 _± 1.1ab	5.1 _± 1.1b
Appearance	6.1 _± 1.2a	5.9 _± 1.2a	4.6 _± 1.3b
Flavour (taste)	4.2 _± 2.0a	5.5 _± 1.0b	5.1 _± 1.3ab
Texture(mouth-feel)	5.7 _± 1.8a	5.2 _± 1.0a	4.5 _± 1.6b
Overall acceptability	4.9 _± 1.8a	5.9 _± 1.1b	4.9 _± 1.0a

^a Mean _± SD (N = 15).

Means along a row followed by the same letters are not significantly different from each other at the 5% significant level.

The mean flavour score was highest for the 15% maize flour-16.7% (w/w) sweet potato flour gruel followed by the scores of the 20% maize flour-16.7% (w/w) sweet potato flour gruel and for the 7.5% maize flour only. The mean flavour score for the 15% maize flour-16.7% (w/w) sweet potato flour gruel was significantly higher ($p < 0.05$) than the mean flavour score of the 7.5% (control) gruel but not significantly higher than the 20% maize flour-16.7% (w/w) sweet potato flour gruel.

The rating for texture decreased with increase in concentration of the flour. The rating of the 7.5% maize flour gruel was not significantly different from that of the 15% maize-16.7% (w/w) sweet potato flour gruel but was significantly higher ($p < 0.05$) than the 20% maize flour-16.7% (w/w) sweet potato flour gruel.

The 15% maize flour-16.7% (w/w) sweet potato flour gruel had the highest mean overall acceptance score. There was a significant ($p < 0.05$) difference between its mean score and those of the 7.5% maize flour only and 20% maize flour-16.7% (w/w) sweet potato flour gruel which were not significantly different from each other.

CHAPTER SIX

DISCUSSION.

So far, most of the dietary assessment studies in developing countries have been concentrated in the urban areas especially in the slums, so that little is known about the situation in the rural settings. These studies have shown that the intake of energy particularly by infants is rather low. This low intake of energy results in widespread stunting.

The most severe effects of stunting are concentrated before a child's first birth day. Even if nutrition improves thereafter, the child is likely to suffer from below-normal growth, impairing physical and mental development (UNICEF, 1994).

In developing countries cereal gruels are used to wean infants, which is the same for Uganda (Sserunjogi, 1988). In Uganda a variety of foods are used for weaning infants. These include: fermented and non-fermented cassava porridge, non-germinated and non-fermented cereal porridges, cow's milk, mashed plantain (matooke, in Luganda language), mashed potatoes, mashed cassava, mashed sweet potatoes, bread, beans, groundnuts, fish, eggs; and fruits like pawpaw, passion fruit, avocado and ripe bananas. Although the feeding of some of these foods is not regular, their contribution to infant nutrition can not be ignored as they render variety to diets and help to fulfil the energy and vitamin

requirements. Most of the weaning diets by the ordinary mothers in Uganda are home prepared from locally available foods and therefore, are affordable by majority of the families. The foods fed to the infants in addition to being limiting in energy since they are mainly starchy are also limiting in micronutrients. In Mpigi district few mothers fed fortified gruels such as Soy-maize, "Baby soy" and any other cereal legume mixture. The commercial baby foods like "Baby soy" and "soy-maize flour porridge" were used by very few of the mothers probably because they are expensive or have unfamiliar tastes. Although a few mothers (4%) were giving black tea to their infants, this is risky as tea would decrease food intake and also reduce availability of iron and possibly other nutrients (Muroki, 1994).

Judged from the recipe, sugar made a contribution to the energy intake of the infants. At a rate of approximately 5g per serving, and frequency of 5 times daily, the total sugar intake was 25g equivalent to 93.75 Kcal, which would contribute 13.4%, 11.6% and 9.7% of RDA for the age groups of 4-6 months, 7-9 months and 10-12 months respectively.

The study found that the infants were given small frequent feedings. The more frequent smaller feedings are necessary to the younger infants since their stomachs are still small. The infants in the study were fed on average 5 times a day as Cameron (1983) recommended that an infant over six months needs to be fed about 4-

6 times a day in addition to breast feeding. The high frequency of feeding observed in this study is encouraging since if the energy density is increased the gruel which for the young infants 4-6 months should form the bulk of the food, would contribute a high proportion of their RDA. A contribution of just 59% of energy RDA by weaning foods for the 4-6 months is rather low.

The results of this study revealed that the daily energy intake by 88% of the infants was below requirement. The FAO/WHO/UNU (1985) requirements for energy are 700 Kcal for 4-6 months, 810 Kcal for 7-9 months and 950 Kcal for 10-12 months. The three categories of infants were taking 416 kcal, 450 kcal and 484 kcal respectively. These intakes were comparable to those from studies in other countries for example Papua New Guinea (Ebrahim, 1990).

The energy density of traditional weaning foods in many developing countries is a critical factor in the translation of estimates of dietary needs into practical food intake. This is largely because of the low fat and frequently, high water content of such foods (FAO/WHO/UNU, 1985). The gruels fed to the infants are low in energy density because of dilution with water to reduce viscosity. Viscosity is the most important factor as it has a bearing on the volumes that can be taken and determines the energy density and nutrient density. Viscosity is related to energy density since cereal porridges, particularly when prepared from maize tend to be very glutinous unless made into a thin gruel by adding water. This

naturally reduces energy density.

It may appear that the intake of energy could be increased by increasing the number of feedings per day to the infant. However, this approach would not be practical, as it would be difficult to feed infants more than the five times that they were already being fed. Earlier studies with Ugandan children have shown that children fed five times daily took in the same energy as those fed three times daily (Ebrahim, 1990). Based on the traditional diets and regardless of the number of feedings, the daily intake was always in the range of 90 - 95 Kcal/kg body weight. This level of energy intake is close to the RDA. The widely reported high levels of PEM (Kahitahi, 1981; Sommerfelt, 1991) are most probably due to low utilization of the energy foods due to micronutrient deficiencies.

Energy contents of the weaning diets could be increased by addition of edible fats and oils (Ebrahim, 1991) without altering the bulk volumes of the diets. Unfortunately the study established that only 4% of the mothers added some fat or oil to the infants' foods. Moreover, fats are not normally added to cereal gruels traditionally. Also fats and oils in Uganda are expensive commodities and they would be out of affordable price range by most common Ugandan mothers.

The intake of energy from breast-feeding could not be accurately established. However, since most of the infants, especially those whose mothers were working away from home were breast-fed at night, it would be difficult for this source of energy to cover the deficit of 300-480 Kcal per day especially given the small capacity of the infants' stomach.

The observation that there was little difference in the proportion of RDA contributed by the supplementary foods between the age categories and that this decreased with increasing age (Table 5.3) is most probably explained by the fact that the capacity of the stomach do not differ significantly and a very small proportion (10%) of the older infants took gruels with relatively high energy density.

The maize gruel used for infant feeding had a mean energy density of 0.25 Kcal/ml. Therefore infants of 4 - 6 months would each have to consume 2240mls of the gruel in a day to meet at least 80% of the energy RDA, assuming that the rest of the 20% could be obtained from breast feeding. Similarly infants of 7-9 months and 10-12 months would have to take 2592mls and 3040 mls respectively to achieve the same percent RDAs. Such bulk volumes daily could not be tolerated by the infants, due to the limited capacities of their stomachs (Ebrahim, 1991). During exclusive breast feeding an infant is fed approximately 850 mls (FAO/WHO/UNU, 1985) of milk about 1/3 of the volumes given. Even if the infants in each of the three age

categories were fed five times a day, this would mean a gruel intake of 448mls per feeding for the youngest infants and 608mls per feeding for the older infants, volumes that are much higher than the average the mothers were noted to be giving the infants. If the maize gruel would supply 60% of the RDA and considering that some infants were fed on other foods which could supply 20% and breast-milk the remaining 20%, the infants of 4-6 months, 7-9 months and 10-12 months would have to consume 336 mls, 380.8 mls and 456 mls respectively per feeding five times a day. Even with addition of sugar which would increase the energy density of the gruel from 0.25 Kcal/ml to 0.35 Kcal/ml large amounts of gruel would still have to be taken. The 4-6 months, 7-9 months and 10-12 months infants would have to consume 1600mls, 1851mls and 2171 mls respectively to cover 80% of their energy RDAs. When fed five times daily the 4-6 months, 7-9 months and 10-12 months would have to take 320mls, 370mls and 434mls per serving respectively. These volumes are still much higher than what the infants could accommodate per serving. Therefore the energy density of the gruels would need to be increased to try and meet infants energy requirements.

Sweet potatoes are widely grown by small farmers in Uganda primarily for home consumption. For fresh consumption, which is the most common in Mpigi district, the potatoes are either boiled or steamed until soft then eaten with a sauce or they are mashed with beans and eaten that way. They could also be roasted. In the drier

North and Eastern parts of the country, Soroti and Kumi, the tubers are often dried as slices and stored, acting as a famine reserve crop (Horton, 1988). In some cases the dried slices are either rehydrated in boiling water for mashing food, or ground to make a flour which is added to porridges and soups. Attempts were made to use the amylolytic activity in both fresh and dried sweet potatoes to increase the energy density of the maize gruels. The process of production of sweet potato flour adopted was simple and could easily be followed by common Ugandan mothers. Because such sophisticated items of equipment as electric ovens are not generally available at the community level in Uganda, the potatoes could be sliced and dried in the sun. The dried slices could then be pulverized by either using a grinding stone or a mortar and pestle. Milling into flour could also be done using the already existing posho mills which are used for milling maize and other cereals. Drying of sweet potatoes is already currently practised. This technology could be popularized to produce flour for gruel preparation.

Most of the research has so far concentrated on the reduction of viscosity of thick porridges using germinated cereals such as millet, wheat, sorghum and even maize. Examples include "power flour" in Tanzania (Mosha and Lorri, 1987) and "Amylase Rich Food" (ARF) in India (Gopaldas *et al.*, 1988). In the present study the sweet potatoes served as both a source of enzyme and energy. It was noted that as the proportion of the sweet potato increased in the

gruel the viscosity decreased, reached a minimum, then started to increase. This behaviour was probably due to the fact that the sweet potato starch which was added to the cooked cereal starch was not hydrolysed fast enough to manifest a net reduction in the product viscosity. The behaviour of sweet potatoes observed here which showed for the 20% flour that there was an optimum amount of sweet potato flour could be an advantage. By using different cereal flour concentrations, it is apparent that the required viscosity of about 8.8 seconds can be reached without considerably lowering the energy density. This is because the amount of sweet potato added increased the concentration of the flour. When using germinated finger millet flour, its increase would result in only decreasing the viscosity. Since finger millet flour is required in small quantities it would have little effect on increasing the flour concentration. Concentration of flour is critical because as observed in section 5.7.2, no amount of ARF could increase the energy density of the 15% gruel appreciably beyond 0.63 Kcal/ml. Furthermore, the decrease in viscosity is considerable for an increase of sweet potato flour concentration from 16.7% to 21% (a 25.7% increase), the decrease in viscosity compared with the relative low energy increase ie 3.33% was high.

Addition of 20g (equivalent to 21% (w/w) of sweet potato flour to a 15% hot gruel reduced the consistency to the desired level but if the infants were fed the volumes per day as shown in Table 5.8, this gruel could provide 61.7%, 62.2% and 59.7% of the energy RDA

for infants in the age groups of 4-6 months, 7-9 months and 10-12 months respectively. Addition of sugar represented only a slight increase to the RDA of 74.76%, 73.79% and 69.5% for the three age categories of 4-6 months, 7-9 months and 10-12 months respectively. Therefore attempts were made to prepare a much thicker gruel then reduce its viscosity to that desired and at the same time produce the required energy density. Since addition of fresh sweet potato equivalents of 40g and 50g which represented sweet potato concentration in the flour of 15.1% and 18.2% (w/w) respectively did not appreciably increase the energy density, it was resolved that a 20% maize gruel be investigated for suitability to increase the energy density. Consequently gruel of 20% maize flour was prepared and treated with 30g of sweet potato flour (equivalent to 23% w/w). Consumption of the resulting gruel of energy density 0.86 Kcal/ml would contribute to the RDA for the 4-6 months, 7-9 months and 10-12 months infants by 84.16%, 84.94% and 81.47% respectively.

At an energy density of 0.80 Kcal/ml and mean gruel volume of 137, 160 and 180mls per feeding for the 4-6 months, 7-9 months and 10-12 months respectively, the infants would have percent RDA of energy intakes above 75% as shown in Table 5.8. if all age groups were fed five times per day. When the contribution of sugar is included, the percent energy RDAs would be 91.7 for 4-6 months, 90.6 for 7-9 months and 85.5 for 10-12 months.

Addition of sweet potato flour to a level of say 28.6% (w/w total flour) to a 20% maize gruel would increase the energy density to 0.90 Kcal/ml and the resulting gruel would meet the RDA for energy by 88%, 88.98% and 85.26% for the age group 4-6 months, 7-9 months and 10-12 months respectively.

When the equivalent of fresh sweet potato pulp was used, the energy density of the gruels was increased to 0.61 and 0.82 Kcal/ml for a 15% and 20% maize respectively. The 15% maize-40% sweet potato gruel would contribute between 57.8 and 59.7% of the energy RDA for the infants. Consumption of the 20% maize-41.2% sweet potato would contribute between 77.7% and 80.2% of the RDA. At an energy density of 0.82 Kcal/ml infants would be able to meet 80% for 4-6 months, 81% for 7-9 months and 78% for 10-12 months of their RDA of energy from the gruels alone.

A 15% maize gruel liquified by 40% (w/w) fresh sweet potato pulp would have an energy density of 0.61 Kcal/ml and would help meet the RDA for energy by 60% ,60% and 58% for the age group 4-6 months, 7-9 months and 10-12 months respectively.

The yellow fleshed sweet potato has the added advantage of providing beta-carotene a precursor for vitamin A. Sweet potatoes are widely grown in most parts of Uganda, with highest production in Mpigi district. Therefore, it would be easy to promote its new form of utilization as it is socially an acceptable food. Even the

poor mothers would manage to use the sweet potatoes as they could obtain them from their home gardens.

In Uganda germinated millet is used to make a beverage known as "obusera" and a local beer known as "ajono". In the present study germinated millet was used to reduce the viscosity of the thick gruels. Since germinated millet has a high amylolytic activity very little flour was required to decrease the consistency to the desired levels (8.8 seconds). For example only 4% and 5% (w/w total flour) of the germinated finger millet flour was required to reduce the 15% and 20% maize flour gruels respectively to the desired consistency. However, because of the low levels of the germinated flours used, the contribution of the flour to the energy when compared to that of the potato was considered negligible. Sweet potato production is considerably less labour intensive than that of millet. For this reason production of finger millet is on the decline. A good number of farmers are reducing the acreage, while others have stopped the production altogether. The little that is produced is mostly used for brewing as it fetches more money that way than when used directly for food preparation.

In order for a food to be accepted by the consumer it has to be appealing in terms of colour, flavour and texture. Before any food can be given to a baby, it has to be acceptable to the mother. Therefore, a team of 15 mothers were requested to carry out sensory evaluation of the maize-sweet potato flour gruel samples, in terms

of colour, appearance, flavour (taste), texture and overall acceptance.

The use of sweet potato flour to increase the energy density has potential since for all the quality characteristics scores were fairly high. Even the observation that the 15% maize-16.7% sweet potato and the 20% maize-16.7% sweet potato had lower rating for colour than the control gruel (7.5% maize only) should not be discouraging since the flavour score of the 15% and 20% maize-16.7% sweet potato was still high.

Addition of sweet potato did not affect the colour acceptability of the gruels, based on a scale of (1=dislike very much, 7=like very much) the gruel samples had mean scores for colour which range between 5.1 and 6.1. However, the colour of the control gruel being the highest but not significantly different from the scores of the 15% and 20% maize-16.7% sweet potato gruels.

Appearance of the food evokes the initial response by the consumer. The liking for the appearance of the control and the 15% maize-16.7% sweet potato flour gruel was nearly the same. The appearance score of the control maize gruel and the 15% maize-16.7% sweet potato was significantly ($p < 0.05$) higher than that of the 20% maize-16.7% sweet potato.

The flavour of the food ultimately determines its acceptance or rejection by the consumer. Both the 15% and 20% maize-16.7% sweet potato gruel samples had a better taste than the control gruel, which was at the verge of rejection. No sugar was added to the gruels for sensory evaluation. The gruel of maize-sweet potato had the highest rating for flavour (taste). The use of sweet potato imparts a sweet flavour which made it more acceptable than the one which had no sweet potato in it. This could be an advantage especially for households which cannot afford to buy sugar.

Fresh sweet potato deteriorates very fast so the processing into flour results into a product with not only better flavour (taste), but also better keeping quality. However, it would be more convenient for working mothers to process the sweet potato into flour, store and use whenever required, since one would not need to pound/grind the sweet potato each time the gruel is prepared.

The gruel samples 7.5% maize and 15% maize-16.7% sweet potato had no significant difference in their texture. Both gruel samples had a better texture than the 20% maize-16.7% sweet potato in which some particles were discernible. The texture of the 15% maize-16.7% sweet potato was mostly preferred for young infants and that of the 20% maize-16.7% sweet potato was recommended for older infants and young children. The 20% maize-16.7% sweet potato flour gruel could most likely be improved by fine milling. For older infants the rough texture would most probably not be of great concern.

The 15% maize-16.7% sweet potato gruel was found significantly more acceptable than the control gruel and the 20% maize-16.7% sweet potato, this was due to its flavour (taste) which was liked and therefore ultimately determined the overall acceptance.

It is important to note that although the appearance score for the 20% maize-16.7% sweet potato flour (w/w) was low compared to that of the 15% maize-16.7% sweet potato flour gruel, its overall acceptability score (4.9) shows that it would be acceptable since it is above the rejection level of flavour score of less than 4. It compares with the score of the conventionally prepared maize gruel which had 7.5% maize flour. Of concern is the texture of the 20% maize-16.7% sweet potato flour gruel whose score (4.6) was relatively low. This and the appearance (with score 4.6) appreciably accounted for the low acceptability score. The low flavour score of the 20% maize-16.7% sweet potato flour gruel is most probably due to high concentration of maize flour since the concentration of the sweet potato flour is the same as that of the 15% maize-16.7% sweet potato flour gruel. Moreover the 7.5% maize gruel had a significantly much lower flavour score than the 15% maize-16.7% sweet potato gruel. The relatively high flavour scores are probably explained by the fact that the gruels containing sweet potato were sweet.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS.

7.1 CONCLUSIONS.

The contribution of the traditionally prepared maize gruels to the energy intake of the infants was less than 60% of the energy RDA.

Eighteen percent of the infants were fed on liquid maize gruels which are thin with an average flour concentration of 7.5%. The energy density of the maize gruels ranged from 0.10 Kcal/ml to 0.39 Kcal/ml and had a mean of 0.25 ± 0.13 Kcal/ml.

Infants were fed on average five meals per day. To meet at least 60% of the energy RDA, infants of 4-6 months, 7-9 months and 10-12 months require 336 mls, 380.8 mls and 465 mls respectively per feeding five times a day which is more than what infants can take.

It was possible to use sweet potatoes to reduce the viscosity of thick gruels to the level at which the gruels could be fed to infants to overcome energy deficits.

When using sweet potato flour to reduce the viscosity, there is a critical level (28.6% w/w) of sweet potato flour above which there is no significant decrease in viscosity, thereby limiting the increase in energy density.

Though added in substantial quantities, the sweet potato inclusion did not affect the organoleptic characteristics of the gruels significantly.

7.2 RECOMMENDATIONS.

Intake trials should be carried out to find out the volumes of the maize-sweet potato gruels the infants can take per day.

Research should be carried out to find out the performance of infants on the maize-sweet potato gruels.

Since the sweet potatoes are locally produced and are affordable, the maize flour could be manufactured commercially in blends with sweet potato flour. Marketing and consumer studies need to be done to establish exactly how this could be done.

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Food Composition Table for Energy and Eight Important Nutrients in Foods commonly Eaten in East Africa. CTA and ECSA.

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APPENDICES.

APPENDIX I: Daily Average Energy Requirements and safe level of Protein intake for infants and children aged 3 months to 5 years.

months	weight (Kg)	KCal/Kg	KJ/Kg	KJ/day	KCal/day	safe protein level	
						g/Kg	g/day

3-6	7.0	100	418	2300	700	1.85	13
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6-9	8.5	95	397	3400	810	1.65	14
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9-12	9.5	100	418	4000	950	1.50	14
------	-----	-----	-----	------	-----	------	----

years

1-2	11.0	105	439	4800	1150	1.20	13.5
-----	------	-----	-----	------	------	------	------

2-3	13.5	100	418	5700	1350	1.15	15.5
-----	------	-----	-----	------	------	------	------

3-5	16.5	95	397	6500	1550	1.10	17.5
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Source: FAO/WHO/UNU (1985) Energy Protein Requirements. pp. 17

KCal = 4.2KJ.

APPENDIX II.

FOOD INTAKE SURVEY.

Date of interview ___/___/___/ Name of interviewer:_____

Village_____ RCI_____

Name of household head:_____

Name of respondent:_____

24-HOUR DIETARY RECALL SURVEY (CHILD).

To be asked of mother or caretaker of a child from 4 months to 12 months of age.

Name of child:_____ Sex:M F Age ___ __ (months).

(circle)

Date of birth ___/___/___/.

PLEASE INTERVIEWER ASK THE MOTHER THE FOLLOWING QUESTIONS AND FILL IN THE TABLE BELOW.

1.Starting from morning yesterday, what did you feed your child ?

2.What was the amount cooked ?

3.What were the ingredients in the dish ? (include amounts).

4.How much did you serve the child ?

5.Did the child leave any of the food ?

3.Amount of food eaten by the child (volumetric measure after deducting the left over).

TIME	DISH	AMOUNT COOKED	RAW INGRED	AMOUNT SERVED (a)	AMOUNT LEFT-OVER (b)	AMOUNT EATEN (a-b)



FOOD COMPOSITION TABLE



FOR ENERGY AND EIGHT IMPORTANT NUTRIENTS IN FOODS COMMONLY EATEN IN EAST AFRICA

* symbols after each nutrient or energy value provide an indication of the contribution that a food can make in supplying that nutrient or energy: - = insignificant contribution ○ = minor contribution ● = good source. The relative contribution is represented by the number of symbols.

COMPOSITION PER 100 GRAMS EDIBLE PORTION (- = not analyzed)	ENERGY		PROTEIN grams	CALCIUM milligrams	IRON milligrams	VITAMIN A micrograms	THIAMIN milligrams	RIBOFLAVIN milligrams	NIACIN milligrams	VITAMIN C milligrams
	kilojoules	(kilocalories)								
CEREALS & GRAIN PRODUCTS										
1. Maize, yellow immature on cob, fresh	585 ●●	106 ●●	80 ●●	18 ○	18 ●	40 ●●	0.18 ●●	0.08 ●	13 ●●	8 ●
2. Maize, white whole kernel, dried	1443 ●●	345 ●●	84 ●●	16 -	38 ●	0 -	0.33 ●●	0.10 ●	22 ●●	0 -
3. Maize, yellow whole kernel, dried	1477 ●●	353 ●●	104 ●●	13 -	49 ●	25 ●	0.32 ●●	0.12 ●	17 ●	4 ○
4. Maize, white on cob, toasted	1523 ●●	364 ●●	80 ●●	2 -	38 ●	0 -	0.02 ○	0.09 ●	22 ●●	4 ○
5. Maize, flour, 80-80% extraction	1397 ●●	334 ●●	80 ●●	6 -	11 ○	0 -	0.14 ●	0.05 ○	16 ●	0 -
6. Maize, meal (unga wa mahindi)	1427 ●●	341 ●●	93 ●●	17 -	42 ●	14 ○	0.30 ●●	0.08 ●	18 ●●	3 ○
7. Maize, meal (dona)	1435 ●●	343 ●●	100 ●●	12 -	25 ●	0 -	0.35 ●●	0.13 ●	20 ●●	3 ○
8. Millet, finger, whole grain	1318 ●●	315 ●●	74 ●	397 ●●	17 ○●●●	4 ○	0.18 ●	0.11 ●	08 ●	1 ○○
9. Millet, finger, flour	1331 ●●	318 ●●	98 ●	315 ●●	510 ●●●	4 ○	0.18 ●	0.10 ●	08 ●	0 -
10. Millet, bulrush, whole grain	1419 ●●	339 ●●	100 ●●	72 ○	210 ●●●	4 ○	0.22 ●	0.10 ●	08 ●	3 ○
11. Rice, lightly milled, parboiled	1393 ●●	333 ●●	78 ●	9 -	17 ○	0 -	0.25 ●	0.03 ○	28 ●●	0 -
12. Rice, milled, polished	1393 ●●	333 ●●	78 ●	9 -	17 ○	0 -	0.25 ●	0.03 ○	28 ●●	0 -
13. Sorghum, whole grain	1435 ●●	343 ●●	110 ●●	28 ○	110 ●●●	3 ○	0.10 ●	0.03 ○	23 ●●	0 -
14. Sorghum, flour	1410 ●●	337 ●●	95 ●●	29 ○	100 ●●●	3 ○	0.15 ●	0.04 ●	33 ●●●	0 -
15. Wheat, whole, parboiled	1361 ●●	330 ●●	120 ●●	54 ○	61 ●●	0 -	0.28 ●●	0.09 ●	34 ●●●	0 -
16. Wheat, flour, 85% extraction	1423 ●●	340 ●●	110 ●●	36 ○	38 ●●	0 -	0.37 ●●	0.08 ●	28 ●	0 -
17. Wheat, flour, 70% extraction	1393 ●●	313 ●●	100 ●●	27 ○	22 ●●	0 -	0.07 ○	0.01 ○	10 ●	0 -
Wheat products:										
18. White bread	1004 ●●	240 ●●	77 ●●	37 ●	17 ●●	0 -	0.18 ●●	0.06 (○)	10 ●	0 -
19. Brown bread	974 ●●	233 ●●	77 ●●	43 ●	22 ●●	0 -	0.20 ●●	0.08 ●	21 ●●	0 -
20. Cakes	1394 ●●	337 ●●	78 ●●	10 -	18 ●	0 -	0.14 ●	0.03 ○	15 ●	0 -
21. Pancakes	552 ●●	132 ●●	19 ●	2 -	0 ○	0 -	0.04 ○	0 -	0 ○	0 -
STARCHY ROOTS, TUBERS & FRUIT										
1. Breadfruit, pulp, raw	414 ●	99 ●	15 ○	28 ○	20 ●●	2 ○	0.09 ●	0.05 ○	07 ●	31 ●●●
2. Cassava, bitter, fresh	877 ●	158 ●	12 ○	69 ●	19 ●●	5 ○	0.04 ●	0.05 ○	08 ●	31 ●●●
3. Cassava, meal	1331 ●●	318 ●●	16 ○	65 ○	38 ●●	0 -	0.08 ●	0.05 ○	09 ●●	4 ○
4. Plantain, raw, raw	538 ●	128 ●	12 ○	8 -	13 ●	130 ●●●	0.08 ●	0.04 ○	08 ●	20 ●●
5. Potato, raw	313 ●	75 ●	17 ○	13 -	11 ●	4 ○	0.07 ●	0.03 ○	13 ●●	71 ●●
6. Sweet potato, yellow, raw	456 ●	109 ●	16 ○	33 ○	20 ●●	300 ●●●	0.09 ●	0.04 ○	07 ●	37 ●●●●
7. Sweet potato, pale, raw	458 ●	109 ●	16 ○	33 ○	20 ●●	6 ○	0.09 ●	0.04 ○	07 ●	37 ●●●●
8. Yam/Cassava, raw	393 ●	94 ●	18 ○	61 ●	12 ○	0 -	0.10 ●	0.03 ○	06 ●	8 ●
9. Turnip/Swede, root, raw	75 ○	18 ○	19 ○	38 ○	0 ○	2 ○	0.03 ○	0.05 ○	05 ●	75 ●●●●
10. Yam, fresh	464 ●	111 ●	19 ○	52 ●	08 ○	2 ○	0.11 ●	0.02 ○	03 ○	8 ●
11. Yam, flour	1297 ●●	310 ●●	34 ○	20 -	11 ○	0 -	0.10 ●	0.07 ○	11 ●●●●	0 -
GRAIN LEGUMES & LEGUME PRODUCTS										
1. Beans, pinto, fresh, shelled	435 ●	104 ●	82 ●●●	22 ○	18 ●	20 ●	0.15 ●●	0.15 ●●	16 ●●●	25 ●●
2. Beans, dried	1338 ●●	329 ●●	220 ●●●	120 ●	82 ●	2 -	0.37 ●●	0.14 ●●	24 ●●	1 ○
3. Beans, green in pod, raw	148 ○	35 ○	25 ●	43 ●	14 ●	30 ●	0.08 ○	0.12 ●	05 ●	27 ●●●
4. Bonavistalyscin bean, dried	1272 ●	304 ●	230 ●●●	90 ●	90 ●●	10 ○	0.31 ●●●	0.14 ●●	23 ●●	0 -
5. Chickpea, whole seeds, raw, dried	1326 ●	327 ●	200 ●●●	250 ●●	110 ●●	10 ○	0.48 ●●●	0.16 ●●	18 ●●	8 ○
6. Cowpea, mature pods, dried	1331 ●	318 ●	230 ●●●	80 ●	50 ●	2 ○	0.40 ●●●	0.15 ●●	80 ●●	2 ○
7. Cowpea, young green pods, raw	153 ○	39 ○	37 ●	54 ●	14 ●	76 ●●	0.14 ●	0.10 ●	10 ●	24 ●●
8. Kidney bean, red, dried	1339 ●	320 ●	220 ●●●	120 ●	82 ●	1 ○	0.37 ●●	0.16 ●	24 ●●	1 ○
9. Lentil, dried	1360 ●	325 ●	250 ●●●	64 ●	70 ●	10 ●	0.41 ●●	0.19 ●●	22 ●●	0 -
10. Mung bean, green, dried	1317 ●	322 ●	240 ●●●	199 ●	70 ●	18 ●	0.52 ●●●	0.26 ●●	24 ●●	0 -
11. Mung bean, black, dried	1305 ●	312 ●	240 ●●●	110 ●	89 ●●	8 ○	0.48 ●●	0.21 ●●	23 ●●	0 -
12. Pea, dried	1251 ●	298 ●	220 ●●●	90 ●	180 ●●●	2 ○	0.28 ●●●	0.17 ●●	30 ●●●	0 -
13. Pigeon pea, dried	1293 ●	309 ●	200 ●●●	160 ●	50 ●	8 ○	0.72 ●●●	0.14 ●●	28 ●●●	0 -
14. Soybean, dried	1703 ●●	407 ●●	340 ●●●	185 ●	81 ●	8 ○	0.71 ●●●	0.25 ●●	30 ●●●	0 -
15. Vetch bean, dried	1361 ●	330 ●	210 ●●●	133 ●	- -	5 ○	0.12 ●	0.10 ●	30 ●●●	2 ○

APPENDIX IV.

Table 5.9b. ANOVA table for Sensory Evaluation.

Source of variation	df	SS	MS	F ratio		
				Calculated	Tabular (p<0.05)	Tabular (p<0.01)
COLOUR						
Total (T)	44	66.58				
Samples						
(treatment)(Tr)	2	6.58	3.29	4.11*	3.34	5.45
Panellist (P)	14	37.25	2.66	3.33*	2.04	2.75
Error (E)	28	22.75	0.80			
APPEARANCE						
Total (T)	41	67.4				
Samples						
(treatment)(Tr)	2	17.76	8.88	8.1**	3.33	5.42
Panellist (P)	13	33.07	2.54	2.31*	2.03	2.73
Error (E)	26	27.73	1.1			
FLAVOUR (taste)						
Total (T)	44	108.8				
Samples						
(treatment)(Tr)	2	13.73	6.87	3.67*	3.34	5.45
Panellist (P)	14	42.8	3.06	1.64	2.04	2.75
Error (E)	28	52.27	1.87			
TEXTURE						
Total (T)	44	111.98				
Samples						
(treatment)(Tr)	2	16.58	8.43	7.66*	3.34	5.45
Panellist (P)	14	64.98	4.64	4.22**	2.04	2.75
Error (E)	28	30.15	1.1			
OVERALL ACCEPTABILITY						
Total (T)	44	89.2				
Samples						
(treatment)(Tr)	2	10.0	5.0	3.05	3.34	5.45
Panellist (P)	14	33.2	2.37	1.45	2.04	2.75
Error (E)	28	45.9	1.64			

* significant at p<0.05

** significant at p<0.01

APPENDIX V.

SENSORY EVALUATION OF AN INFANT WEANING FOOD

Name _____

Date _____

You are provided with 3 gruel samples. Please rate colour, appearance, flavour(taste), texture, and overall acceptability of the samples on the score sheet provided using the scale below:

- 7- Like very much
- 6- Like moderately
- 5- Like slightly
- 4- Neither like or dislike
- 3- Dislike slightly
- 2- Dislike moderately
- 1- Dislike very much

Ensure you thoroughly rinse your mouth after tasting each sample.

A: COLOUR AND APPEARANCE.

First without tasting the samples, score each sample for colour and appearance.

	503	725	571
Colour			
Appearance			

B: FLAVOUR (TASTE), TEXTURE AND OVERALL ACCEPTABILITY.

	503	725	571
Flavour(taste)			
Texture(mouth feel)			
Overall acceptability			

COMMENTS.

APPENDIX VI.

Table 4.1 Sample selection

<u>Zone</u>	<u>No of women</u>	<u>Zone</u>	<u>No of women</u>
1-Ndejje	22 x 1/3= 7	9-Ngobe	21 x 1/3= 7
2-Mirimo	15 x 1/3= 5	10-Kisingiri	7 x 1/3= 2
3-Zana	75 x 1/3= 25	11-Central	4 x 1/3= 1
4-Kyeyagalire	9 x 1/3= 3	12-Lubowa	24 x 1/3= 8
5-Kirimanyaga	7 x 1/3= 2	13-Seguku-zone	20 x 1/3= 7
6-Lufuka	21 x 1/3= 7	14-Kitende B	9 x 1/3= 3
7-Kikumbi	22 x 1/3= 7	15-Dewe	24 x 1/3= 8
8-Kisigula	23 x 1/3= 8		
	64	+	36
		=	100

APPENDIX VII.

Table 11. Proximate composition of sweet potato and other plant foods (per 100 g)

Food	Moisture (%)	Energy		Protein (g)	Lipid (g)	Total carbohydrate (g)	Dietary fibre (g)	Ca (mg)	P (mg)	Fe (mg)
		----- (Kcal)	(kJ)							
Sweet potato										
Boiled	71	114	477	1.7	0.4	26.3	2.4	32	47	0.7
Baked	64	141	590	2.1	0.5	32.5		40	58	0.9
Flour	12	336	1406	2.4	0.7	79.2		70	98	3.2
Cassava										
Flour	13	341	1427	1.5	0.5	83.4		99	92	3.3
Rice										
Boiled, white	68	135	565	2.3	0.3	28.0	0.8	8	36	0.3
Flour	12	365	1527	6.8	0.7	80.0		17	135	1.6
Noodles cooked	79	88	368	1.0		20.3		7	7	0.6
Maize										
Porridge	81	76	318	1.8	0.8	15.6		4		0.6
Tortilla	48	210	879	4.6	1.8	45.3		196	138	2.6
Meal	12	354	1481	9.3	3.9	73.6		19	237	3.3
Wheat										
Chaphati	46	202	860	7.3	1.0	43.7	3.4	60		2.1
Bread	33	278	1163	8.7	1.6	55.7	2.7	24	98	1.3
Noodles cooked	75	108	452	2.7	2.1	19.4		21	25	0.8
Pasta, cooked	66	132	552	4.1	0.7	26.7		8	59	0.5
Sorghum										
Porridge	80	85	365	2.7	0.5	17.0		4	31	1.7
Meal	11	343	1435	9.5	2.8	75.5		28	238	10.0
Beans(<i>Phaseolus vulgaris</i>)										
Boiled	69	118	494	7.8	0.5	21.4	7.4	38	140	2.4

Source: Woolfe.J.A, 1992.