MAKERERE  **UNIVERSITY**

POTENTIAL OF GRAIN AMARANTH TO IMPROVE FOOD AND NUTRITION SECURITY IN RURAL UGANDA

THE CASE STUDY OF APAC, KAMULI AND NAKASONGOLA DISTRICTS

BY

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DECLARATION

I, Tibagonzeka Evas Juliet, declare that this is my original work and has never been presented for a degree in this or any other University or Institution of higher learning.

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DEDICATION

This Dissertation is dedicated to my best friend and husband; Isaac Wamatsembe, my dear mum; Joy Nairuba Kifuko, beloved children; Josiah, Jordana and Jude, my brothers; Hudson, Herbert and Andrew & sisters; Esther & Phoebe and my late grandma who greatly encouraged me throughout the course.

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ACRONYMS

ACC/SCN	-	Administrative Committee on Coordination Sub-committee on Nutrition
AIDS	-	Acquired Immune Deficiency Syndrome
ANOVA	-	Analysis of Variance
CED	-	Chronic Energy Deficiency
CFSVA	-	Comprehensive Food Security Vulnerability Analysis
CRS	-	Catholic Relief Services
EPRC	-	Economic Policy Research Center
FANTA	-	Food and Nutrition Technical Assistance
FAO	-	Food and Agriculture Organization
FCS	-	Food Consumption Scores
FEWSNET	-	Famine and Early Warning System Network
FGCs	-	Food Consumption Groups
GA	-	Grain Amaranth
Hb	-	Hemoglobin
HDDS	-	Household Dietary Diversity Score
HFISS	-	Household Food Insecurity Scale Score
HIV	-	Human Immunodeficiency Virus
HMIS	-	Health Management Information System
IDA	-	Iron Deficiency anemia
IDDS	-	Individual Dietary Diversity Score
IFPRI	-	International Food Policy Research Institute
IYCF	-	Infant and Young Child Feeding practices
MAAIF	-	Ministry of Agriculture Animal Industry and Fisheries
MOFPED	-	Ministry of Finance, Planning and Economic development
MOH	-	Ministry of Health
MUAC	-	Mid Upper Arm Circumference
NAS	-	National Academy of Sciences
NCD	-	Non communicable Diseases
NCHS	-	National Centre of Health Statistics
NECDP	-	Nutrition and Early Childhood Development of Health

NI	-	Nutrient Intake
NQI	-	Nutritional Quality Index
NWGFF	-	National Working Group on Food Fortification
RDA	-	Recommended Daily Allowances
SPSS	-	Statistical Package for Social Sciences
SRLP	-	Sustainable Rural Development Program
UBOS	-	Uganda Bureau of Statistics
UDHS	-	Uganda Demographic and Health Survey
UFNS	-	Uganda Food and Nutrition Strategy
UNCST	-	Uganda National Council of Science and Technology
UNDP	-	Uganda National Development Plan
UNHS	-	Uganda National Household survey
USFDA	-	United States Federal Drug Authority
VAD	-	Vitamin A deficiency
VAM	-	Vulnerability Assessment Mapping
VEDCO	-	Volunteer Efforts for Development Concerns
WFP	-	World Food Programme
WFS	-	World Food Summit
WHO	-	World Health Organization

ABSTRACT

Malnutrition is widespread in Uganda and is partly attributed to the poor dietary quality. Dietary quality can be improved in a range of ways including diversification of local diets using grain amaranth. The latter is a nutritious food, fortunately; it can be produced in many parts of Uganda. However, currently, grain amaranth production and utilization in the country is dismal. The aim of this study was to evaluate the potential of grain amaranth to alleviate malnutrition in Uganda. The study was undertaken in Apac, Kamuli and Nakasongola districts. Firstly, the study set out to establish the current nutrition and food security status of rural households; consequently identifying the nutrient gaps: This involved interviews with 420 farmers (representing 21 farmer groups from 420 different households) to obtain information about food intake, nutrition related knowledge and practices, food insecurity indicators, amaranth production and consumption. Mid upper arm circumference (MUAC) measurements were taken for all children aged 6-59 months in the 420 households studied. Based on food intake data, dietary nutrient gaps were determined. Secondly there was need to develop from grain amaranth and other locally available food materials, recipes that fill the identified nutrient gaps. Thirdly, the study set out to determine sensory acceptability and nutritional properties of the developed products and lastly there was need to evaluate sensory characteristics of the developed products by panelists and followed it with the trial on acceptability of selected recipes by farmer groups in Apac, Kamuli and Nakasongola. The products were also analyzed for nutritional composition. Analysis of the demographics of the study respondents showed that majority (89.5%) were females and the dominant age category (79.5%) was 18-49 years. A total of 88.6% of the respondents had attained some education. Nearly all (92.1%) of the respondents practiced subsistence farming. Food insecurity was generally prevalent, with 36.5% of studied respondents stating that they ate less than the recommended three meals a day. Apac district had the highest percentage (48.92%) in this category, while Kamuli had the lowest (20.71%). More than half of the households **(**52.2%) had low dietary diversity (‹ 6 food groups consumed in 7 days). Nakasongola had the highest percentage of households with low dietary diversity (56.6%) while Apac had the lowest percentage of households (46.1%). Generally, the majority (80.7%) of the households surveyed in all the 3 districts generally did not consume an adequate diet, based on the Food Consumption Score (FCS). Children from households with a low FCS (<35) were more likely to be malnourished than those from households with an acceptable FCS. Only 6% of the

households were asset rich, while about one third (35%) were asset poor. Children from households categorized as asset poor were more likely to be malnourished compared to those from asset rich families. Households categorized as asset poor were also more likely to be food insecure compared to those who were asset rich. With respect to nutrition status, no case of severe malnutrition was recorded among the 420 household studied, based on MUAC. Prevalence of moderate malnutrition was at 22%. The proportion of children at risk of being malnourished was 7%. Children whose mothers/caregivers had no formal education were more likely to be malnourished compared to those whose mothers had attained formal education. Regarding child feeding practices, only 36.9% of children had adequate diets. Child morbidity was found to be high, with 62.67% of all children reporting cases of diarrhea, vomiting or fever over the 2 weeks preceding the study. Dietary analysis showed inadequate intake of lipids, niacin, iron, calcium and zinc. The grain amaranth recipes designed to address these nutrient gaps were found to be highly acceptable by communities, with 15 out of 17 scoring ≥4 on a scale of 5. The products developed using developed recipes were generally acceptable (with 16 out of 17 scoring ≥4 on a scale of 5) and found to contain enhanced levels of zinc, iron, calcium and lipids; the very nutrients found to be inadequate in the local diets of the 3 study districts.

The study results show that grain amaranth has potential to contribute to improvement in nutrition and food security of communities in the three study districts. The high acceptability of both recipes and products shows high potential for increased consumption of grain amaranth. Since the food habits and agro-ecological conditions in the study districts are similar to those in many other parts of the country, it is recommended that grain amaranth production and utilization be scaled up, as a strategy for improving nutrition and food security.

Key words: Grain amaranth, recipes, food and nutrition security

CHAPTER ONE
1.0 INTRODUCTION

1.1 Background to the Study

Under-nutrition and food insecurity remain significant challenges in Uganda, though the country has considerable potential to produce enough food. Nineteen percent of the country's population is undernourished (FANTA, 2010), while the proportion of those unable to access adequate calories increased from 59% in 1999 to 69% in 2006 (UBOS, 2006). Under-nutrition among children under 5 years of age is particularly high, with rates of stunting reported at 33%, while those for underweight and wasting reported at 14% and 5% respectively (UBOS, 2011). Micronutrient deficiencies especially of vitamin A, iron and zinc are also reported to be widespread (UBOS, 2006).

Both the Uganda Nutrition Action Plan (UNAP) 2011-2016 and the Nutrition Situation Analysis report (FANTA, 2010) identify inadequate dietary in-take and the high disease burden as largely being responsible for much of the malnutrition in the country. In addition, they cite low dietary diversity as one of the causes of the poor quality of household diets and hence under-nutrition in many parts of the country. Other studies (Horton *et al*., 2008; Bahiigwa, 1999) indicate that a majority of rural household diets in the country are based on a narrow range of staples, usually; maize, rice, millet, sweet potatoes, plantain (*matooke*) and cassava or combinations thereof. In their evaluation, enunciated in the National Food and Nutrition Strategy (UFNS) 2005, the Ministries of Agriculture and Health in the country, cite the fact that many households have good access to sufficient food for their caloric needs; nevertheless, remain susceptible to suffering from poor nutrition for dietary reasons. One of the reasons cited was the consumption of monotonous and unvaried diets lacking in most of the critical micronutrients.

Most of the staple foods cited are much cheaper and more available than nutrient rich animal foods such as meats, milk and milk products or even eggs. However, when consumed on their own or with only very small amounts of the animal, legume or oil seed products, the result is a poor-quality and undiversified diet that is inadequate in protein, fat and micronutrients. For example, cassava root, one of the cheapest and common staple food in much of sub-Saharan

Africa, is particularly low in protein i.e. 0.8 g protein/100 edible grams (Wargiono, Richana & Hidajat, 2002).

Diet diversification has been identified elsewhere, as one of the food-based strategies with high potential to improve the quality of individual dietary intakes as well as the nutritional and food security situation in poor and resource-poor communities (Thompson *et al.*, 2004; Gibson, 2005). According to Thompson *et al*. (2004), dietary diversification and modification, combined with nutrition education can improve availability, access to and utilization of foods with a high content and bioavailability of micronutrients throughout the year. The same authors cite the fact that dietary diversification and modification relying on product formulation and recipe development can enhance the energy and nutrient density of cereal-based porridges.

As previous studies have indicated, under-nutrition in Uganda is not entirely due to an absolute lack of food but implicates a limited diversity in the household diet. Consequently, availability of diverse and more nutrient-rich food crops in the country, education and support in product formulation and recipe development offer viable opportunities for communities to improve their nutrition through dietary diversification and modification. The recent introduction of Grain Amaranth among resource-poor and marginalized communities in some parts of the country is an anticipated opportunity.

Grain amaranth is a relatively new plant source of food in Uganda; both the leaves and grains can be consumed. The plant possesses unique nutritional and agronomic attributes, making it a valuable food crop especially among resource-poor and marginalized communities; with potential to contribute to improve nutrition and food security possibly also the alleviation of under-nutrition.

The crop has high levels of quality protein, whose amino acid composition compares favorably with the protein standard for good health (FAO, 2003) and better than most of the grains and root crops commonly consumed in the country. Grain amaranth is particularly rich in lysine, the most critical essential amino acids that must be present in the diet for good health (Sseguya, 2007). It is also rich in fiber and other valuable nutrients including calcium with, twice the amount

available in milk. Others include iron that is five times the level available in wheat and higher amounts of potassium, phosphorous, vitamins, A, E and folic acid than available in most cereal grains (Becker *et al*., 1981). The grain is known to contain 6–10% oil, consisting predominantly of unsaturated fatty acids, especially the essential linoleic acid. In addition to the nutritional quality, the crop has a host of beneficial agronomic features including shorter maturity periods, high yields in marginal soils, resistance to stresses such as low moisture and soil fertility.

Preliminary reports on the dietary utilization and consumption of grain amaranth in areas where it has been recently introduced indicate improvements in the general wellbeing of individuals (SRLP, 2005; Mwangi, 2003). Despite such reported improvements and the genuine potential of this crop, grain amaranth production and utilization in Uganda remains rather low. Annual production in all the areas where the crop appears to have made most advances hardly exceeds 10 metric tons. It is apparent that, for the crop to release its full potential in mitigating the country's nutrition and food security challenges, more concerted research and developmental efforts need to be undertaken. Based on this, the study proposed to assess the potential of Grain Amaranth towards enhancing nutrition and food security of rural farmer households in the districts of Kamuli, Apac and Nakasongola and to generate information that would form the basis for the scale up process.

1.2 Problem Statement

Current staple diets for most resource poor people in Uganda are mainly composed of starchy foods such as maize, rice, millet, sweet potatoes, plantain (*matooke*) and cassava. Although these staples dominate diets in both proportion and frequency, they are typically low in lipids, protein, vitamins and minerals and therefore, do not provide the households with adequate nutrients. Complementation with nutrient rich foods like grain amaranth can help to improve the dietary quality.

A number of efforts towards dietary diversification have focused on promoting of identified nutritious foods. However, there is evidence indicating that food insufficiency per se, may not necessarily be the major cause of undernutrition currently witnessed. According to MAAIF (2010), the average caloric intake per person per day declined from 2,193J in 2002 to 1,971J in 2005 despite general increase in food production. This indicates that a general increase in food production may not necessarily be associated with increased consumption. In addition, communities may adopt production of a crop while targeting economic gains. Such may be true for grain amaranth because they are not familiar with the consumption of such a relatively new crop since there are no locally adaptable grain amaranth recipes to be used within households in support of nutrition and food security.

Grain amaranth production has been promoted in different parts of Uganda before however, the actual contribution of the crop to food and nutrition security state of the communities among which it has been promoted is yet to be determined. Thus, this study sought to assess the potential of grain amaranth to enhance food and nutrition security of rural farmer households in Kamuli, Apac and Nakasongola Districts.

1.3 Objectives

1.3.1 Overall Objective

The main objective of the study was to assess the potential of grain amaranth towards enhancing food and nutrition security of rural farmer households in Kamuli, Apac and Nakasongola Districts

1.3.2 Specific Objectives

The specific objectives of the study were:

- To establish the current food and nutrition security status of rural households in Kamuli, Apac and Nakasongola; consequently identifying the nutrient gaps.
- To develop from grain amaranth and other locally available food materials, recipes that fill the identified nutrient gaps.
- To determine sensory acceptability and nutritional properties of the developed products.
- To determine the acceptability of the developed recipes and products among farmers in Kamuli, Apac and Nakasongola.

1.4 Hypotheses

- Diets of rural households in Kamuli, Apac and Nakasongola are deficient in some nutrients.
- Acceptable nutritious food products can be made from grain amaranth and other locally produced food materials.
- Grain amaranth based recipes are acceptable by rural households in Kamuli, Apac and Nakasongola.

1.5 Significance of the Study

Grain amaranth has been adopted by some farmers in Kamuli, Apac and Nakasongola districts. The study therefore sought to develop recipes that could be used by farmers wishing to utilize the new crop by incorporating it into already existing foods so as to cover some of the existing nutrient intake gaps. Growing grain amaranth was likely to benefit resource poor crop producers directly by contributing to nutrition and food security and possibly, income. Increasing consumption of grain amaranth could help to alleviate nutrition and health problems faced by people living with HIV (PLHIV) and other vulnerable groups within the rural households. Children, pregnant and breastfeeding mothers have special nutritional requirements and consumption of grain amaranth was likely to contribute towards that realization. Since the problems of nutrition food insecurity are on the increase particularly in Uganda, findings could be of use to policy makers for formulating strategies in addressing the problem.

1.6 Justification

The current nutritional related knowledge, practices, nutrient intake gaps in Kamuli, Nakasongola and Apac could be improved through participatory development and dissemination of recipes containing the nutrient rich grain amaranth. This could also create a wide interest in the new crop, especially when such a crop is associated with improved food security, nutrition and health benefits.

1.7 Conceptual Framework

Participatory development of recipes/products using grain amaranth (G.A) enrich the local staples available in the communities of Apac, Nakasongola and Kamuli districts will help in increased nutrient intakes, dietary diversity and incomes. This will eventually enhance the nutrition and food security of the households of participants. Figure 1 Gives details of the framework.

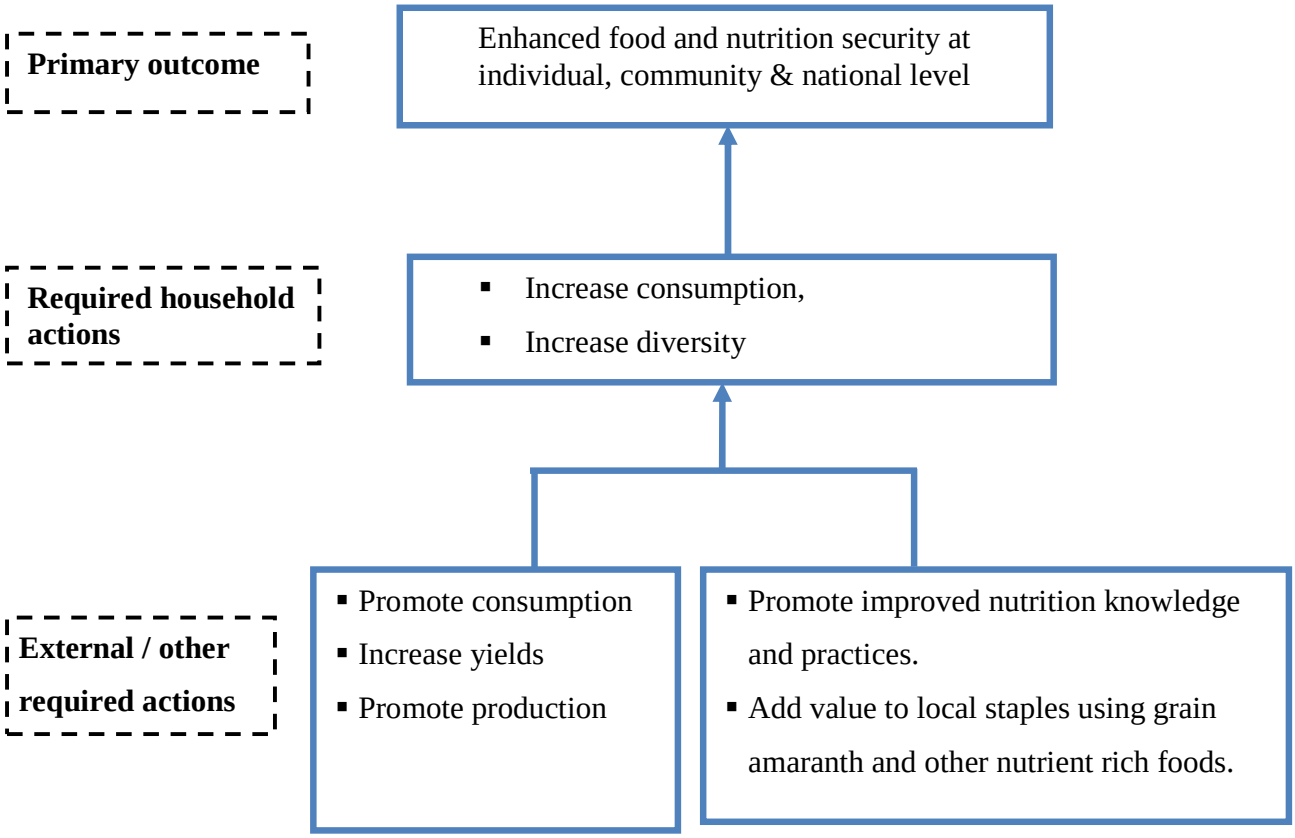


Figure 1.1: The study conceptual frame work

CHAPTER TWO
2.0 LITERATURE REVIEW

2.1 Grain Amaranth

Amaranth (*Amaranthus spp)* is an herbaceous annual with upright growth habit, cultivated for both its seeds which are used as a grain and its leaves which are used as a vegetable or greens. Both leaves and seeds contain protein of unusually high quality (Myers, 2010). Amaranth is often called a pseudo cereal because it is used much like cereal grains although it is not in the grass family. Grain amaranth belongs to the cosmopolitan *Amaranthus* genus of some 60 species (NRC, 1972). The most important species include *A. hypochondriacus, A. cruentus* (grain type) & *A. tricolor, A. dubius, A. lividus, A. creuntus*, *A. palmeri* and *A. hybridus* (vegetable type) (Teutonico & Knorr, 1985). Grain amaranths and many other amaranth species show tremendous potential for human consumption and other uses, and are particularly promising as a remedy for hunger and malnutrition in developing countries (NRC, 1972).

In Uganda, wild amaranth species are weedy and often eaten as vegetable especially in rural areas. In Kamuli and Nakasongola, the weed is called "*dodo*" or "*amaransa*". Three amaranth species are grown for grain including: *Amaranthus candatus* has the shortest season (45-75 days), *Amaranthus cruentus* (60-120 days), *Amaranthus hypochondriacus* (150 days). The potential of grain and vegetable amaranth as a food resource has been reviewed extensively by Haas & Kauffman (1984), Saunders & Becker (1984), NAS (1984), and Sanchez-Marroquin (1980). Amaranth produces a large amount of biomass in a short period of time (Kauffman & Weber, 1990) and therefore has the potential to contribute to a substantial increase in world food production. Grain yield of up to 5,000 kg/ha has been reported (Stallknecht & Schulz-Schaeffer, 1993).

2.1.1 History of Grain Amaranth

The earliest archaeological record of pale-seeded grain amaranth is that of *A. cruentus*, found in Tehuacan Puebla, Mexico, about 4000 BC (Pal & Khoshoo, 1974; Sauer, 1979), making it one of the oldest known food crops. It probably originated in Central and South America (Grubben & van Sloten, 1981). Amaranth was a major grain crop in the pre-conquest Aztec empire (Sauer,

1950b; Pal & Khoshoo, 1974; Early, 1977; Haughton, 1978). Ancient Mexicans made idols of dough from seeds of the crop they called huahtli, which has been identified as grain amaranth (Sauer, 1950b; Marx, 1977). Pale-seeded amaranths were also grown in Germany in the 16th century, India and Ceylon in the 18th century, the Himalayas in the early 19th century, and interior China and Eastern Siberia in the late 19th century (Sauer, 1977).

2.1.2 Utilization of Grain Amaranth in Uganda

Some of the products made out of amaranth seeds include soup, porridge, *posho* (stiff bread/porridge), paste (usually mixed with groundnuts) and pops. Amaranth flour is also used as a sauce thickener (Muyonga *et al.,* 2008). The SRL program has promoted the use of grain amaranth for feeding malnourished children. The amaranth is usually blended with other grains (mainly maize and millet) and given to children in the form of porridge. Amaranth-based porridge has also been adopted for the feeding of normal children as a complementary food, and for feeding the sick, including PLWHA. Feedback from communities in Kamuli district shows a strong association of amaranth consumption and fast recovery from childhood malnutrition and these snacks are commonly consumed by children in Uganda. Snacks commonly consumed in Uganda such as cookies, cakes and *baggia* are normally made from wheat flour while *kabalagala* is usually made from cassava flour. By substituting the wheat or cassava flour with amaranth, the protein content and quality as well as the iron, zinc, calcium and B vitamins content of the snacks were improved (Muyonga *et al.,* 2008).

2.1.3 Utilization of Grain Amaranth Elsewhere

Amaranth was a major food of the Aztecs and earlier American cultures, having been domesticated thousands of years ago (Myers, 2010). According to Kelly & Price, (2008) amaranth was a staple of the Aztecs and was incorporated into their religious ceremonies. In Mexico, grain amaranth is used chiefly for making *alegria* candies; a confection made from popped seeds and molasses (Early, 1977) and for preparing *atolea*, a drink from roasted and powdered seeds mixed with syrup and water (Oke, 1983). In Peru, seeds are popped and ground into flour or bound with syrup and made into belles (Sumar, 1983). In India, the seeds are most commonly used in the form of candy known as *laddoos* (Vietmeyer, 1978), though the seeds are sometimes boiled with rice (Oke, 1983). Amaranth seeds are parched, ground into flour, and

eaten as gruel *(sattoo*) in Nepal and as *chapattis* in the Himalayas (Vietmeyer, 1978). Amaranth has been used as seeds or flour to make products such as cookies, cakes, pancakes, bread muffins, crackers, pasta and other bakery products (Teutonico & Knorr, 1985).

2.1.4 Nutrition and Health Benefits of Grain Amaranth Consumption

Consumption of grain amaranth is reported to have nutritional and health benefits, ranging from a general improvement in well-being to prevention and improvement of specific ailments and symptoms including recovery of severely malnourished children and an increase in the body mass index of people formerly wasted by HIV/AIDS (SRLP, 2005; Tagwira *et al*., 2006). Tagwira *et al*., (2006) documented perceived benefits of consuming grain amaranth among communities in Zimbabwe. The communities claimed that eating grain amaranth made them feel healthier and they noticed improvements in the health of their children. Specific health improvements noted included improvement in appetite, fast healing of mouth sores and herpes zoster, and weight gain for PLWHAs. Amaranth consumption was also associated with higher milk production among breast feeding mothers. The improvements in general well-being and health reported by people who included grain amaranth in their diets are generally explainable by its high nutritional value.

Some specific nutritional and health benefits of amaranth consumption have been elucidated. Amaranth oil has been shown, in animal studies, to lower total serum triglycerides and levels of low density lipoproteins (LDL) (Escudero *et al*., 2006). Similar effects have been reported in humans (Martirosyan *et al*., 2007). High levels of serum LDL are associated with coronary heart disease. The serum LDL lowering effect of amaranth has been attributed to the tocotrienols (unsaturated forms of vitamin E) and squalene in amaranth oil. These compounds affect cholesterol biosynthesis in humans (Martirosyan *et al*., 2007). They are also believed to have anti-tumor and antioxidative activity (Kim *et al*., 2006a), pointing to potential anti-cancer effects. Supplementation of patients with coronary heart disease with amaranth oil has been shown to contribute to a decrease or disappearance of headaches, weakness, increased fatigability, shortness of breath during a physical activity, edema of the legs towards the evening hours and feeling of intermission of heart function in most patients (Martirosyan *et al*., 2007). In addition, decrease in body weight has also been reported. Consumption of grain amaranth has also been

shown to have potential benefits to diabetics. Studies suggest that supplementation of diets with amaranth grain and amaranth oil improves glucose and lipid metabolism in diabetic rats (Kim *et al*., 2006b). The fasting serum glucose levels and the glucose tolerance of the diabetic rats were both improved.

2.1.5 Nutritional Value of Grain Amaranth

According to Muyonga *et al*. (2008), analysis of grain amaranth obtained from farmers' fields in Uganda showed that the grains were rich in proteins, lipids, energy and fiber (Table 2.1). Amaranth grains are also known to contain substantial amounts of vitamins and minerals (Table 2.2). Amaranth grains contain twice the level of calcium found in milk, five times the level of iron in wheat, and higher sodium, potassium and vitamins A, E, C and folic acid than cereal grains.

Table 2.1: Proximate composition of grain amaranth varieties commonly grown in Kamuli, Uganda

Nutrient	Cream amaranth (%)	Golden amaranth (%)
Protein	12.37	13.04
Carbohydrate	63	63.4
Lipid	6.89	7.29
Fiber	6.33	7.01
Ash	2.85	3.6

Source: Muyonga *et al*., 2008

Table 2.2: Amaranth content of selected vitamins and minerals

Nutrient	Content (mg/g)
Iron	17.4
Zinc	3.7
Sodium	31
Potassium	290
Calcium	175
Vitamin C	4.5
Niacin	1.45
Riboflavin	0.23
Thiamine	0.1

Source: (Muyonga *et al*., 2008)

According to Muyonga *et al*. (2008), the varieties grown in Uganda have been found to have protein content of 12-13%, which is higher than that of most cereal grains and other common staples. Grain amaranth proteins contain substantial amounts of the essential amino acids that tend to be marginal in common cereals and pulses (Table 2.3). The level of lysine in both varieties grown in Uganda was found to be above the FAO/WHO reference and more than double the level reported for maize. Methionine levels in the amaranth grains, though slightly lower than FAO/WHO recommended level, is about 3 times the levels in beans. However, amaranth has lower levels of threonine and phenylalanine than the FAO/WHO reference protein and marginal levels of leucine and valine. It should be noted however, that the essential amino acids that are low in amaranth are quite abundant in most diets.

Table 2.3: Amino acid composition of grain amaranth varieties commonly grown in Uganda in comparison to that of maize and beans Amino Acid Content (g/100 g protein)

Amino Acid	White amaranth	Golden amaranth	Maize	Beans	FAO/WHO Reference
Aspartic acid	7.929	7.492	7.48	10.61	
Glutamic acid	19.248	19.72	18.37	13.29	
Serine	6.462	6.09	4.51	4.85	
Glycine	8.983	8.7	3.85	3.3	
Histidine	3.346	2.997	5.5	2.28	
Arginine	9.853	10.295	5.5	4.99	
Threonine*	2.291	2.03	3.63	4.01	4
Alanine	4.216	4.447	5.72	3.75	
Proline	4.812	4.833	6.49	3.25	
Tyrosine	3.941	4.108	4.07	2.94	
Valine*	4.812	4.785	4.51	5.41	5
Methionine*	2.2	2.513	1.76	1.04	3.5
Cysteine	0.275	0.193	2.31	0.09	
Isoleucine*	4.491	4.35	4.29	4.06	4
Leucine*	6.279	6.187	13.75	7.1	7
Phenylalanine*	4.629	4.592	3.63	4.96	6
Lysine*	6.233	6.67	3.41	5.87	5.4

*Essential amino acids

Source: Muyonga *et al*., 2008

It is critical to know according to Muyonga *et al*., (2008) that the protein digestibility of the 2 varieties grown in Uganda is around 72% but roasting and popping, the two commonly-used preparation methods, were found to reduce digestibility to 60.6% and 52.5%, respectively. They further state that the level of tannins, an anti-nutrient known to reduce protein digestibility, in the grain amaranth varieties grown in Uganda was found to range from 0.11% catechin equivalent to 0.42%, which is higher than the levels in other grains like millet and sorghum. The level varied with the geographical area where the amaranth was grown. The levels of other nutrient inhibitors such as hemagglutinin, trypsin inhibitor and saponins in amaranth have been reported to be within the non-critical range (Escudero *et al*., 1999). The carbohydrates in amaranth grain consist primarily of starch made up of both glutinous and non glutinous fractions. Amaranth starch granules are much smaller (1-3 μm) than those found in other cereal grains (Teutonico & Knorr, 1985). Due to the unique size and composition of amaranth starch, the starch may exhibit distinctive characteristics which could be of benefit to the food industry (Lehman, 1988). Amaranth starch seems to have potential for use in the preparation of custards, pastes and salad dressing (Singhal & Kulkarni, 1990a, b). Amaranth grain obtained from farmers in Kamuli was found to contain 6.9-7.4% oil (Table 1) and the oil was made up predominantly of unsaturated fatty acids, with high levels of the essential fatty acid linoleic acid (Table 2.4). Based on its fatty acid profile, it can be concluded that grain amaranth is reasonably safe for consumption by individuals that are at high risk of chronic non-communicable diseases such as coronary heart disease and diabetes. Children need essential fatty acids for proper growth and development. Therefore, the high content of linoleic acid (an essential fatty acid) in grain amaranth makes it suitable for consumption.

Table 2.4: Fatty acids profile for grain amaranth from Kamuli, Uganda

Fatty acid Content (mg/g)	White	Golden
Palmitic acid	1.92	2.31
Stearic acid	0.17	0.21
Oleic acid	2.19	1.92
Linoleic acid	2.8	2.41

Source: Muyonga *et al*., 2008

2.1.6 Processing of Grain Amaranth

The procedures used in the processing and preservation of amaranth seeds in Uganda are quite similar to those documented elsewhere. When the mature amaranth seeds are harvested, they are dried in the sun, winnowed and stored until ready for use. Grain amaranth should be dried to a moisture content not exceeding 12% to limit mold growth. It is also important to clean the grains since the presence of vegetative material in the grain encourages mold growth. Mold growth is particularly undesirable because it leads to the accumulation of mycotoxins which are carcinogenic. It is also important to store the grain on raised pallets in containers that allow for heat and moisture exchange. Sisal bags, which are widely used for grain storage in Uganda, are quite suitable for storage of grain amaranth. To maintain grain quality and to prevent loss, it is also important to prevent attack by pests and rodents. Storage pests such as weevils and grain borers do not commonly attack the amaranth grains, and therefore post-harvest losses are minimal if storage is under the conditions described above (Muyonga *et al*., 2008).

Processing of amaranth seeds involves heat treatment (popping, toasting/roasting), sprouting and milling. Heat treatment helps to overcome milling problems due to the small size of the amaranth seeds; it also takes away the grittiness of the seeds (Oke, 1993). It may be done by popping and toasting/roasting. Popping of amaranth seeds is normally done in a large, hot pan at a high temperature (an air temperature of about 220°C for 10 – 15 seconds). The seeds are stirred constantly while popping to prevent them from burning and to allow most of them to pop (Teutonico & Knorr, 1985). Popping of amaranth seeds results in an increase in volume of up to 1,050 % and gives the grains a gritty flavor (Saunders & Becker, 1984). The increased volume makes milling easier. In Uganda, popping is done using an open fire. The seeds are put on a pre-heated pan and the seeds stirred until most of them are visibly popped.

Roasting/toasting can be done in an oven at around 200°C for 5 - 10 minutes. In rural Uganda, ovens are rare and toasted seeds are those that remain in the pan, un-popped, after open fire popping of amaranth seeds. The toasted seeds are brownish and give a nutty flavor as well when milled (Muyonga *et al*., 2008). To sprout grain amaranth, clean amaranth seeds are soaked in water overnight at room temperature. The seeds are removed from the water and heaped on a tray, then covered with a clean towel to keep the seeds warm. After 2 days the spouted seeds are

sun dried for 2 days. The dry seeds are rubbed together to get rid of the shoots (these give a bitter taste to the product made out of sprouted seeds), winnowed and the seeds stored (as described above under the preparation and storage section) until ready for milling into flour. Sprouting the seeds increases digestibility and bioavailability of nutrients (Muyonga *et al*., 2008). The seeds are milled into flour using a milling machine. In Uganda, some families pound the seeds in a mortar and pestle or grind them using a grinding stone. Pounding and grinding are done on a small scale and usually for a few meals to be consumed at home. This is because the flour quickly develops rancidity if it is kept for more than a month at room temperature

2.2 The Food and Nutrition Security in Uganda

Uganda faces many development challenges, among them food insecurity and adult and child malnutrition. Uganda is among the least well-nourished countries in the world. In 2005, the United Nations World Food Program conducted a Comprehensive Food Security & Vulnerability Analysis (CFSVA) in Uganda which showed that 6 per cent of households were food insecure and 21% were moderately food insecure and at risk of becoming food insecure if conditions deteriorated (McKinney, 2009).

Overall, Uganda does not lack food: 72.4% of households are categorized as food secure(WFP, 2011), and a declining expenditure share for food—from 68% in 1990 to 44% in 2002—indicates an overall improvement in food access (FAO, 2011a). Nevertheless, the typical Ugandan diet lacks diversity and fails to provide sufficient micronutrients. Moreover, seasonal patterns of food insecurity persist in many parts of the country. For example, although we are not aware of recent data that disaggregate food insecurity by agro-ecological zone (AEZ), Bahiigwa (1999) reports data from 1997 and 1998 that show highly varying patterns of food insecurity across AEZs and seasons, but consistently high rates in the Pastoral system (Table 1).The degree of undernourishment is indicated by the depth of hunger. On average, a food-insecure Ugandan falls 240 kcal short of the minimum food needed, in terms of dietary energy (FAO, 2010). Due to adverse climate, low agricultural productivity and civil unrest, Karamoja is the most vulnerable region with 208,000 people (20%) estimated to be food insecure and 387,000 people moderately food insecure. The prevalence of food insecurity is somewhat higher in the southern part of Karamoja: 30% in Moroto and 23% in Nakapiripirit. The largest absolute number of food

insecure, 500,000 people, is found in Busoga, where roughly 15% of the region's population is estimated to be food insecure (McKinney, 2009).

Although rural dietary diversity remains low and tied to harvest patterns and local availability, urban Uganda has been experiencing a nutritional transition – from a dietary emphasis on plantain, starchy roots, and cereals to greater emphasis on rice, pulses, nuts and green leafy vegetables. Consuming one meal a day is not uncommon in rural areas or among the urban poor, especially during the pre-harvest period. Overall, consumption of fruits, vegetables, and animal protein (including fish) has been discouraged by high and rapidly rising costs as well as poor availability, especially in rural areas (FAO, 2010). Micronutrient deficiency is a severe and widespread problem in Uganda. Riboflavin deficiency was reported in 2009 in Northern Uganda (UNICEF, undated) as was a high frequency of vitamin A and vitamin B-12 deficiency; iron, zinc, and calcium deficiencies are also prevalent in Kampala (FAO, 2010). As an example, 19% of Ugandan women and 20% of children have vitamin A deficiency.

The current nutritional situation in Uganda is not adequate for good health and sustainable human development as evidenced by the dismal scores on major nutritional indicators. Approximately 19% of Uganda's population is undernourished (UBOS, 2006).The majority of the undernourished are the vulnerable groups like infants, young children and the women of child bearing age. The immediate factors associated with children malnutrition include; inadequate dietary intake resulting from sub optimal infant & young child's feeding practices which include; consumption of monotonous and unvaried diets lacking in most of the critical micronutrients, low feeding frequency, less nutritious type of food given to the children, insufficient knowledge on how to; utilize nutrient rich foods like grain amaranth to complement staple foods, prepare nutritious/balanced meals for the children (6-59 months))and high disease burden resulting from fever and diarrhea. Other factors include; Lack of household assets, low household food consumption. The three most important micronutrient deficiencies are Vitamin A, iron deficiency anemia and Zinc (UNAP, 2011-2016)

2.2.1 Frequency of Feeding Complementary Foods

Breastfed children 6-8 months need 200 kcal of complementary foods per day, those 9-11 months need about 300 kcal per day and those 12-23 months need about 550 kcal per day (WHO, 2003). A key indicator of adequate complementary feeding is the frequency of feeding. Because their stomach capacities are small, infants and young children need to eat small frequent meals that are energy and nutrient dense every day. According to national guidelines on infant feeding, breastfed infants 6-8 months should be fed complementary foods two to three times a day, while children 9-23 months should be given complementary food three to four times a day. Non-breastfed children should be fed at least four times a day.

The feeding patterns in Uganda are detailed described in the UDHS (2006) report:
Overall, only about 40 percent of breastfed children 6-23 months were fed the minimum recommended number of times a day. It is common in Uganda for young children to eat the same foods at the same time as adults in a household: The frequency a child eats is the same as the number of meals eaten in the household, which might vary by region and season. Households in the north normally reported eating fewer meals in a day. Proportionally more children in the north east (Karamoja), IDPs were fed at an adequate frequency. According to the National Household Survey 2005/06, 18 percent of households in northern Uganda reported that they ate only one meal a day, compared with 5 percent in eastern and 4 percent in western regions.

2.2.2 Dietary Diversity and Nutrient Density

The Uganda DHS 2006 report further indicates that there is significant regional variation in the diet diversity of infants and young children. Only about 60 percent of children in Uganda received adequate variety in their meals. The range was from 28 percent in Karamoja to 79 percent in Kampala, again indicating lowest variety for children in the North. In Uganda, most times infants and young children eat with their mothers. The quality of the infant's food is as good as the family meal. The difference is that the infant's food is softer, mashed and many times made more watery. When there is no food in the household the child, especially infants, might rely entirely on breast milk. Data from this UDHS shows that many children get a variety of foods, but the most commonly consumed foods in this age group are those made from grains such as millet, maize or sorghum that tend to be low in nutrient density. The food eaten in the

household is the common first food given to young children. Children are also given porridge, soups and other milks. Porridge, where available, is the only food prepared specifically for an infant. It is commonly made from plain cereals or cassava and water, and usually nothing is added. Maize-based porridge is common across the country, while millet-based porridge is more common in Northern, Western and Southwestern regions (Kikafunda *et al*., 2003).

2.2.3 Prevalence and Trends in Chronic Energy Deficiency (CED) Among Women

The national prevalence of CED, defined by body mass index (BMI) <18.5 kg/m, was 12 percent among non-pregnant women of childbearing age (ages 15-49 years) in the UDHS 2006 (ORC Macro, 2006). Overall the prevalence of CED has increased slightly over time, with CED highest for women 35 and older. This increasing prevalence among older women of childbearing age might be linked to the increasing prevalence of HIV (and its progression to AIDS with age) among women and/or the high fertility rate in this age group. The UDHS data reveal that rural women were more than twice as likely as urban women to be undernourished (14 percent of rural women vs. 6 percent in urban areas). Similarly, women from households in the lowest wealth quintile were at highest risk of CED (23 percent). Among women with no education, CED was 18 percent compared with 5 percent for women with secondary or higher education. Nationally, the prevalence of CED among women has risen slightly in the past 10 years (by about 0.4 percentage points per year between 2001 and 2006).

2.2.4 Prevalence of Vitamin A Deficiency in Children and Women

Vitamin A deficiency (VAD) levels among children and women are similar within regions. VAD negatively affects resistance to illnesses and is the leading cause of blindness in the world. In the case of children, VAD increases fatality from common childhood illnesses such as measles and respiratory infections. In Uganda, prevalence of VAD is estimated at 20.4% for children aged 6-59 months and 19.4% for women aged 15-49 years and VAD is linked to 11,000 cases of blindness and approximately 8,000 deaths annually (UBOS, 2006). The main source of vitamin A in the Ugandan diets is green leafy vegetables, usually boiled or steamed with hardly any fat added. Foods of animal origin, known to supply retinol, a readily available form of vitamin A are scarce and too expensive for the poor. WHO classifies Uganda as having a moderate public health problem with VAD (FANTA, 2010)

2.2.5 Prevalence of Anemia and Iron Deficiency in Children and Women

Iron Deficiency Anemia (IDA) is characterized by weakness, low productivity, slow mental development, poor concentration and poor health and in children, can lead to poor learning and therefore affects school performance. Data from the ORC Macro 2006 UDHS report indicate that almost three quarters (73 percent) of children 6-59 months were reported to be anemic (Hb < 11.0 g/dl), with 22 percent mildly anemic (Hb 10.0-10.9 g/dl), 43 percent moderately (Hb 7.0-9.9 g/dl) and 7 percent severely (Hb < 7.0 g/dl). The prevalence of anemia was higher among children than adults and declined with age. Among women of childbearing age, 49 percent were anemic (Hb < 12.0 g/dl if not pregnant, < 11.0 g/dl if pregnant), with 35 percent mildly anemic, 13 percent moderately and 0.8 percent severely. This was an increase from the 2001 UDHS report data, mainly due to a slight increase in the proportion of women with mild anemia. The majority of women and children affected by anemia fell in the mild or moderate categories. More women had mild anemia, and more children had moderate anemia across the regions of Uganda. Anemia is very high in preschool children, and the prevalence appears to be rising across much of Uganda for both women and children.

The prevalence of anemia among children under 5 years of age was higher than that for women of childbearing age. The highest prevalence of anemia for women and children was in the Central 1 region and the lowest was in Kampala. Anemia is so widespread in Uganda that it is difficult to determine region-specific underlying causes. It is more likely that across Uganda some common factors are driving the high prevalence of anemia, such as high disease burden and inadequate dietary sources and intake of iron. Prevalence of anemia is highly associated with wealth ranking, being lowest in the upper wealth quintiles. The UDHS 2006 supplemental study correcting for infection determined that almost all children had iron deficiency (ORC Macro. UDHS, 2006). It also shows that 88 percent of women had iron deficiency, with or without anemia. About 55 percent of women had iron deficiency without anemia, while 32 percent had IDA. Only 5 percent of women had anemia with no iron deficiency. Similarly, almost all children under 5 had iron deficiency, with or without anemia. About 28 percent of children had iron deficiency without anemia and 70 percent had IDA. Only 1 percent of children had anemia with no iron deficiency.

2.2.6 Zinc Deficiency

Although limited data exist, given the kind of food staples in most of Uganda, zinc deficiency could be a potential public health problem. The prevalence of zinc deficiency has been estimated to range between 20 to 69 percent in children and 21 to 29 percent in adults (Srinivansan, 2007). The efficacy of zinc as adjunct therapy in the treatment of severe diarrhea. Low zinc levels among children might have some bearing on the high rates of stunting among young children in Uganda. WHO recommends that all children with severe diarrhea who are seen at a health facility be provided with zinc supplementation (Dehbozorgi *et al.*, 2007).

2.3 Food Security Situation in Uganda

2.3.1 Definition of Food Security

Food security exists when "when all people at all times have both physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preference requirements for a productive and healthy life." (WFS, 2010). Food security at a national or regional level occurs when the nation/region is able to command enough food to meet the aggregate requirements of its people. In this context attention is paid to fluctuations in aggregate food supply. However, adequacy at the aggregate level does not necessarily ensure adequacy at the household or individual level. This has redirected focus on food security from macro level towards the household and still further towards the individual (FAO, 1996). Food security is therefore a broad and complex concept. It is determined by the interaction of a range of agro-physical, socioeconomic, and biological factors. There is no single direct measure of food security. It is generally accepted as entailing not only *food availability* (adequate supply of food) but also *food access* through home production, purchase in the market or food transfer. It also includes food *utilization,* which refers to the appropriate biophysical conditions (good health) required to adequately utilize food to meet specific dietary needs (FAO, 2003). Effective food utilization depends to a large extent on knowledge of food storage and processing techniques, basic principles of nutrition and proper childcare, and illness management within the household (FAO, 2003; Bonnard *et al.*, 2002; USAID, 1999).

2.3.2 Vulnerability to Food Insecurity in Uganda

The World Food Programme's Vulnerability Assessment Mapping (VAM) survey provides some insights into the regional variation, pattern and underlying causes of food insecurity in Uganda. The results of the Uganda CFSVA 2009 indicate that 6% of households are food insecure, 21% are moderately food insecure and at risk of becoming food insecure if conditions deteriorate. The remaining 73% are classified as food secure. The reasons for food insecurity differ across the country (CFSVA, 2009). The effects of the long conflict in the North continue to fuel poverty and food insecurity there. Food production is not yet at capacity because of fear of insecurity and land disputes. In addition, households are still highly dependent on food aid, incomes are low and livelihoods are undiversified. In Eastern and East Central Uganda, lack of livelihood diversification, reduced wages and dependence on agriculture alone are keeping incomes low and have been identified as plausible explanation of the prevalence of food insecurity in these regions. Chronic illness among adults also appears to be a factor in increasing the risk of food insecurity. In the Central region, inadequate production of food stocks at the household level, lack of income and increasing food prices appear most likely to explain the prevalence of food security. The Western and Southwestern regions have the lowest food security, but because agriculture is a mainstay among the poor, many of whom work as agricultural laborers, their income is subject to seasonality, and wages can fluctuate significantly. In the WFP assessment, reduced wages and rising food prices appear to be factors in the prevalence of food security. Overall, low wages and incomes, dependence on agriculture and lack of diversification in livelihood activities appear to be factors that reduce food security (CFSVA, 2009)

2.3.3 Household Food Security

ACC/SCN (1991) defines household food security as a state when the household has access to the food needed for a healthy life for all its members (adequate in terms of quality, quantity and culturally acceptable), and when it is not at undue risk of losing such access. When a household is persistently unable to meet the food requirements of its members over a long period of time marked by continuous, temporary blips of good and bad moments, then there is a long-term problem known as chronic food insecurity. The short-term sudden reduction of a household's access to food to below the nutritionally adequate level is known as transitory food insecurity. Chronic food insecurity involves an inability to meet food requirements over a long period, while

transitory food insecurity entails shocks that briefly push the level of food consumption below the requirements. A household can be said to be food secure only if it has protection against both kinds of insecurity. The average access to food over the long term should be nutritionally adequate, and a household should be able to cope with short-term vicissitudes without sacrificing the nutritional needs of any of its members.

2.3.4 Factors Affecting Household Food Security

Factors that negatively affect a household's or individual's food availability or food access can be divided into four categories: Individual-level constraints such as food habits, reduced capacity to eat because of infection symptoms, level of knowledge of the benefits of proper feeding, and psychosocial factors such as depression (Egal & Valstar, 1999). Household-level constraints such as lack of production and purchasing power, inequitable intra-household distribution, lack of knowledge about nutritional needs and dietary practices, food taboos, and changes in prioritization among household members (Meyer, 1997). Constraints external to the household such as seasonal variation in production, price fluctuations, social stigma, market availability, legal issues, and social customs (Remancus, 2004) and shocks such as droughts, floods, or conflict (Devereux *et al.*, 2004; Remancus, 2004).

CHAPTER THREE
3.0 METHODOLOGY

3.1 The Study Area

The study was conducted in three districts of Uganda which included Nakasongola, Kamuli and Apac. These districts represented 3 of Uganda's agro-ecological zones namely: the banana-coffee system, the banana-millet-cotton system and the northern system respectively. They therefore represented agro-ecological diversity in the country.

3.1.1 Apac

Apac is located in Northern Uganda (Figure 3.1). It is bordered by Oyam District to the northwest, Lira District to the northeast, Dokolo District to the southeast, Amolatar District to the south, Nakasongola District to the southwest and Masindi District to the west. The main economic activity in Apac district is subsistence agriculture. The major crops grown include tobacco, cotton, simsim, maize, beans, sunflower, potatoes, cassava and ground nut. Fishing and livestock husbandry are also important economic activities. The topography of Apac is characterized by low plains and rolling hills. The vegetation is predominantly of the dry savannah type. The soils consist of a reddish-brown layer of clay loam which covers almost all cultivable land (90 per cent) and is very suitable for rain-fed agriculture. Apac has dry and wet seasons. The wet season extends from April to November with a total annual rainfall of 1,330 mm. On average, the maximum temperature is 29° and the minimum is 17°. Apac population estimate is 490,688 people with population density of 106 persons per km^2 (2007 estimates).

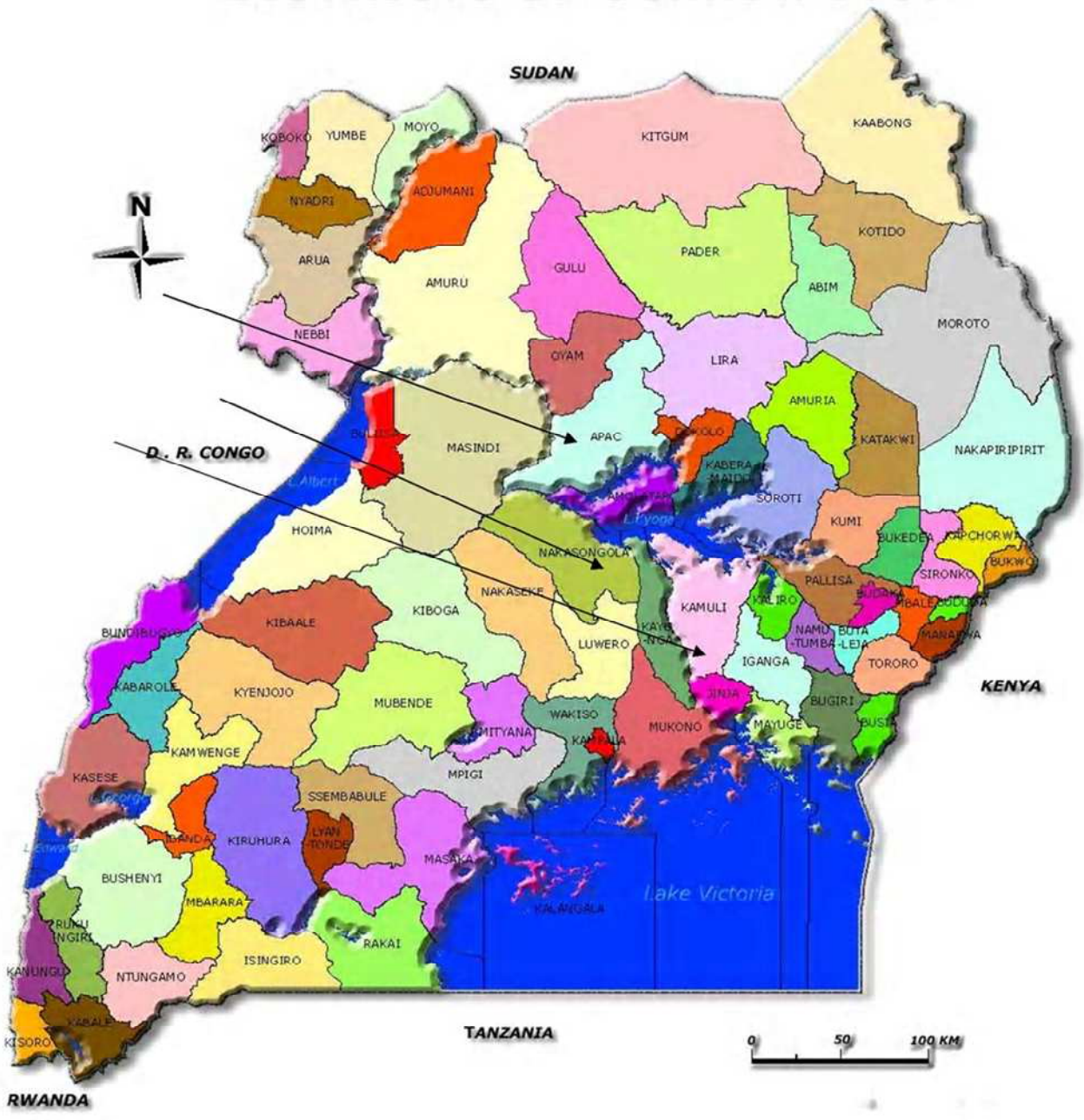
3.1.2 Kamuli

Kamuli district is located in southeastern Uganda (Figure 3.1). It lies at average altitude of 1083m above sea level and extends from latitude 00- 56' N /330-05' E to longitude 01- 20 N /330- 20' E. Kamuli covers an area of 4,348km^2 of which 3332km^2 is land and 1016km^2 (23%) is water. The predominant vegetation cover in the district is the forest/ savannah type of mosaic consisting of a mixture of forest remnants and savannah trees with grass and shrubs. Much of it is secondary vegetation that has succeeded the original forest cover as a result of farming, fuel harvesting and other forms of land use. Kamuli's population is estimated at 662,407 people and

the population density is approximately 236 persons per sq km (2007 estimates). The district experiences a bimodal type of rainfall with peaks in March – June as well as August – November. The annual average rainfall is 1350 mm; while the monthly mean is 75 mm to 100 mm. Kamuli is a warm district with average annual temperature range in most areas of 19 C – 25C. Livestock husbandry, fishing and subsistence crop farming are the major economic activities in Kamuli. Crops grown include potatoes, rice, beans, bananas, maize, millet, vanilla, coffee, cocoa, cotton, groundnuts, citrus fruits, mangoes.

3.1.3 Nakasongola

Nakasongola district is located in Central Uganda (Figure 3.1). It boarders with the districts of Masindi in the West and North West, Luwero and Nakaseke in the south, Kayunga in the east, Amolatar in the north east and Apac in the North. The district covers an area of 3424 sq km representing about 1.42% of the country's total surface area. Nakasongola is generally flat area topographically adulating between 3800ft above sea level. Much of the low lying areas are drained by seasonal streams into Lake Kyoga in the North, and has tributaries to rivers like Sezibwa in the east, Lugogo on the west, south and Kafu on the north western. The District is mainly covered by Bululi soil catena, and the Lwampanga catena in the low lying areas and valleys. Vegetation type is mainly open deciduous savannah woodland with short grasses. Dominant tree species include *cumbersome ssp*, Terminala and Acacia. Nakasongola receives rainfall ranging from 500-1000mm per annum. There are two rain seasons. The main seasons occur in march-April-June/July and October to Nov/Dec. It is estimated that the population of Nakasongola District is approximately 156,200 (2009 estimates). Subsistence crop production and livestock husbandry are the main economic activities in Nakasongola district. The main crops grown include cassava, maize, sweet potatoes, sorghum, bananas, millet, coffee and cotton.



Map **3.1: The study area (Kamuli, Apac and Nakasongola districts)**

3.2 Research Design and Sampling Strategy

The study followed a cross-sectional block design, covering 3 districts and a total of 9 sub-counties purposefully chosen to represent area variation. Pre–testing the questionnaire was done to improve the reliability and accuracy of the tools. Pretested Structured questionnaires were used to obtain data from 420 households. Out of each of the selected districts, the farmers that belong to VEDCO (a leading NGO that supports farmers in the study area) were organized into 7 separate "strata" i.e. farmer groups. Each stratum/farmer group was then sampled as an independent sub population, out of which individual farmers who had children aged 6-59 months were randomly selected. From each of the selected Farmers, base line information regarding nutrient intake, nutrition knowledge, food insecurity indicators, amaranth production and consumption were collected. Cross tabulations between the nutrition related data and household demographics were then made.

The Snowball Sampling Method was used to select sites and participants in the collection and evaluation of baseline data relating to Grain Amaranth utilization through one on one interviews The results from the 2 surveys were used to design recipes (using a participatory approach) to cover the nutrient intake gaps. Since maize, cassava, rice, beans and wheat are major staples in all the study areas, these were chosen to act as bases for complementation by combining them with identified nutrient rich foods. (Sesame, soybeans, groundnuts and ginger). Particular foods were combined with grain amaranth in different ratios. Mass balance was used to determine the ratio of ingredients required to achieve recommended USFDA theoretical nutrient levels. Traditional preparation methods were then used to produce different food products. The developed products (39) were subjected to a nine-point hedonic scale sensory analysis using untrained panel of 54 to determine acceptability. The best ranking products (17) were analyzed in the laboratory to confirm that they were fit to be used in bridging the identified nutrient intake gaps. The tested best ranking recipes were further subjected to trials and evaluation by 21farmer groups (within the study area) using group interviews entailing a 5point hedonic scale to determine their acceptability and assess applicability. The basis of this design was therefore to have recipes/products that are nutritious, affordable, sustainable, well balanced and worth because the intended /target consumers preferred them.

3.3 Sample Size

Four hundred and twenty households were studied during the baseline survey for situation assessment. To obtain a representative sample, Fisher's formula was employed (Fisher *et al.*, 1998). That is: nf = n/1+ (n/N)

where nf is the desired sample when the population is less than 10,000; n is the sample when the total population is more than 10,000; and N is the estimated population of the households in the target areas (From each of the 3 districts, 7 farmer groups (clusters) were considered and from each farmer group 20 farmers were to be considered). n was determined as follows: n = Z^2pq divided by d^2 where n = the desired sample size when the population is more than 10,000; Z = the standard normal deviation at the required confidence level; p = the proportion in the target population estimated to have characteristics being measured; q = 1 p; and d = the level of statistical significance set. The calculation was:

n = (1:96)2 (0.50) (0.050) divided by (0:05)2 = 384:00.

n = $(1.96)^2$ x [(0.5 x 0.5)/ $(0.05)^2$] = 384. Forms a representative sample of crop farmers, taking an assumption that about 2% grow grain Amaranth, and adjusting to the population using the formula N1=N/(1+N/the target population), N1=384/(1+384/420)=419

However, for the purpose of this study, this figure was rounded down to the nearest hundred, that is, to 420 households.

3.4 Data Collection Instruments

The instrument for data collection were interviewer-administered questionnaires which was divided into four major groups according to the study objectives; the first questionnaire was to collect information on nutrition and food security, the second was to collect the baseline grain amaranth recipes, the third questionnaire entailing the 9 point hedonic scale was for sensory evaluation and ranking of products by panelists and the last questionnaire was to evaluate both the products and recipes by the target farmers in the field. Interviewer-administrated questionnaires were preferred to other types of instruments because a higher completion rate was expected. Open ended and closed ended questions were used, to obtain information about specific aspects outlined by the researcher as well as unanticipated views from respondent (Kabali & Mwesigye, 2003). A 5 point hedonic scale was used during the group interviews to establish acceptability by ranking the products and recipes.

The questionnaires were tested for its reliability during the pre-testing exercise. Twenty farmers were selected from Apac, Kamuli and Nakasongola who were interviewed twice by the researcher using the same questionnaire. The interval between the interviews was two weeks. Two weeks were appropriate because it is anticipated that the respondent would have forgotten the previous response. This was meant to check for the consistency of the responses given by the same respondents during the two interviews. When the results were correlated, reliability coefficients ranging from0.57 to 0.68 were obtained. Hence the questionnaires were considered reliable for data collection, as the reliability coefficients were reasonably high.

3.4.1 Data Collection

The average length of the questionnaire interview for objective one (first questionnaire) was 45 minutes. For each district, data were collected for a period of four days. The major problems encountered during the fieldwork included: resistance of respondents to reveal exactly what they ate and the assets they owned for fear that it could be a government plan to impose taxes. This had a potential to impact on data quality but the well trained enumerators assured the respondents that data collected was to be held in a confidential manner and that the survey was done for the sole purpose of determining how best grain amaranth could contribute to the diets of the households. High data quality was also maintained in the field by spot checking questionnaires in order to determine their completeness and consistency.

3.5 Food Security Assessment

This entailed determination of diet quantity (i.e. number of meals consumed by the household), dietary diversity and quality (recall period-24 hours), food consumption scores (recall period-7 days), weekly consumption patterns, asset ownership and average crop yield/output per household.

3.5.1 Determination of Diet Quantity

Diet quantity was determined from the number of meals consumed per day in the households.. A meal was defined as consumption of food at a particular time in the 24 hours prior to the assessment within the household. The meal timings were categorized as morning meal, any food between morning and lunch, lunch, any food between lunch and supper, supper, or any food after

supper. The number of meals consumed per day in the households were recorded and used as an indicator of food security. All households that had less than 3 meals a day were considered food insecure while those having 3 or more meals a day were considered food secure (FANTA, 2006).

3.5.2 Dietary Diversity

3.5.2.1 Household dietary diversity

This was assessed by totaling the number of food groups consumed in the households for the past 24 hours (Gibson, 2005). The following set of 13 food groups was used in the questionnaire to calculate the Household Dietary Diversity Score (HDDS) adapted from FANTA, 2006 guide on household dietary diversity:

A. Cereals, **B**. Root and tubers, **C**. Vegetables, **D**. Fruits, **E**. Meat, poultry& offal, **F**. Eggs, **G**. Fish and seafood, **H**. Pulses/legumes/nuts, **I**. Milk and milk products, **J**. Oil/fats **K**. Sugar/honey, **L**. Miscellaneous, **M**. Grain Amaranth. Grain amaranth was considered as a separate group because it was being promoted among the farmer groups for nutrition improvement.

Households were classified as follows: those consuming 1–3 groups were considered low diversity; those consuming 4–6 groups were medium, those consuming 7–9 were considered the high-diversity group while those consuming 9 and above groups were considered very high. In terms of dietary quality, those who consumed ≤ 6groups were considered low while those consuming >6 groups were considered high. After collecting data on the HDDS for every H/H, the average HDDS for the Households under the survey was calculated using the formula below;

$$Average\ HDDS = \frac{Sum\ (HDDS)}{Total\ Number\ of\ Households}$$

3.5.2.2 Individual Dietary Diversity (For children 6-59 months):

Dietary diversity was assessed by interviewing the mother / caretaker to determine what the child ate and thereafter totaling the number of food groups consumed by the child (6-59 months) in question for the past 24 hours. The following set of 9 food groups was used in the questionnaire to calculate the Individual Dietary Diversity Score (IDDS) adapted from FANTA, 2006 guide on household dietary diversity:

A. Grains, roots or tubers, **B**. Vitamin A rich plant foods, **C**. Other fruits or vegetables, **D**. Meat, poultry, fish, seafood, E. Eggs, **F**. Pulses/ legumes / nuts, **G**. Milk and milk products, **H**. Foods cooked in oil/ fat, **I**. Grain Amaranth.

The assessed children were classified as follows: those consuming ≤ 4groups were considered low diversity and quality group while those consuming >4 groups were considered the high-diversity group.

3.5.2.3 Minimum Dietary Diversity (For children 6-23 months):

This is one of the core infant feeding practices. It was determined according to WHO, 2010 - Indicators for measuring Infant and Young Child feeding practices part 2.

Definition: Proportion of children 6–23 months of age who receive foods from 4 or more food groups i.e.

$$\frac{\textit{Children 6 – 23 months of age who received foods from 4 food groups during the previous day} * 100}{\textit{Children 6 – 23 months of age}}$$

3.5.3 Food Consumption Scores

Food consumption data was analyzed by calculating the Food Consumption Score (FCS) based on the WFP VAM, Technical guidance Sheet. Briefly, the data collected with a standard WFP seven day recall tool was reduced from the **80** food items in the questionnaire and grouped into eight food groups. **Table 3.1** indicates the food groups developed and their weights. Using the data on the food within the above groups, all the consumption frequencies of food items of the same group were summed up. Food groups that were consumed more than 7 times were recorded as 7 implying that the food group was consumed daily. The value for each group was multiplied by the appropriate weight as indicated in **Table 3.1.** The weights were assigned based on the nutrient density of the food groups. The highest weight was attached to foods with relatively high energy, good quality protein and a wide range of micro-nutrients that can be easily absorbed. All the scores were summed up to give a Food Consumption Score (FCS). The FCS were used to set the thresholds for Food Consumption Groups (FGCs) based on the frequency of the scores.

Table 3.1: Food groups and their weights used to calculate FCS

Group No.	Food Items (as per questionnaire)	Food Groups	Weight
1	Maize , sorghum, , wheat, Rice, millet, cassava, potatoes, yams, *Matooke*, *mandazi*, *chapatti*, Biscuit, cookies, cakes, doughnuts, macaroni, Grain Amaranth	Staples	2
2	Beans, Peas, Groundnuts, Sim-sim	Pulses	3
3	leafy greens, egg plants, Bitter tomatoes, Pumpkin, Tomatoes, onion, green pepper, cabbage, Mushrooms, carrots	Vegetables	1
4	Mango, passion fruits, Tangerines, Tamarinds, Pineapples, Pawpaw, Apple, Pears, Guavas, Oranges, water melon, sweet bananas, Avocado	Fruits	1
5	Beef, goat, mutton, pork, poultry, eggs, liver, offal's, white ants, Grasshoppers, and fish(Nile perch, Tilapia, 'Mukene', 'Nkejje', Cat fish)	Meat and fish	4
6	Fresh milk, Yoghurt, cheese, butter, Ghee, soy milk	Milk	4
7	Sugar, sugar products(Soda, *Busheera*), honey	Sugar	0.5
8	Vegetable oil, animal fats (ufuta, mukwano, kimbo, cowboy, blue band)	Oil	0.5

Source: Adapted from WFP Technical guidance sheet, 2008

The thresholds were used as proxy indicators for food security. Households in the poor category were regarded as food insecure, those in the borderline as vulnerable while those in the acceptable category as food secure. The thresholds used are indicated in Table 3.2.

Table 3.2: Thresholds of food consumption profiles

Food Consumption Score (FCS)	Profiles	Food security status
0-21	Poor	Food insecure
21.5-35	Borderline	Vulnerable
> 35	Acceptable	Food secure

Source: WFP and CSFVA, 2008 report

3.5.4 Asset Ownerships

Asset ownership was analyzed by calculating an asset index to act as a proxy indicator for asset based wealth. In order to create the asset index, the households were categorized into three groups as shown in **Table 3.3.**

Table 3.3: Asset based wealth categories

Number of assets owned by households	Wealth Category
0-3	Asset poor
4-8	Asset medium rich
Above 9	Asset rich

Source: WFP and CSFVA, 2008 report

3.6 Dietary Nutrient Intakes

The nutrient intakes were computed from the summation of the amounts of the different foods consumed and their respective nutrient composition based on the Tanzanian food composition tables (Zohra Lukmanji & Ellen Hertzmark, 2008). The nutrient intake levels were compared to recommended intakes and the proportion of subjects whose intake was lower that recommended levels for the different nutrients were determined.

3.6.1 Hansen's Nutritional Quality Index (NQI)

The Hansen's nutritional quality indices (NQI) were also derived (Hansen, 1973) and used to identify nutritional deficiencies. The NQI measures the amount of nutrient in a diet or food relative to the total energy value of the food or diet. The US RDA (Fda.gov, 2008; Ecfr.gpoaccess.gov, 2011) values were used as reference values in the NQI calculations.

The NQI was the ratio of its percentage standard relative to the standard of calories. In other words, if a given food contained X mg of a nutrient in C kcal and the US RDA for that nutrient was mg of a nutrient in C kcal and the US RDA for that nutrient was Y mg in 2000 kcal, then

$$NQI = (X/Y)/C/2000$$

NQI values ›1.0 were desirable

Table 3.4: Thresholds of Nutrient Intakes

NUTRIENTS	US THRESHOLDS
Macro Nutrients	
Proteins	50g
Fiber	25g
Fat	65g
Vitamins	
Thiamine	1.5mg
Riboflavin	1.7mg
Niacin	20mg
Vitamin C	60mg
Minerals	
Calcium	1000mg
Zinc	15mg
Iron	18mg
Energy	2000Kcals

Source: 1999 - 2002 Dietary Reference Intakes, Institutes of Medicine 2005 Dietary Guidelines ©Children's Nutrition Research Center at Baylor College of Medicine

3.7 Nutritional Status

The nutrition status for children aged 6-59 months was determined using the Mid Upper Arm Circumference (MUAC**)** (Gibson, 2005). The children were then categorized into the different nutrition status groups (Table 3.5). Only children above six months were assessed for MUAC. The measurement was taken on the left arm, halfway between the shoulder and the elbow. MUAC was recorded to the nearest 0.1 cm.

Table 3.5: Nutritional status cut-offs points for MUAC

MUAC	Diagnosis
< 11cm	Severe malnutrition
≥ 11 and < 12.5 cm	Moderate malnutrition
≥ 12.5 and < 13.5 cm	Mild malnutrition (at risk)
≥13.5 cm	Good nutrition status

Source: MOH

3.8 Morbidity

Any episodes of diarrhea, fever/malaria and vomiting occurring in the two weeks preceding the assessment among children aged 6-59 months were recorded. This allowed for morbidity patterns to be assessed within a short time frame to account for appropriate recall periods. The prevalence of diarrhea, fever and vomiting were estimated from the number that reported cases of illnesses over the last 2 weeks prior to the assessment.

$$Prevalence\ of\ Diarrhea = \frac{Number\ of\ children\ that\ reported\ diarrhea\ x\ 100}{Total\ number\ of\ children\ surveyed}$$

Nutrition related knowledge and practices of mothers and caretakers with regard to feeding of children (6-59 months) was determined through one on one interview using the questionnaire (appendix 1)

3.9 Practices

Two of the core feeding practices that affect the nutrient intakes of infants and young children (6-23 months old) were determined according to WHO, 2010 - Indicators for measuring Infant and Young Child feeding practices part 2.

3.9.1 Continued Breastfeeding at 1 Year

Definition: Proportion of children 12–15 months of age who are fed breast milk.

$$\frac{Children\ 12-15\ months\ of\ age\ who\ received\ breast\ milk\ during\ the\ previous\ day\ \ x100}{Children\ 12-15\ months\ of\ age}$$

3.9.2 Introduction of solid, semi-solid or soft foods

Definition: Proportion of infants 6–8 months of age who receive solid, semi-solid or soft foods.

$$\frac{Infants\ 6-8\ months\ of\ age\ who\ received\ solid,semisolid\ or\ soft\ foods\ during\ the\ previous\ dayx100}{Infants\ 6-8\ months\ of\ age}$$

3.10 Recipe Development and Determination of Nutrient Composition

3.10.1 Identification of Grain Amaranth Recipes Used By Communities

The Snowball Sampling Method, targeting persons already utilising grain amaranth within the study areas, was used to select participants in the collection and evaluation of data relating to grain amaranth utilization, recipe and product development. The participants were interviewed using a one on one approach to identify the grain amaranth recipes they use.

Figure 3.2: Farmers in Nakasongola (left) and Kamuli (right) districts being interviewed on how they utilized grain amaranth at their households during the baseline recipe collection exercise

3.10.2 Identifying Foods to Develop Recipes

Based on the baseline survey which sought to determine the current nutrient intakes, the identified nutrient intake gaps included calcium, zinc, iron, fats and niacin. Table 10, show locally produced foods identified to enrich products with the nutrients identified to be deficient in the diets in the study districts.

Table 3.6: Foods identified to fill identified dietary gaps for Apac, Kamuli and Nakasongola districts

Nutrients	Foods
Zinc	Sesame, soybeans, groundnuts, ginger
Iron	Sesame
Calcium	Sesame, soybeans
Niacin	Peanut, millet
Lipids	Sesame, soybean

Since maize, cassava, rice, beans and wheat are major staples in all the study areas, these were chosen to act as bases for complementation by combining them with identified nutrient rich foods. All these foods were combined with grain amaranth in different ratios. Mass balance was used to determine the ratio of ingredients required to achieve recommended USFDA nutrient levels. Traditional preparation methods were then used to produce different food products. The developed products were subjected to a nine-point hedonic scale sensory analysis using panels of 54. The best ranking recipes were further subjected to trials and evaluation by farmers using group interviews entailing a 5point hedonic scale determine their acceptability and assess applicability. The final formulations used for the different food products are provided in Table 11. Figures from the USDA Nutrient Database in Appendix 7 were used in the recipe formulations.

3.11 Pre-processing and preparation of Materials

3.11.1 Grain Amaranth Winnowing and Cleaning

Before further processing and use in recipe formulation, Grain Amaranth was cleaned to remove sand and debris using winnowing methods traditionally used for finger millet grain.

3.11.2 Grain Amaranth Popping and Milling

Popping of amaranth seeds was done in a large, hot aluminum saucepan at high charcoal fire temperature. A spoonful of cleaned and sorted grains were introduced into the pan. The grains popped instantly however stirring was constantly done to prevent them from burning and to allow most of them to pop. Popping of amaranth seeds resulted in an increase in volume and gave the grains a gritty flavor. Some of the popped grain was milled into flour using a commercial mill or used directly in recipe formulations.

3.11.3 Grain Amaranth Roasting and Milling

Cleaned and sorted GA was roasted using a low charcoal fire-heated aluminum saucepan. The grains were introduced into the pan and continuously stirred, using a wooden ladle until they acquired a golden-brown color and nutty flavor. The roasted grains were used directly in recipe formulations or ground into flour using a domestic mortar and pestle.

3.11.4 Millet Roasting and Milling

Cleaned and sorted millet grains were roasted using a low charcoal fire-heated aluminum saucepan. The grains were introduced into the pan and continuously stirred, using a wooden ladle until they acquired nutty flavor. The roasted grains were ground into flour at a commercial mill.

3.11.5 Processing Grain Amaranth Leaf Powder

Mature green Grain Amaranth leaves were picked from the garden in the morning, cleaned and thoroughly washed to remove debris, soil and other foreign matter. They were then placed in a sauce pan with a little water and steamed for 15 minutes. Once cooked, the contents were cooled and dried under direct sun on a clean drying stand. The dry leaves were pulverized using a mortar and pestle. The powder was sieved and subsequently used for sauce making at household level.

3.11.6 Sesame Roasting

The sesame grains were soaked twice in fresh clean water and allowed to float in order to remove sand. The grains were removed from the water, drained and then roasted in a clean dry saucepan on very low charcoal fire. The roasting stopped when grain started popping, giving off sweet aroma and becoming firm when pressed. The roasted grains were cooled and kept in a dry plastic container. The roasted grains were used directly in recipe formulations or ground into flour using a domestic mortar and pestle.

3.11.7 Groundnut Roasting

The groundnuts were roasted over very low charcoal fire. The roasting stopped when they became crunchy. The roasted nuts were cooled and kept in a dry plastic container.

3.11.8 Cassava Flour Processing

Fresh cassava roots were washed, peeled and chopped into chips. The chips were sundried for five days and then ground into flour using a mortar and pestle. The resultant flour was sieved.

3.11.9 Other Ingredients and Materials

Materials such as maize flour and other materials were obtained in shops and markets.

Table 3.7: Formulation used for producing the seventeen grain amaranth containing food products

Food products	Ingredients and their mixing proportions	Preparation method
Chapatti	Wheat flour (1400g), popped powdered grain amaranth (600g), water (1000ml), grated carrots (156g), grated onions (86g), cooking oil (35ml) & salt (15g)	Ingredients mixed, kneaded into dough. Portions (95g) of dough rolled into flat round shapes (about 12cm diameter and <1cm thickness), shallow fried with hot charcoal stove flame while turning to have both sides heated to golden brown.
Baggia	Cassava flour (500g), water (1000ml), roasted powdered soybean (300g), popped powdered grain amaranth (200g), ground fresh onions (43g), ground fresh ginger (17g) & salt (15g)	Solid ingredients mixed using a wooden stirrer, water added gradually while stirring. Resulting paste cold extruded using Baggia machine and deep fried over a medium charcoal stove fire until golden brown and crunchy.
Pancakes	cassava flour (500g), popped grain amaranth flour (250g), freshly peeled sweet bananas (560g), ginger (17g) and cooking oil (1litre)	Two flours were sifted and thoroughly mixed then blended with freshly peeled sweet bananas and ground ginger in a large mixing bowl to form dough which was rolled on a board to about1 cm thickness, cut into small round shapes of about 5cm-diameter using a plastic drinking container and deep fried in hot cooking oil until light brown.
Sesame balls	Roasted sesame seeds (250g), popped grain amaranth grains (250g) and granular sugar (250g)	Sugar was melted in a heated saucepan over hot fire of charcoal stove while stirring constantly using a metallic spoon until golden brown. Roasted sesame and popped grain amaranth mixture were added to the melted sugar and stirred vigorously. Ladleful scoops of the grain-molten sugar mixture were hand-shaped into round balls

		and left to set.
Creamy soup	Roasted grain amaranth grains (350g), water (1400 ml), salt (7g), ginger (3g), tomato puree (184g), onion (40g) and margarine (36g)	Roasted G.A was soaked in four times its weight of cold water for one hour. Salt, tomatoes and spices were added and mixed thoroughly to achieve uniform distribution. The mixture was prepared by boiling for 5 minutes on high charcoal fire and gently simmering for 20 minutes until most of the water was absorbed and the amaranth grains were puffed up. The cover was removed and the mixture was gently stirred to allow some of the remaining water to evaporate. Margarine was added melted into the now thick mixture. The mixture was then strained through a sieve to get a thick creamy soup as the final product
Sesame instant porridge	**To make the porridge flour**: Roasted sesame seeds (2kg), Popped grain amaranth (4kg), Granular sugar (1kg)**.** **To make porridge**: Fresh water (100ml), Fresh milk (200mls), porridge flour (60g), sugar (34g)	Ingredients were hand mixed in a clean dry saucepan & placed over medium open fire of the charcoal stove to allow the sugar to melt (*not to caramelize/turn brown*) while stirring the contents. The Cooled loosely bound sugar-sesame- grain amaranths molten mixture was transferred into a motor and pounded with a pestle until a powder was formed. The so formed powder was sieved to get a finer powder. Flour and sugar was placed in a 500ml cup (*Tumpeco*).Water and milk were mixed in a sauce pan and boiled over medium open fire of a charcoal stove for 5 minutes and poured into the cup while stirring fast with a spoon to form a uniform consistence with no lumps.

Rice porridge	**To make the mixed flour:** Freshly milled rice flour (3kgs),Popped grain amaranth flour (3kgs). **To make porridge**: Porridge flour (100g), fresh milk (500ml, Fresh water (1000ml), sugar (125g).	Ingredients hand mixed in a clean dry saucepan The porridge was made from the flour mixture using conventional boiling method for 15 minutes. Sugar was added with stirring.
Maize porridge	**To make the mixed flour:** Freshly milled maize flour (3kgs), Roasted grain amaranth flour (3kgs). **To make porridge**: Porridge flour (100g), fresh milk (500ml, Fresh water (1000ml), sugar (125g).	Ingredients hand mixed in a clean dry saucepan The porridge was made from the flour mixture using conventional boiling method for 20 minutes. Sugar was added with stirring.
Millet porridge	**To make the mixed flour:** Roasted milled millet flour(3kgs),Roasted grain amaranth flour (3kgs) **To make porridge**: Porridge flour (100g), fresh milk (500ml, Fresh water (1000ml), sugar (125g)	Ingredients hand mixed in a clean dry saucepan The porridge was made from the flour mixture using conventional boiling method for 10 minutes. Sugar was added with stirring.
Peanut sauce	**To make the sauce flour mix:** Grain amaranth leaf powder (2400g), Peanut flour (12kg) **To make the sauce**: Fresh water (250ml),	Ingredients mixed in a clean dry plastic container. The sauce flour mixture was added to fresh water, stirred using a

	sauce flour mix (120g), salt (2g)	wooden spoon and boiled at medium heat for 30 minutes with continuous stirring. Salt was then added.
Bean sauce	Freshly soaked beans (800g), water (3liters), popped grain amaranth flour(100g), salt (30g), curry powder (3.5g), grounded pilau Masala (2g), grounded ginger (17g), grounded onion (43g), margarine (36g).	Beans soaked in clean cold water overnight. Decorticated beans cooked together with salt and spices with minimum stirring to avoid mashing. The excess water was removed, cooled and some of it poured into the G.A flour and kneaded to make dough that was shaped into attractive tiny fragments to easily dry. The beans and G.A were then sun dried for 5days on a tray and sealed in polythene. Preparation of product was done by boiling/frying and addition of spices and salt
Rice meal	500g Rice, 1500mls of salted water (3g salt), 17g freshly pounded ginger 500g G.A grains previously soaked for 2 hours, 2000mls salted water (4g salt)	Rice and G.A were boiled separately and later (when ready) mixed and spread over a tray and sun dried for five days (while covered with transparent polythene to prevent contamination) and later sealed in polythene. Preparation of product was done by boiling/frying and addition of spices and salt
Cassava meal	7000g cassava flour, 7000g toasted G.A flour, Water: flour =2:1	The flours were mixed in a flour blender and the mixture used in preparation of stiff porridge using the conventional method.
Cassava-millet meal	Millet flour, cassava flour and Popped G.A flour were mixed in a ratio of 2:1:1 respectively (i.e. 12000g: 6000g: 6000g)	The flours were mixed in a flour blender and the mixture used in preparation of stiff porridge using the conventional method.

	Water: flour =2:1	
Ginger masala	**To make the Masala:** 300g freshly ground ginger, 20g pilau Masala, 100g popped G.A flour **To make the tea:** 6g G.A ginger Masala1g tea leaves,34g sugar,500mls hot water	Fresh ginger was peeled, washed to remove the dirt and pounded in a motor to fineness, mixed with 20g of pilau masala and 100g of popped G.A flour. The 'juice' in the ginger formed dough with the G.A flour which was then molded into tiny fragments that could easily dry. The pieces dried for two days under very hot sun and later pounded to powder which was sieved to get a finer powder The tea was made though the conventional methods
Sesame-peanut paste	Roasted sesame (1000g) Roasted ground nuts (500g) Popped G.A flour (250g)	Roasted sesame and roasted groundnut were mixed and milled into a thin paste to which popped G.A flour was added to form a thicker paste for use as a spread.
Peanut-bean snack	Decorticated beans (300g), water, popped grain amaranth flour (300g), salt (30g), curry powder (3.5g), grounded pilau Masala (2g), grounded ginger (17g), grounded onion (43g), margarine (36g)	Decorticated beans (soaked overnight) cooked together with salt and spices with minimum stirring to avoid mashing. The excess water was removed, cooled and some of it poured into the G.A flour and kneaded to make dough that was shaped into attractive tiny fragments to easily dry. The beans and G.A were then sun dried for 5days on a tray and then deep fried until crispy. The three ingredients: beans, peanut and G.A Pieces in a ratio of 1:3:1 respectively were mixed uniformly then packed in polythene.

3.12 Sensory Analyses of the Developed Products

Sensory evaluation was conducted using a panel of 54 (35 females and 19 males) untrained panelists. Before the study, all panelists were briefed about the procedure and each had to verbally consent to participation. All Participants were none smokers, English speakers, self-reported to be have normal taste or smell sensitivity. Panelists were requested to refrain from eating or drinking for at least 1 hour prior to their scheduled session when tasting was involved. The panelists assessed the acceptance of 39 products using a 9 point hedonic scale. The 17 products that had the highest score of 1 were selected out. Each of the 17 products were also analyzed by 21 farmer groups (7 from each of the 3 participating districts) who scored both the products and the production recipes using a 5 point hedonic scale, with 1 as least desirable and 5 as most desirable. The groups were required to derive the score through consensus, after trying out the recipes and testing the resulting products.

3.13 Determination of Nutritional Value

The crude protein, fat, total ash and moisture contents of the food products were determined using AOAC (2000) methods. Moisture content, total ash, crude fat and crude protein were determined by oven method, hot furnace, Soxhlet and Kjeldahl (N x 6.25) methods respectively. Carbohydrates were estimated based on the nitrogen free extract and energy was derived based on the energy values of the macro-components.

The dietary fiber content of the foods was determined by the method described by Kirk and sawyer (1991). About 0.5g of the sample was weighed into a 600ml flask, 50 ml of acid detergent fiber were added and the mixture boiled for 1 hour. The mixture was then filtered over a Buchner funnel connected to a vacuum pump using a sinter glass. The sinter-glass crucibles were taken to the oven maintained at 100^{o}C for 45 minutes to drive off the moisture. Dietary fiber was obtained as the difference between the weight of the empty sinter-glass and that after removal from the oven. The food content of iron (Fe) and zinc (Zn) were determined using Atomic Absorption Spectrophotometer, Perkin-Elmer 2380 (A.O.A.C., 2000). The flame photometer was applied for calcium (Ca) determination according to the method described by Pearson (1976). All values were expressed in mg/100g of sample.

3.14: Data Analysis and Reporting

Data were analyzed using Statistical Package for Social Scientists Version 16, and Microsoft Excel package; 2007. Descriptive statistics (means and standard deviations) were derived for the different products for all attributes measured. Data on food adequacy, consumption patterns and scores, asset and dietary diversity were used to categorize farmer households in different food security groups. Chi-square analysis was used to determine the factors associated with food insecurity and malnutrition.

3.15: Ethical Consideration

The study was approved by the Makerere University School of Food Technology, Nutrition & Bio-Engineering research committee. Before actual data collection, consent was sought from local authorities in the study areas and from individual respondents. The purpose of the assessment was clearly explained as well as the assurance of confidentiality.

CHAPTER FOUR

4.0 RESULTS

4.1 CHARACTERISTICS OF RESPONDENTS

Table 4.1: Socio-demographic characteristics of respondents

Socio-Demographic Characteristic	Option	Percentage			
		Nakasongola	Kamuli	Apac	Mean
Sex	Male	7.1	7.86	16.55	10.5
	Female	92.9	92.14	83.45	89.5
Age (years)	<18	2.1	1.43	0	1.18
	18-49	68.1	81.43	89.2	79.58
	>49	29.8	17.14	10.8	19.24
Physiological state	Expectant/pregnant mother	2.13	15.71	6.47	8.1
	Lactating/Breastfeeding mother	29.8	31.43	25.9	29.05
	Expectant and Lactating mother	5.67	1.43	15.83	7.64
	None of the above	62.4	51.43	51.8	55.21
Education level attained	None	9.93	15.7	8.63	11.42
	Primary	73.05	62.9	59	65
	Secondary	15.6	20.7	26.62	20.97
	Tertiary	1.42	0.7	5.75	2.62
Main occupation	Trader	0	1.4	8.63	3.34
	Salaries worker	5	3.6	5.04	4.55
	Subsistence farmer	95	95	86.3	92.1
Marital status	Single	2.8	5	10.1	5.97
	Married	75.2	5	79.1	53.1
	Divorced/separated	7.1	86.4	6.5	33.33
	Widowed	14.9	3.6	4.3	7.6
Household size	≤ 4,small	22.7	20.7	20.9	21.43
	2-5, moderate	35.5	43.6	38.8	39.3
	8-10, big	32.6	26.4	32.4	30.47
	>10, extremely big	9.2	9.3	7.9	8.8

Most (89.5%) of the respondents were females (Table 4.1) and about 80% were married. The majority of the respondents (79.58%) assessed were aged 18-49 years. A total of 88.6% of the respondents had attained some education. Subsistence farming was named as the main occupation for 92.1% of the respondents.

4.2 FOOD AND NUTRITION SECURITY STATUS OF RURAL HOUSEHOLDS

4.2.1 Dietary Quantity

The data shows that a big percentage of households (36.5%) ate less than the recommended three meals a day (Table 4.2). Apac district had the highest percentage (48.92%) of such households that ate less than 3 meals a day, while Kamuli had the lowest (20.71%).

Table 4.2: Number of meals consumed by the target households

Number of meals	Nakasongola	Kamuli	Apac	Mean
1	2.84%	2.14%	0.72%	2%
2	36.17%	18.57%	48.92%	34.50%
% of Households that ate <3 meals	39.01%	20.71%	49.64%	36.50%
3	56.03%	72.14%	50.36%	59.50%
4	4.25%	7.14%	0%	3.80%
5	0.71%	0%	0%	0.24%
% of Households that ate 3 or more meals	60.99%	79.28%	50.36%	63.54%
Total	**100%**	**100%**	**100%**	**100%**

4.2.2 Household Dietary Diversity Score (HDDS)

The data showed that more than half of the households **(**52.2%) had low dietary diversity (i.e. ‹ 6 food groups) (Table 4.3). Nakasongola had the highest percentage of households with low dietary diversity (56.6%) while Apac had the lowest percentage of households (46.1%) with low diet quality based on HDDS. Kamuli and Apac districts had households having HDDS from as low as 1 to12. Each of these extreme cases contributed 0.7%.

Table 4.3: Household Dietary Diversity Score (HDDS)

HDDS	Percentage of households			
	Nakasongola	Kamuli	Apac	Mean
1	0	1.43	0.72	0.7
2	2.1	2.14	5.04	3.1
3	5.5	6.43	3.6	5.2
4	12.1	7.14	6.5	8.6
5	15.6	12.14	11.5	13.1
6	21.3	24.3	18.7	21.4
≤6 low dietary diversity total	56.6	53.8	46.1	**52.2**
7	23.4	21.4	19.4	21.4
8	11.3	15.7	11.5	13
9	2.8	6.4	9.35	6.2
10	4.96	1.4	10.79	5.7
11	0.71	0.71	1.44	0.9
12	0	0.71	1.44	0.7
>6 High dietary diversity total	43.4	46.2	53.9	**47.8**

4.2.3 Weekly Food Consumption Patterns

The food groups least eaten by the respondents' households were pulses (1.2 days a week), meat (0.7 days a week) and milk (0.2 days a week) while those most frequently consumed included the staples (5.4 days a week), vegetables (4.6 days a week) and fruits (3.9 days a week) (Table 4.4).

Table 4.4: Weekly consumption of food groups in Nakasongola, Apac and Kamuli

DISTRICT	FOOD GROUPS (FREQUENCY OF WEEKLY CONSUMPTION)								Mean
	Staples	Pulses	Vegetables	Fruits	Meat	Milk	Sugar	Oil	
Nakasongola	5.4	1.4	4	4.8	0.6	0.02	2.7	1.8	28.33
Kamuli	5.3	0.8	5.2	3.4	0.7	0.1	4.3	3	28.56
Apac	5.5	1.3	4.6	3.6	0.7	0.04	3.6	3.2	29.42
ALL DISTRICTS	5.4	1.2	4.6	3.9	0.7	0.2	3.5	2.7	28.77

Standard error = 0.332

4.2.4 Food Consumption Groups (FGCs)

The results indicate that the majority (80.7%) of the households surveyed in all the 3 districts generally did not consume an acceptable diet, based on the FCS (Figure 4.1). The diets for 19% of the households were in the poor category while 61.7% were at the borderline with FCS mean of 28.4. Only 19.3% of the total households surveyed were in the acceptable group of food secure households with a mean FCS of 41.5. Nakasongola district had the highest percentage of households (19.8%) in the acceptable food consumption group while Kamuli had the lowest percentage (18.7%) of households in the same group. The mean Food Consumption Score for all the three districts was (28.77%). This falls under the borderline profile of food security.

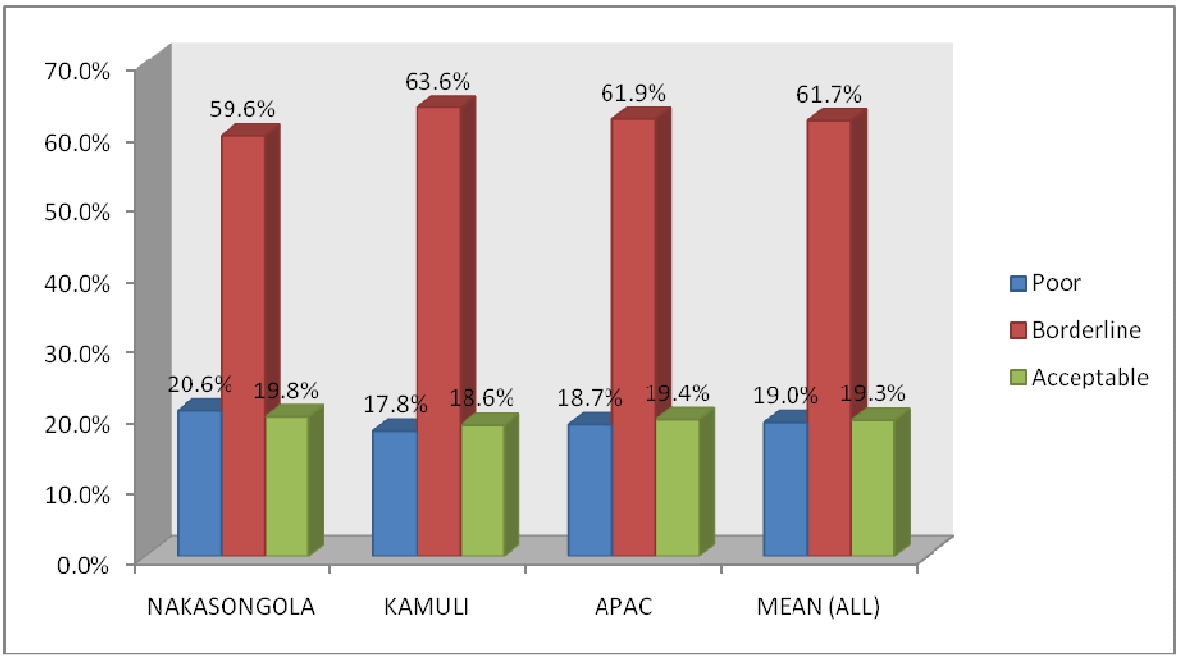


Figure 4.1: Food Consumption Groups for households in target districts

A chi square test (p = 0.039, odds ratio=4) indicated that children from households with a low food consumption score (<35) were more likely to be malnourished than those from households with an acceptable food consumption.

4.2.5 Consumption of Food Groups

The assessment of the consumption of food groups was done a day preceding the survey. The food groups that were widely consumed included: Roots and tubers and bananas (92.1%), while

the groups least eaten included eggs (5.2%) and milk (1.9%). The animal protein foods were generally not widely consumed by households (Figure 4.2).

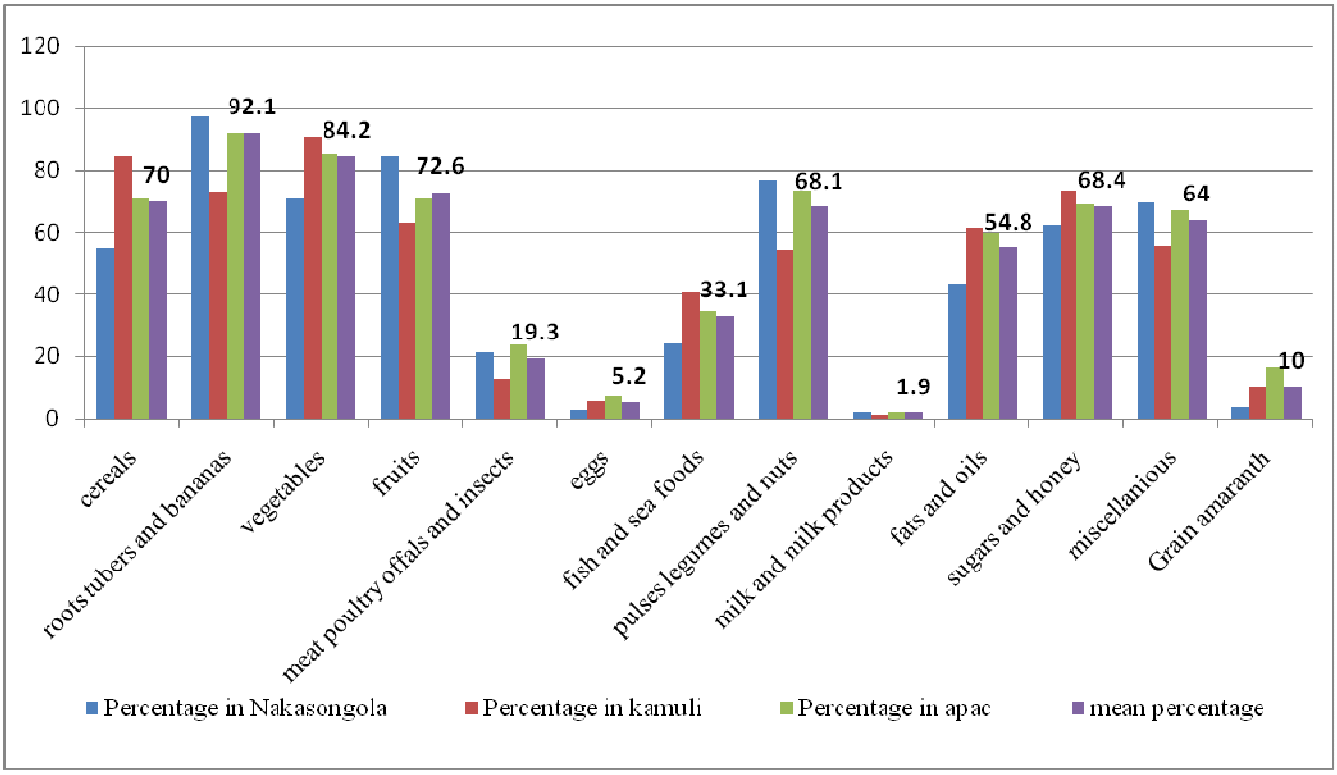


Figure 4.2: Food groups consumed by farmer households in Nakasongola, Kamuli and Apac districts based on 24 hour recall data

4.2.5.1 Consumption of grain amaranth

A mean of only 10% of the household surveyed consumed grain amaranth in the 24 hours preceding the study. Apac district consumed grain amaranth most (16.5%) of household, Kamuli district (10%) while Nakasongola consumed least (3.5%) of households.

4.2.5.2 Food restrictions

The food intake of 24% of the households in general was affected by restrictions. Restriction from pork consumption was the most widespread and was reported by 14% of the respondents. Restriction of women from consumption of chicken (2.62%), eggs (0.95%), fish (2.62%), goat meat (0.48%), beef mutton (1.9%) and white ants (0.24%) was also reported. A limited proportion reported restriction against mushroom (0.71%) and white ant (0.24) consumption.

4.2.6 Household Asset Ownerships

The household assets (Figure 4.3) owned by most of the households were hoes (95%), radios (82.4%) and bicycles (70.4%). The household asset least owned by households was car/truck (1.43%). The data showed that only 6% of the households were asset rich, while about one third (35%) were asset poor. The other households (59%) fell in medium category. A chi square-test ($p<0.05$, odds ratio=3) revealed that children from households categorized as asset poor were more likely to be malnourished compared to those from asset rich families. Another chi square-test ($p<0.006$, odds ratio=4) revealed that households which were categorized as asset poor were more likely to be food insecure compared to those who were asset rich.

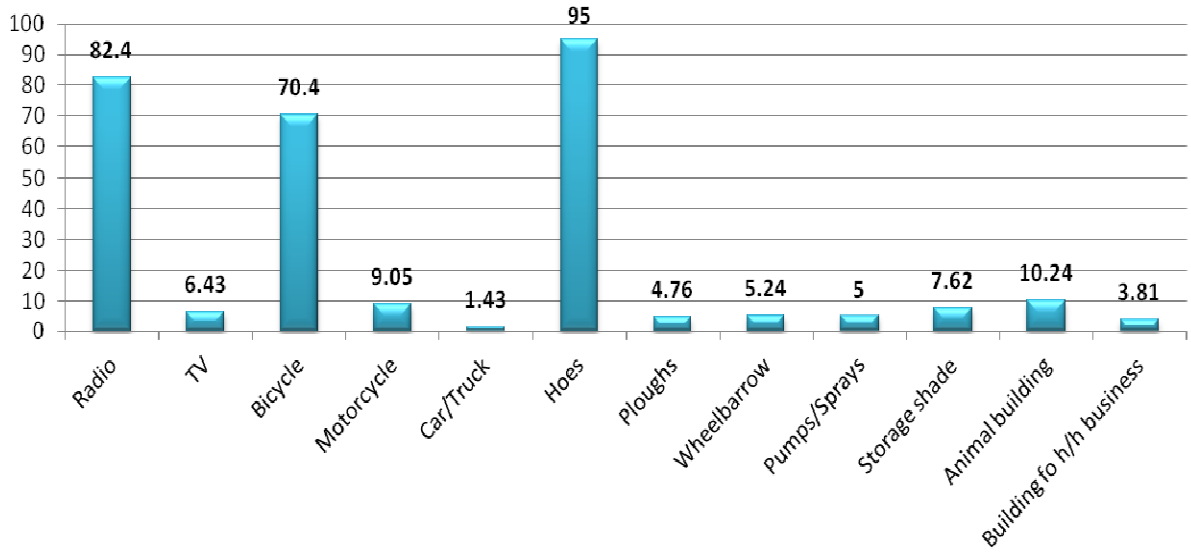


Figure 4.3: Percentage of different household assets owned by the target population

4.2.7 Crops Grown By the Target Communities

Maize (60%), sweet potatoes (56%), cassava (52.38%) and beans (42.14%) were the most common crops grown by the households (Table 4.5). Those least grown included; onions (0.24%), cotton (0.24%), coffee (0.48%). The average harvest of grain amaranth per household (based on the households which reported grain amaranth production) was found to be only 0.6 bags.

The yield and crop output in the three communities is presented in Table 4.5. The average land per household was 4.00 acre. The average acreage used for grain amaranth production was found

to be 0.28 acres. A small proportion of respondents in Kamuli (2.0%) and Nakasongola (1.6%) districts considered grain amaranth one of the major crops they grew. The average crop output per household is low for all crops. In particular Grain amaranth output of 0.60 bags is still very low.

Table 4.5: Yields & Average crop output per household in the target communities

CROP	Total land (acreage)	Total yield (bags)	Average output per Household (bags)	Households (%)
Amaranth	2.25	25.20	0.60	8.00
Matooke	2.50	30.00	0.07	0.95
Beans	172.01	342.81	0.82	42.14
Cassava	196.60	2495.76	5.94	52.38
Yams	1.13	21.50	0.05	0.95
Coffee	0.75	8.00	0.02	0.48
Cotton	0.50	3.00	0.01	0.24
G. nuts	18.00	67.00	0.16	6.43
Maize	310.85	1163.45	2.77	60.00
Millet	34.75	97.75	0.23	10.50
Onions	1.00	7.00	0.02	0.24
Peas	10.25	19.00	0.05	2.14
S. potatoes	194.65	2471.70	5.89	56.00
Rice	4.50	33.50	0.08	1.43
Simsim	45.06	125.50	0.30	11.00
Soya beans	3.06	7.50	0.02	1.20
Sun flower	1.00	2.00	0.01	0.24
Tomatoes	1.50	11.75	0.03	0.71
Sorghum	1.00	1.50	0.00	0.24

4.3 Nutrition Status for Children Using MUAC

The households which had children (6-59 months) were 317, within these households, a total of 434 children in the same age bracket were assessed. No case of severe malnutrition was

recorded, based on MUAC, while moderate malnutrition was 22%. The proportion of children at risk of being malnourished was 7%.

Chi-square test (p = 0.048, odds ratio=2.5) revealed that the children whose mothers/caregivers had no formal education were more likely to be malnourished compared to those whose mothers had attained formal education. Also children from households with poor diet were more likely to be malnourished compared to those from households with an acceptable diet according to a chi square test (P=0.036, odds ratio=4).

4.3.1 Dietary Adequacy

The results from the survey show that 36.9% of children had adequate diets (Table 4.6). The diets for the bigger percentage of the children (63.1%) were not adequate, when gauged against IYCF recommendation of at least 4 food groups i.e. IDDS>4 (WHO, 2010).

Table 4.6: Individual Dietary Diversity Score (IDDS) for children aged 6-59 months

IDDS	Percentage of children 6-59 months			
	Nakasongola (%)	Kamuli (%)	Apac (%)	Mean (%)
1	2.3	9.6	0.9	4.4
2	8.0	20.2	22.0	17.4
3	19.3	14.0	20.8	18.0
4	30.7	18.4	22.6	23.3
≤4 groups	**60.3**	**62.2**	**66.3**	**63.1**
5	26.1	23.7	13.0	20.5
6	10.2	7.0	6.9	7.9
7	3.4	3.5	5.2	4.1
8	0	2.6	5.2	2.8
9	0	1.0	3.4	1.6
>4 groups	**39.7**	**37.8**	**33.7**	**36.9**
Total	100	100	100	100

4.3.2 Diversity of Diets Given to Children 6-59 months

The food groups that are widely consumed included grains, roots and tubers (62.3%) while the groups least eaten included eggs (18%) and grain amaranth (3.8%) (Figure 4.4).

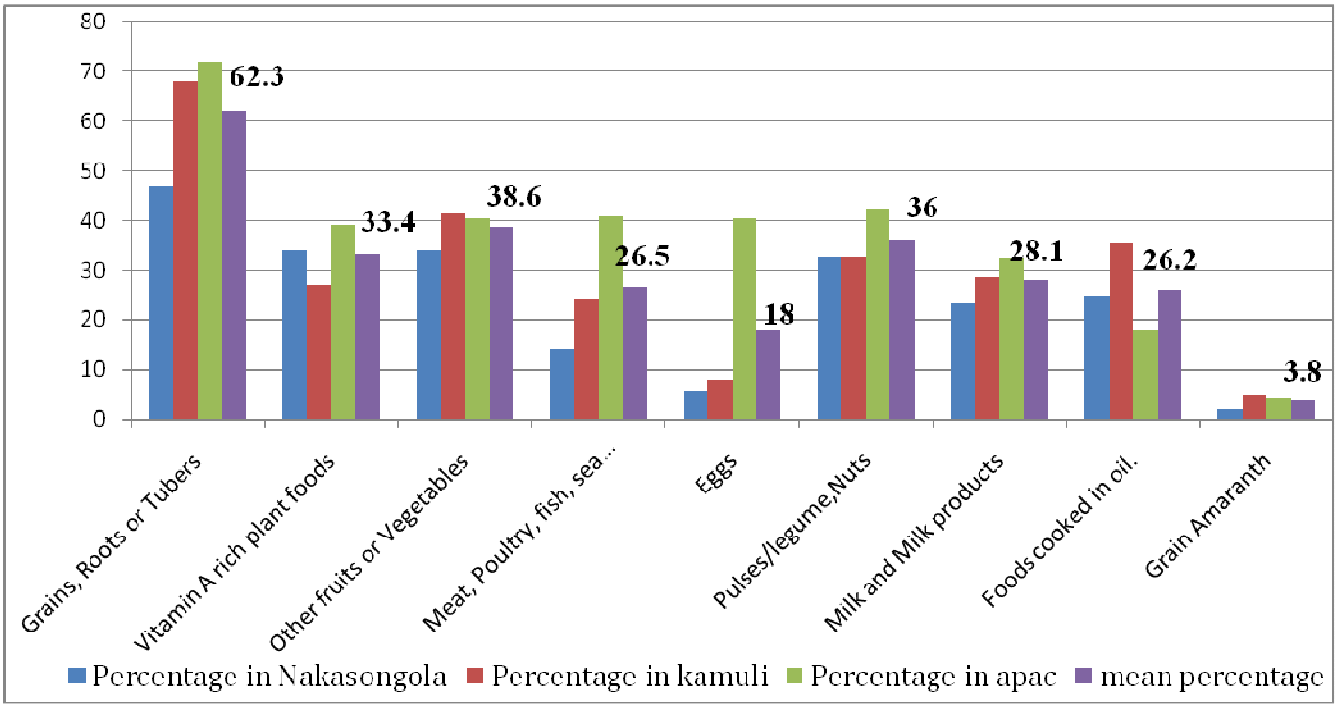


Figure 4.4: Percentage of food groups given to children (6-59 months) in Kamuli, Nakasongola and Apac

4.3.3 Morbidity

Out of the 434 children within the study respondent's households, 62.67% had experienced diarrhea, vomiting or fever in the 2 weeks preceding the study (Table 4.7). Fever was the most prevalent ailment reported for 33.64% of the children.

Table 4.7: The prevalence of ailments affecting nutrition status of children in the target communities

Disease	No. of Children	Percentage
Diarrhea	86	19.8
Vomiting	40	9.22
Fever	146	33.64
Total number of children with at least one ailments	272	**62.67**
No ailment	162	37.33
Total no. of children	434	100

4.3.4 Household Energy Intakes

The household energy intake is presented in Figure 4.5. Nakasongola recorded the highest average energy intakes of 2125.1Kcals; Apac recorded an energy intake of 2017.9Kcals while

Kamuli had the lowest energy intakes of 1861.1Kcals. Overall the mean intake for the 3 districts was 2001.4Kcals which meets the US set standard of 2000Kcals.

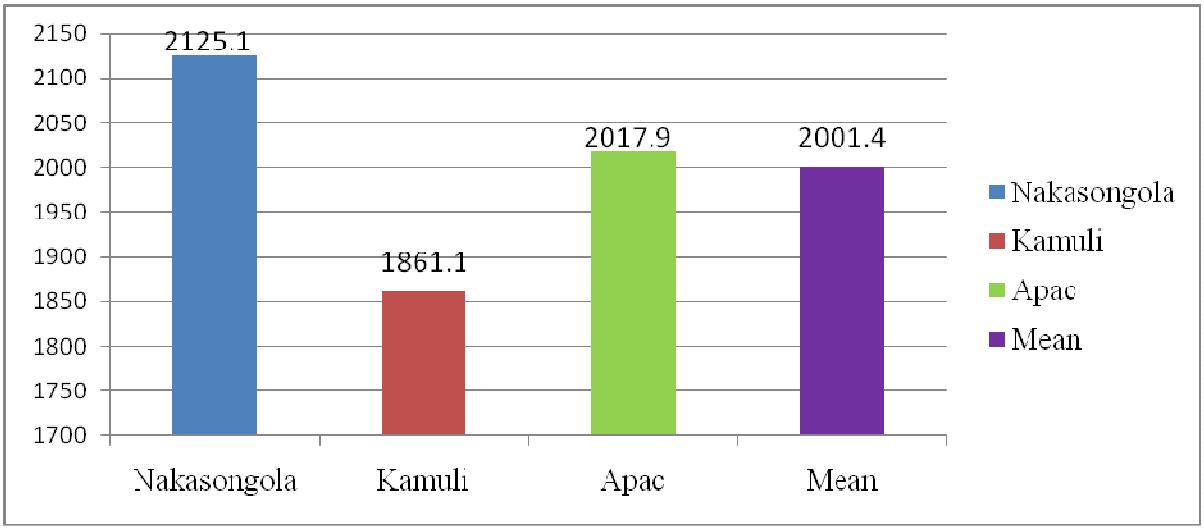


Figure 4.5: Average Energy Intakes of the target districts the day preceding the assessment

4.3.5 Nutrient Intakes

Based on the NQI values, the nutrients that were deficient in the diets of the respondents were fats, thiamine, niacin, calcium and zinc (Figure 4.6). Fat intake was also low. While the NQI for iron was above 1 (1.08), the intake for a large proportion (74.1%) of the respondents was below the recommended level (Figure 4.7., The NQI for proteins was 1.23 which was an indication of sufficient protein intake.

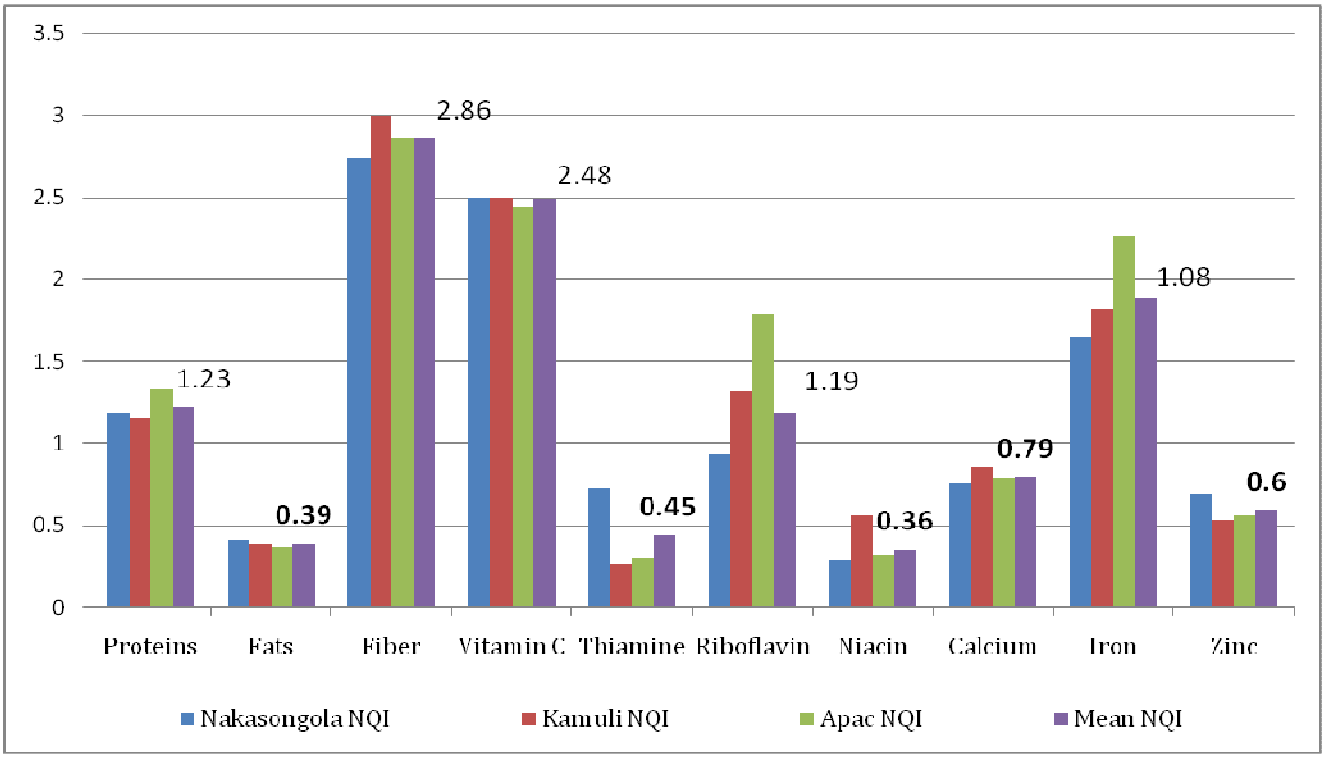


Figure 4.6: Nutritional quality index (NQI) of foods consumed by farmer households in Nakasongola, Kamuli and Apac districts based on 24 hour recall data

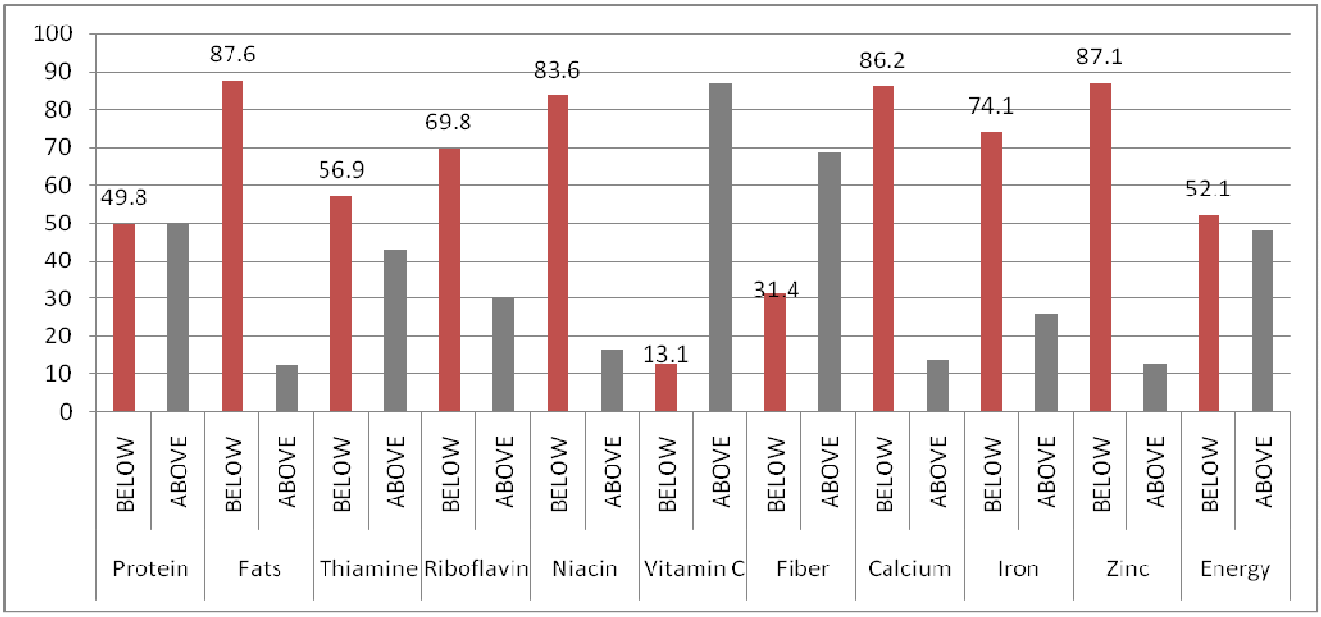


Figure 4.7: Distribution of study population based on adequacy of the intake of the different nutrients

4.3.6 Dietary and Infant & Young Child Feeding Practices

Out of the 317 children whose mothers/caretakers were interviewed, 161 (50.8%) were 6-23 months and 156 (49.2%) were 24-59 months. The children below 2 years who were breastfed the previous 24 hours before the assessment were 126 (78.3%).

4.3.6.1 Core indicators of infant & young child feeding practices (IYCF)

All (100%) children aged 6-8 months assessed had been introduced to solid, semi-solid or soft foods, 68.3% of children 12–15 months of age received breast milk during the previous day while 58.4% of children aged 6-23 months had the minimum dietary diversity (i.e. >4 food groups). Generally, a bigger percentage (62.8%) of the older children aged 24-59 months were given less diverse diets as compared to the younger ones aged 6-23 months (41.6%) as shown in Table 4.8.

Table 4.8: Percentage of children 6-59months in the different IDDS groups

AGE (MONTHS)	IDDS GROUP	FREQUENCY	PERCENTAGE
6 to 23	≤4	67	41.6
	>4	94	58.4
Sub-total		**161**	**100**
24-59	≤4	**98**	**62.8**
	>4	**58**	**37.2**
Sub-total		**156**	
6 to 59	≤4	200	63.1
	>4	117	36.9
Total		**317**	**100**

4.3.6.2 Practice of giving solids, semisolids or soft foods to children aged 6-59 months in households

Most of the children were given solids, semi solids/soft foods two (39.4%) to three (39.1%) times a day. Only 3.7% of children were given the food five or more times the previous day as recommended by the IYC Feeding guidelines (WHO, 2010).

Table 4.9: Number of times children were given Solids, semisolid or soft foods

No. of times	Frequency	Percentage
1	22	6.9
2	125	39.4
3	124	39.1
4	34	10.7
5	9	2.8
≥6	3	0.9
Total number of children	**317**	**100**

4.3.6.3 The practice of meal preparation and using own plate

A big proportion (87.7%) of the children involved in the survey had meals taken from the family meal whereas only 39% of the children had meals prepared separately. Most of the children in the survey (89.9%) ate using their own plates while 10.1% used shared plates**.**

4.3.6.4 Time for serving the last meal for children (6-59 months)

Many of the children in the survey (86.1%) had their last meal in the evening (6-8pm) and were left to eat alone whiles 13.9% had their meals after 8pm (Table 4.10).

Table 4.10: Percentages of children's last meal times

Last meal time for the child	Frequency	Percentage
Early evening (6 to 8) pm alone	273	86.1
late evening after 8 pm	44	13.9
Total	317	100

4.3.6.5 Consumption of porridge

Most of the children (72%) were fed on porridge whereas 28% did not (Table 4.11). This could be one of the target dishes where grain amaranth could be incorporated since it's widely considered a dish for the vulnerable groups like under-fives, the sick, pregnant and lactating mothers.

Table 4.11: Percentage of children that were given porridge

consumed porridge	Frequency	Percentage
Yes	228	72
No	89	28
Total	317	100

4.3.6.6 Number of main meals given to children

Most of the children were given main meals, two (36.28%) to three (42.59%) times a day (Table 4.12). Only1.9% of children was given food five or more times the previous day as recommended by the IYC Feeding guidelines (WHO, 2010). Chi-square test revealed a significant relationship (p = 0.001) between low MUAC measurements (malnutrition) and frequency of feeding on complementary foods (odds ratio=4). The highest percentage (65.9%) of children ate snacks once a day while 0.3% of the children did not have any snacks.

Table 4.12: Percentage of number of times main meals were given children the day prior to the survey

No. of times	Frequency	Percentage
1	35	11.04
2	115	36.28
3	135	42.59
4	26	8.2
5	5	1.58
≥6	1	0.32
Total no. of children	**317**	**100**

4.3.7 Special Preparation of the Children's Food (*Kitobero*)

Out of the 317 mothers/caretakers interviewed, only 40.4% had heard about *kitobero* and only 39 (12.3%) had practiced cooking *kitobero* (Table 4.13). The highest percentage (8.83%) of those who had practiced cooked it only once a week. A big percentage (28.1%) had heard about *kitobero* but did not practice cooking it. The most widely reported reason (reported by 20.8% of the respondents) for not cooking *kitobero* was not knowing how to prepare it. Among the 12.3% that had practiced cooking kitobero, 9.15% did not have the right knowledge about kitobero.

Table 4.13: Percentage knowledge on special preparation of children's food (kitobero)

Attribute	Option	Frequency	Percentage
Respondents who had about kitobero	Yes	128	40.4
	No	189	59.6
	Total	**317**	**100**
Practiced cooking kitobero	Yes	39	12.3
	No	89	28.1
	Total	**128**	**40.4**
Respondent's Knowledge about Kitobero	Right	10	3.15
	Wrong	29	9.15
	Total	**39**	**12.3**
Frequency of preparation of kitobero (in 7 days)	Once	28	8.83
	2 to 3 times	9	2.84
	more than 4 times	2	0.63
	Total	**39**	**12.3**
Reasons for not preparing kitobero	1.Do not know how to prepare it	66	20.8
	2.Can't get the ingredients	21	6.62
	3.It takes too much time to prepare	0	0
	4.What I give the child is enough	1	0.32
	5.No particular reason	1	0.32
	Total	**89**	**28.1**

4.4 Grain Amaranth Recipe/Product Development

4.4.1 Baseline recipe collection

In the first stage of the recipe development which entailed gathering information from communities about food preparation methods and how grain amaranth was utilized, information was obtained from seventy (70) farmers already utilising grain amaranth within the study areas. A total of one hundred (100) recipes were collected. Thirty four (34) interviews were conducted

in sub counties of Namasagali, Butansi and Bugulumbya of Kamuli district and generated a total of fifty one (51) recipes. In Nakasongola, twenty nine (29) G.A recipes were generated from 16 interviews carried out in sub counties of Kyabutaika, Kyambogo and Kakooge while in Apac district 20 recipes were generated from 20 individual interviews carried out in the sub counties of Chegere and Apac. The results generally indicate that grain amaranth was utilized in making porridges, meals, sauces, snacks, medicine and paste (Figure 4.8).

Kamuli district respondents utilized amaranth mainly (reported by 37.25% of respondents) in form of sauce. Respondents in Nakasongola district mainly utilized it as porridge (31%), sauce (65.5%) and a very small percentage (3.5%) for snacks. All respondents (100%) in Apac reported utilization of grain amaranth leaves in form of sauce. Generally, the most widespread form for grain amaranth use in all the three districts was sauce (67.6% of the respondents) made from the fresh leaves. Figure 10 gives details of grain amaranth processing in Nakasongola, Kamuli and Apac districts at the baseline. Most households processed the grains into flour by milling at nearby mills, pounding in mortars or grinding on stones. Thirty nine (39) recipes were later developed based on the information on recipes and diets collected from the communities. The recipe development was guided by the need to develop products containing grain amaranth and other locally available foods that would address the nutrient gaps identified.

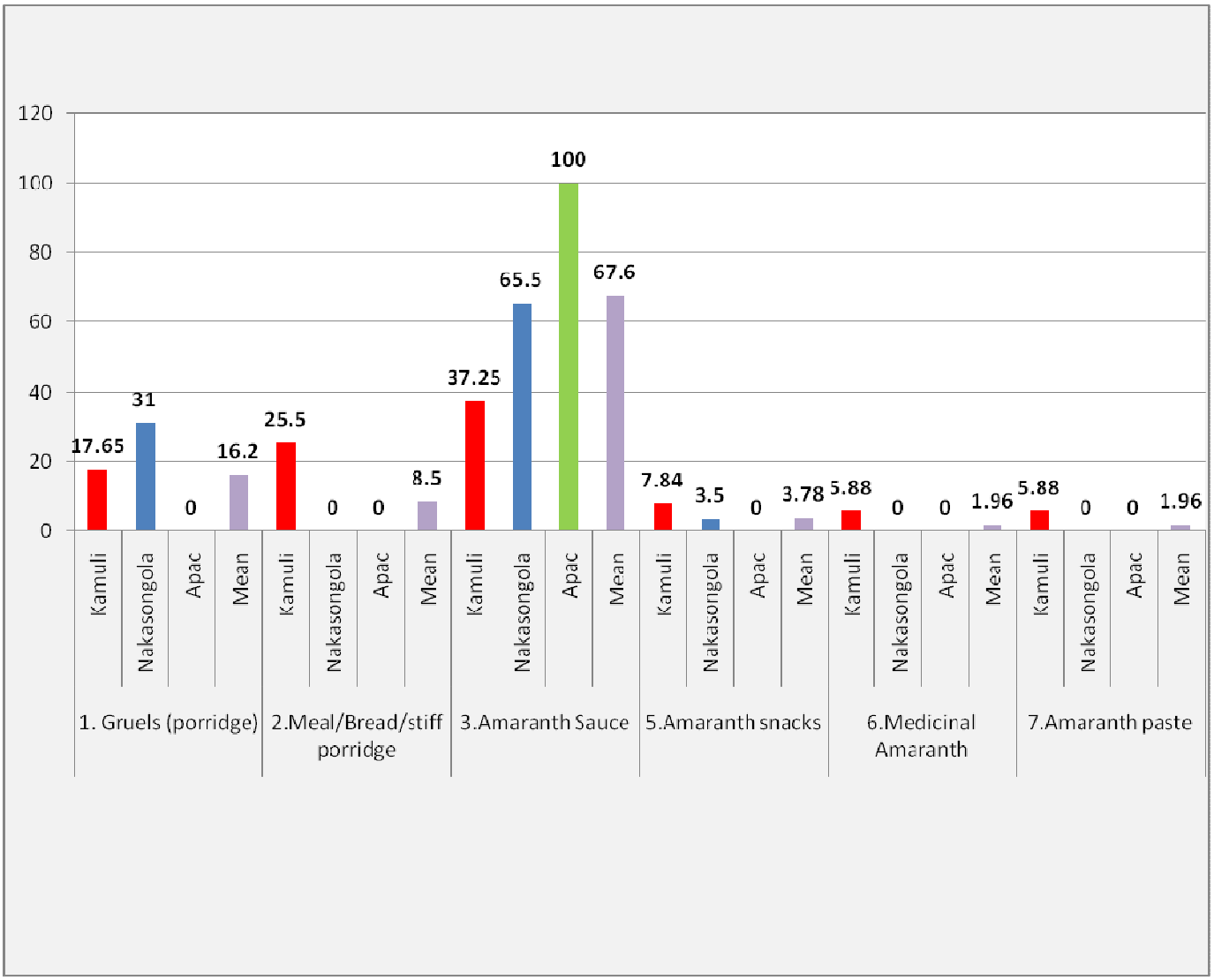


Figure 4.8: Percentage utilization of grain amaranth in Kamuli, Apac and Nakasongola during the baseline survey for recipe collection

4.4.2 Sensory Evaluation of the Developed Products

The thirty nine (39) recipes/products were subjected to sensory evaluation and 17 ranked best as shown in Table 4.14. The 17 products developed were found to be highly acceptable, all scoring ≥7.5 on a scale of 9.

Table 4.14: Acceptability of sensory attributes of the products that ranked best

PRODUCT	SENSORY ATTRIBUTES (n= 54)				
	Texture	**Flavor**	**Appearance**	**Odor**	**Overall acceptability**
Chapatti	8	8.3	9	7.5	**8.2**
Baggia	8.3	7.3	8.8	8	**8.1**
Pancakes	7	8.8	8.3	7.8	**7.9**
Balls	8.8	9	7.8	8	**8.4**
Sauce	7.3	7.3	9	8.5	**8**
Sesame Instant porridge	8.8	8	7.3	8.8	**8.2**
Millet porridge	7.3	8.3	8.8	7.8	**8**
G.A Maize porridge	7	7.3	7.3	8.5	**7.5**
G.A Rice porridge	7.5	7.5	7.3	8.8	**7.8**
G.A Cassava meal	8.5	8.8	7	8	**8.1**
G.A Millet-Cassava meal	8	8.8	7.8	8.3	**8.2**
G.A Rice meal	7.5	8.3	8.8	7.8	**8.1**
G.A Tea Masala	9	8.5	8.3	9	**8.7**
G.A Soups	7.5	8.3	9	7	**7.9**
G.A Paste	7	8.8	8.3	8.9	**8.2**
G.A Snack	7.8	8	8.5	8.3	**8.1**
G.A Leaf powder- peanut sauce	8	7.3	8	7.5	**7.7**

Some of the products development and rated best included grain amaranth chapatti, grain amaranth baggia, grain amaranth pancakes, grain amaranth cassava flour, grain amaranth sesame balls, grain amaranth beans, grain amaranth millet flour, grain amaranth ginger masala, grain amaranth peanut –sesame paste, grain amaranth rice flour, grain amaranth leaf powder, grain amaranth rice meal and grain amaranth sesame instant flour (Figure 4.9).

Grain Amaranth
Chapatti

Grain Amaranth
Baggia

Grain Amaranth
Pancakes

Grain Amaranth
Cassava Flour

Grain Amaranth
Sesame Balls

Grain Amaranth
Beans

Grain Amaranth
Millet Flour

Grain Amaranth
Ginger *Masala*

Grain Amaranth -
Peanut-Sesame Paste

Grain Amaranth
Rice Flour

Grain Amaranth
Leaf Powder

Grain Amaranth
Rice Meal

Grain Amaranth
Sesame Instant Flour

Figure 4.9: Photos of some of the developed products that ranked best

According to the panelists, the chapatti, sesame balls, paste, peanut sauce, bean-peanut snack, and sesame instant porridge products with grain amaranth were preferred to the ones without

grain amaranth (Table 4.15). Grain amaranth contributed to improvement in flavor, odor and overall acceptability of all the products.

Table 4.15: Statistical significant differences of the products with and those without Grain amaranth

Products	P-value at alpha=0.05	Statistical differences
Chapatti	0.037	significant
Baggia	0.541	
Pancakes	0.171	
Sesame balls	0.038	significant
Bean sauce	0.444	
Sesame Instant porridge	0.036	significant
Millet porridge	0.146	
Maize porridge	0.934	
Rice porridge	0.928	
Cassava meal	0.983	
Millet-Cassava meal	0.992	
Rice meal	0.940	
Ginger Masala	0.997	
Sesame-peanut Paste	0.038	significant
Bean-peanut Snack	0.028	significant
Peanut sauce	0.013	significant

The method of preparation of grain amaranth did not significantly affect the sensory properties of the products (Table 4.16).

Table 4.16: Effect of method of cooking grain amaranth on product preference

Product	Method of preparation of grain amaranth	Preference	P-value at 0.05
Bean sauce	Popped, roasted	popped	0.443
Millet porridge	Popped ,roasted	popped	0.998
Maize porridge	Popped ,roasted	popped	0.669
Rice porridge	Popped, roasted	popped	0.863
Cassava meal	Popped, roasted	popped	0.802
Millet-Cassava meal	Popped, roasted	roasted	0.997
Soup	Popped, roasted, boiled	roasted	0.984

4.4.3 Energy and Nutrient Density of Developed Products

Incorporation of the different foods identified as good sources of nutrients which were deficient in diets of people in the 3 districts, generally led to products with enhanced levels of these target nutrient (Table 4.17). Sesame, soybeans and peanuts in addition to contributing to nutrient enrichment also enhanced the energy content of the foods to which they were added.

Table 4.17: Energy, proximate and mineral composition per 100g of the developed products

Grain amaranth product	Energy	Protein	Fat	Carbohydrates	Fiber	Ash	Moisture	Zn	Fe	Ca
	(Kcals)	(g)	(g)	(g)	(g)	(g)	(g)	(mg)	(mg)	(mg)
Chapatti	460.91	9.1	16.41	69.2	3.8	1.48	31.2	1.1	2.5	46.6
Baggia	499.81	8	34.63	39	3.82	2.25	6.48	1.25	1.94	55
Pancakes	453.36	3.38	38.8	22.65	2.94	1.8	24.38	0.7	1.8	34.8
Sesame balls	441	11.29	24	44.96	8.11	3.1	5.43	3.35	7.47	383
Bean sauce	453.59	17.05	4.13	87.1	4.72	6.06	3.72	1.26	3.05	68.1
Sesame Instant porridge	428.7	12.6	22.49	43.97	12.6	2.2	86	3.7	8.57	373.6
Millet porridge	394.26	12.2	5.64	73.7	9.07	2.9	85.2	2.87	7.61	86.5
Maize porridge	366	10.25	5.44	69	1.37	2.7	88	2.3	5	83
Rice porridge	400.5	9.76	4.22	80.9	1.7	1.1	89.4	1.84	3.98	84.5
Cassava meal	377.55	9.1	3.95	76.4	3.18	2.82	42	2.1	3.94	50.75
Millet-Cassava meal	399.22	9.11	3.95	81.81	8.07	2.7	40.3	2.12	3.94	50.75
Rice meal	388.12	9.76	4.22	77.8	1.19	2.6	45	1.84	3.98	84.5
Ginger Masala	363.24	9.985	7.29	64.4	7.83	4.4	7.58	3.6	168	125
Soup	395.42	0.45	0.54	97.2	0.58	1.25	90.26	2.6	8	17
Sesame-peanut Paste	543	18.39	42.6	21.5	2.76	3.4	2.49	5.45	10.2	603.3
Bean-peanut Snack	463.7	20.15	29.8	28.73	17.5	3.83	3.23	2.64	3.65	82.3
Peanut sauce	534	21.72	45.2	10.1	8.2	6	6.9	3.31	2.26	68.1

4.4.4 Effect of GA Incorporation on the Energy and Nutrient Composition of the Developed Products

The presence of grain amaranth in the products led to a positive change in the nutrient content of most foods, when compared to the traditional recipes without grain amaranth (Table 4.18).

Table 4.18: Nutrient changes due to grain amaranth incorporation

Grain amaranth product	Percentage change in Energy/Nutrients due to G.A incorporation					
	Energy	**Protein**	**Fat**	**Zinc**	**Iron**	**Calcium**
Chapatti	11.9	9.64	10.8	96.4	166	288.3
Baggia	45.8	6.7	24.6	25.3	55.2	28.2
Pancakes	19.5	293	32.4	250	445.4	284.5
Sesame balls	-7.35	32.8	-4	-6.9	0.95	-22.6
Bean sauce	215	86.14	282.4	18.9	23	9.84
Sesame Instant porridge	-9.9	48.6	-6.25	3.1	15.7	-24.4
Millet porridge	5.7	13.1	32.7	9.1	93.1	517.9
Maize porridge	1.38	47.8	40.9	32.95	110.1	1085.7
Rice porridge	9.4	64	197.2	129.4	1037.14	745
Cassava meal	136	569.1	1310.7	517.6	1359	217.5
Millet-Cassava meal	32.2	19.5	34.8	13.4	44.9	245.9
Rice meal	6	64	197.2	130	1037	745
Ginger Masala	8.42	11.2	71.9	-1.09	-15.2	9.65
Sesame-peanut Paste	-5	-4.2	-12.3	-7.3	-3.8	-10.9
Bean-peanut Snack	0.8	6.9	-10.95	3	56.6	45.1
Peanut sauce	-8.72	-8.28	-8.98	3.4	7.62	26.1

4.4.5 Contribution of the Developed Products to the RDA of Children Aged 4-8 Years

The contribution of the developed products to the RDA of children is presented in Table 4.19. Energy dense food identified included baggia, sesame balls, bean sauce, bean-peanut snack and peanut sauce were rich in energy, protein, fats, Zn, Fe and Ca per serving

Table 4.19: Contribution of the developed products to the RDA of children aged 4-8 years

Grain amaranth products	Amount (g)	Typical serving	% Contribution per serving					
			Energy	Protein	Fats	Zn	Fe	Ca
Chapatti	**100**	1 piece	25.8	47.9	25.2	13.8	25	5.8
Baggia	**200**	1 packet	55.9	84.2	106.6	31.3	38.8	13.8
Pancakes	**100**	4 pieces	25.3	17.8	59.7	8.8	18	4.4
Sesame balls	**200**	4pieces	49.3	118.8	73.8	83.8	149.4	95.8
Bean sauce	**200**	1 ladle	50.7	179.5	12.7	31.5	61	17
Sesame Instant porridge(flour)	**60**	In 1 *tumpeco*	14.4	39.8	20.8	27.8	51.4	28
Millet porridge(flour)	**34**	In 1 *tumpeco*	7.5	21.8	3	12.2	25.9	3.7
Maize porridge(flour)	**34**	In 1 *tumpeco*	7	18.3	2.8	9.8	17	3.5
Rice porridge(flour)	**34**	In 1 *tumpeco*	7.6	17.5	2.2	7.8	13.5	3.6
Cassava meal(flour)	**100**	for 1 plate	21.1	47.9	6.1	26.3	39.4	6.3
Millet-Cassava meal(flour)	**100**	for 1 plate	22.3	47.9	6.1	26.5	39.4	6.3
Rice meal(dried grains)	**100**	for 1 plate	21.7	51.4	6.5	23	39.8	10.6
Ginger Masala	**7**	1tea spoon	1.4	3.7	0.8	3.2	117.6	1.1
Soup	**100**	1 ladle	22.1	2.4	0.8	32.5	80	2.1
Sesame-peanut Paste	**72**	2 table spoons	21.9	69.7	47.2	49.1	73.4	54.3
Bean-peanut Snack	**200**	1 packet	51.8	212.1	91.7	66	73	20.6
Peanut sauce	**200**	1 ladle	59.7	228.6	139.1	82.8	45.2	17

4.4.6 Recipe and Product Acceptability

The recipes (17) of the most acceptable products were taken back to the farmers in Kamuli, Nakasongola and Apac to participate in their trials and evaluation. A total of 15 of the 17 developed recipes were rated at ≥4 on a scale of 5 (Table 4.20). The rice meal and bean sauce recipes were the only 2 to score below 4. This shows that the recipes were generally acceptable to the communities in the three districts. There were no marked differences in the scores given to the different recipes by farmer groups in the 3 districts. The products made using the developed recipes were also found to be highly acceptable by the farmer groups, with 16 out of 17 scoring ≥4 on a scale of 5 (Figure 4.10). The high acceptability of both recipe and products shows high potential for increased consumption of grain amaranth once the recipes are widely disseminated.

Table 4.20: Farmer acceptability score for different grain amaranth recipes and products

Product	Recipe				Product			
	Kamuli	Apac	Nakasongola	Overall mean	Kamuli	Apac	Nakasongola	Overall mean
Chapatti	4.7	5	5	4.9	5	5	5	5
Baggia	4.5	4.3	4.5	4.4	4.5	4.7	4.5	4.6
Pancake	5	4.5	4.7	4.7	4.5	4.5	5	4.7
Sesame balls	5	5	5	5	5	5	5	5
Soup	3.5	4.5	4	4	3.5	4	4	3.8
Sesame instant porridge	5	5	4.5	4.8	5	5	4.5	4.8
Rice Porridge	4.5	4.5	4.5	4.5	5	4.5	4.5	4.7
Maize Porridge	5	5	5	5	4.5	4.5	4	4.3
Millet porridge	5	5	5	5	4.5	4.5	4.5	4.5
Peanut sauce	3.5	4	4.5	4	4	4	4.5	4.2
Bean sauce	4	4	3.5	3.8	4	4	4	4
Rice meal	3.5	3	3.5	3.3	3.5	4.5	4	4
Cassava meal	5	5	5	5	5	5	5	5
Millet-Cassava meal	5	5	5	5	5	5	5	5
Ginger Masala	5	4	4.5	4.5	5	4.5	5	4.8
Paste	4	4.5	4	4.2	4	4.5	4.5	4.3
Bean peanut snack	4.5	4	5	4.5	4	4.5	5	4.5

Figure 4.10: Farmers tasting grain amaranth-millet bread during participatory recipe/products trials and evaluation in Apac district

CHAPTER FIVE
5.0 DISCUSSION

5.1 Current Food and Nutrition Security Status of Rural Households in Kamuli, Apac and Nakasongola

The study conducted revealed that majority of the respondents interviewed were females and married. This is consistent with the fact that most child caregivers are normally female. Their age bracket suggest that they are active and in the working class of the population. Primarily, most the people in the study area had some form of basic education. Subsistence farming which was identified as the main occupation of respondents suggest that they mainly grow food crops to feed their families and probable sell the surplus to generate some income to take care of the home and some basic needs. The household size ranged from moderate (2-5) to big (8-10). A moderate household size may be easier to feed and cater for but a big household size may present some challenges which may affect the nutrition, health and education of the most vulnerable group which are likely in this case to be infants and young children since the main source of income is through subsistent agriculture which may not be sufficient enough for keeping the home.

Dietary assessment is used to determine whether a household is food insecure or food secure. Assessment of the three communities showed that most of the household in general eats less than three meals which is the recommended per day. Apac district rather showed a disturbing trend with about almost half of the households interviewed taking less than the recommended three meals per day. This was followed by Nakasongola district and finally Kamuli which had a small proportion of the household not taking three meals in a day. The 2005/06 National Household Survey indicated that about 18 percent of households in northern Uganda ate only one meal a day. This therefore suggests that the current dietary intake of the three districts is in conformity with the national situation. Inadequate dietary intake, consumption of monotonous diets, unvaried diets lacking in most of the essential micronutrients, low feeding frequency and less nutritious type of food given to the children as reported by UNAP (2011-2016) are immediate factors associated with child malnutrition. According to FANTA (2006), household with less than three meals per day is considered as food insecure. It can therefore be concluded that most

of the households in Nakasongola, Kamuli and Apac are food insecure compared to 6% of households in Uganda as reported by the Comprehensive Food Security & Vulnerability Analysis (2009). Hence, the possibility of children in this three districts being malnourished are high. These may be contributing to the persistent malnutrition problem in Uganda as reported by UBOS (2006).

Household dietary diversity score (HDDS) of the households in the three districts showed that more than half of them had low dietary diversity that is less than six (6) food groups. Households in Nakasongola district had low dietary diversity score followed by Kamuli and Apac. It can be inferred that although households in Apac district were food insecure compared to the others, they had a relatively better diet diversity than Nakasongola and Kamuli districts. This disparity could be attributed to seasonal difference in the agro-ecological zone as there is variation in harvest patterns and availability of food. Nevertheless, the typical Ugandan diet lacks diversity and fails to provide sufficient micronutrients. The diet is mostly composed of carbohydrate with little emphasis on pulse, nuts and green leafy vegetables. There is significant regional variation in the diet diversity of infants and young children as most times, infants and young children eat with their mothers. The quality of the infant's food is as good as the family meal. However, 60% of the children in Uganda received adequate variety in their meals as reported by Uganda DHS (2006).

Also, the weekly food consumption pattern shows that the least eaten food group included pulses, meat and milk and the most frequently consumed included staples, vegetables and fruits. The study revealed that most of the households had a limited dietary diversity. Starchy foods, fruits and vegetables formed the bulk of the diet for most households. Such diets may not provide the adequate amounts of all the required nutrients and this would contribute to malnutrition. Furthermore, results indicate that there was limited consumption of protein containing foods. The protein foods consumed were mainly of plant sources which provide low quality proteins compared to animal sources.

Household Food Consumption Score showed that most households did not consume an acceptable diet. Majority of the households were on the borderline with a small proportion in the

acceptable group of food secure households. The study showed that children from households with low food consumption score of <35 were more likely to be malnourished than those from households with an acceptable food consumption. The significant association between child malnutrition and food consumption score of the households seems to suggest that there may be no preferential treatment for children over adults.

Roots, tubers and bananas were the most consumed of the main food groupings whiles eggs and milks were the less consumed food group. The studied revealed that animal protein foods were generally not widely consumed. Grain amaranth was consumed by a few households in the three districts surveyed. Apac district consumed more grain amaranth than Kamuli and Nakasongola districts. This shows that promotion of grain amaranth within the communities is required for significant nutritional benefits to be recorded. The study also showed that a fewer percentage of the households had food restriction especially pork consumption. This restriction was mainly practiced by Muslims in the various communities. Others food restrictions identified include the consumption of chicken, eggs, fish, goat meat, beef mutton, white ants and mushrooms.

With regards to household asset ownership, hoes, radios and bicycles were found to be common to most households in the three districts. More than half of the households were moderately rich in assets with a small percentage of been asset rich. One-third of the households were asset poor. The implication is that the target community is resource constrained and is vulnerable to be food insecure. The analysis also indicated a link between malnutrition of the children and household assets. The results point to the fact that asset poor families lack the resources to provide adequate food and other basic necessities to the children. Having assets provides the households with a number of opportunities to food access thus ensuring food security.

The main crops commonly grown by households in the three communities included maize, sweet potatoes, cassava and beans. The less grown crops included onions, cottons and coffee. This information was useful in designing grain amaranth recipes. The accessibility to agricultural land implies that with adequate farming inputs, most of the households may be able to achieve food security. Only a small proportion of the households interviewed grow grain amaranth. This implies that promotion of grain amaranth within the communities is required for significant

nutritional benefits to be recorded. The average land holding per household of 4acres is not enough. Land put under grain amaranth production is relatively very low. This land can be put to great use if grain amaranth is considered, because it's high yielding and does not take a lot of space. Grain Amaranth is not grown as a major crop in the three districts of study. Out of the three districts, Kamuli and Nakasongola districts considers grain amaranth as a major crop.

5.2 Nutritional Status of Children in the Households

Malnutrition assessment based on MUAC at the household for children with the ages of 6-59months showed that there was no severe malnutrition. However, a few of the children were moderately malnourished and a small percentage was at the risk of been malnourished. Further analysis showed that children with mothers with no formal education were more likely to be malnourished than those with some formal education. This is consistent with other studies (Smith *et al*., 2002; Quisumbing *et al*., 2001; Quisumbing, 2003) which have identified mothers/caregivers education level as a major determinant of children nutrition status. Therefore it is possible that the relatively low level of mothers/caregivers' education among the study respondents was a contributing factor to the relatively poor nutritional status of their children. Also, the study revealed that children from households with poor diet were more likely to be malnourished than those from households with an acceptable diet The poor dietary diversity coupled with limited consumption of proteins could explain the high levels malnutrition among children 6-59 months.

The dietary adequacy of the children from few households shows that children had adequate diets whereas majority did not. This according to WHO (2010) gauge, for a diet to be adequate it should contain at least 4 food groups. A larger proportion of the children were fed on diet which had less than the 4 food groups recommended, hence been diet inadequate. The low dietary diversity also indicated that households where the children belonged had low access to food, an important attribute of household food security.

The diversity of diet given to children showed that it was poor and mostly contained more grains, roots and tubers and less of eggs or grain amaranth. Most of the staple foods dominating in the diets of these children are deficient in proteins, fats and most of the critical micronutrients.

Generally consumption of animal protein foods was low probably because they are more expensive. Grain amaranth (plant source) incorporation in such meals could be such an opportunity to boost the quality .This result shows a need for more rigorous promotion of nutritious crops like grain amaranth. Its Consumption is reported to have nutritional and health benefits, ranging from a general improvement in well-being to prevention and improvement of specific ailments and symptoms including recovery of severely malnourished children (Tagwira, 2006).

On morbidity of the children surveyed, more than half of them had experienced diarrhea, vomiting and fever. These ailments negatively affect the nutritional status of the children by either lowering their appetite thereby causing low dietary intake or causing mal-absorption leading to low utilization and nutrient intake

The household energy intake from the three districts shows that Nakasongola and Apac districts had an energy intake greater than the US standard of 2000Kcals. It was only Kamuli district which had an energy intake lower than the standard USRDA of 2000Kcal. The overall mean energy intake for the three districts also meets the US set standard of 2000Kcals (*Dietary Reference Intakes for Energy, Carbohydrate. Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acid*s *(2002/2005)).* The Food and Agriculture Organization's Food Balance Sheets estimate Uganda's average per capita dietary energy availability at 2,380 kcal per day, well above Uganda's computed minimum per capita daily energy requirement of 1,700 kcal per day (FAOSTAT, 2010). This implies that the energy intake of the three districts are above the Uganda's computed minimum energy requirement but rather lower than the FAO estimates.

Fats, thiamine, niacin, calcium and zinc were found to be deficient in the diet of the children based on the NQI values. Fat intake was low probably because in the rural setting vegetables which are widely used as sauce are simply boiled in water without any fat added. Iron intake by most of the children was relatively low indicating the need for dietary iron enrichment in their diet. However, it should be noted that most of the proteins consumed were of plant origin an indication that they were low quality proteins. The protein quality could be boosted by incorporation of grain amaranth which is more balanced than most other plant source proteins.

Fiber and vitamin C intake were exceptionally high. This may be attributed to seasonal fruit harvest peaks.

Dietary and Infant and young child feeding practices revealed that children aged 6-59 months were either breastfed, introduced to solid, semi-solid or soft foods. Older children aged 24-59 months were given less diverse diets compared to the younger ones aged 6-23 months. This could imply that as the children grow older less attention is paid to their diets. If this is not addressed, it could play a role in contributing to undernourishment among the older children.

Feeding of children solids, semisolids and soft foods were mostly done 2 to 3times in a day. Only a few household did feed their children 5 or more times in a day which is recommended by WHO (2010). Children have small stomachs and therefore have to feed on thick (dense) solid food in order for them to benefit from the little intake. The denser the feed could also imply more nutrient intake for the child.

The practices of meal preparation for children were assessed. The study revealed that most households do not prepare separate meals for their children. It is a common practice in Uganda for young children to eat with their mothers. In such cases, the quality of the infant's food is the same as the family meal. The difference is that the infant's food is softer, mashed and many times made more watery. This implies that meals for the general household have to be enriched, to avoid malnutrition among children. Current staple diets for most of the resource poor people in Uganda are dominated by starchy staples like millet, sorghum, banana, maize and cassava, which contain inadequate protein, essential amino acids (lysine and the sulphur amino acids) and most micronutrients. Production and consumption of grain amaranth presents an opportunity for improvements of local diets, food and nutrition security of the communities. Most the households have different plates for their children. The use of separate plates for feeding children is a very good practice because the quantity of the food the child eats can be known.

The time meals are eaten at home was also assessed. Generally, most households take their meals between 6-8pm. This practice of eating early help children eat a reasonable portion of food given because at such a time they are not so sleepy, however, the principle of active feeding is clearly

left out. Without supervision from adults, the children may waste food by pouring down or they may have low appetite due to lack of encouragement from caretakers

Porridge was one of food found to be ideal for incorporation of grain amaranth because it is widely considered a dish for the vulnerable group which include under-fives children, the sick, pregnant and lactating mothers. The frequency of feeding children was food to have a relationship with malnutrition. Children who were not fed complementary foods in accordance with the guidelines were more likely to be malnourished than those who were fed based on the guideline. The study also revealed that more than half of the households interviewed did not know about specially prepared food for children or "*Kitobero*" meaning children food. The few who have heard of Kitobero cooked it while a few others

5.3 Development of Recipes and Sensory Acceptability of Developed Products from Grain Amaranth

A baseline study conducted revealed that grain amaranth was used in various recipes such as porridges, meals, sauces, snacks, paste and sometimes as medicine. In Kamuli district, the amaranth was mainly utilized in sauce. In Nakasongola district, it was utilized as porridge, sauce and for snacks whereas in Apac, it was mainly used as sauce. General, it can be inferred that the fresh leaves of grain amaranth were mostly used in sauce preparation. This was an indicator that there was a knowledge gap on how to utilize grain amaranth especially the grains which needed to be bridged by helping farmers to fully participate in developing grain amaranth recipes/products that would eventually help to boost their nutrient intakes and dietary diversity.

For the product development, thirty-nine (39) products were developed using different combination and proportions of grain amaranth and locally available foods. Out of these products, 17 of the products were liked very much (sensory score $\geq$7.5) and were the most accepted in terms of their texture, flavor, appearance and odor. The products highly accepted included chapatti, baggia, pancakes, balls, sauce, sesame instant porridge, millet porridge, grain amaranth maize porridge, grain amaranth rice porridge, grain amaranth cassava meal, grain amaranth millet-cassava meal, grain amaranth rice meal, grain amaranth tea masala, grain amaranth soup, grain amaranth paste, grain amaranth snacks and finally grain amaranth leaf

powder-peanut sauce. The preference for products enriched with grain amaranth suggests that the addition of grain amaranth to the products improves the flavor and aroma of the developed products, hence the overall acceptability of the products.

On the method of preparation, popping and roasting the seeds of the grain amaranth were the most preferred cooking method. For the preparation of bean sauce, porridge (maize, millet, rice) and cassava meals, the grain amaranth seeds were popped before used whereas in the case of cassava-millet meals and soups, the grain amaranth seeds were roasted before use. The methods of preparation of the grain amaranth do impact some characteristics to the product that explains why the method of preparation is very important in each product.

The incorporation of different food into a product improves the energy and nutrient density of the developed products. Incorporation of nutrient rich foods such as sesame, soybeans and peanuts enhances the energy content of the food product developed. Products such as peanut sauce, sesame-peanut paste and baggia were high in energy. The incorporation of grain amaranth into the products significantly improves the nutrient content of most of the foods developed compared to the traditional recipes with the grain amaranth. The most marked positive changes attributable to presence of grain amaranth in the food formulations were recorded in the levels of the minerals (Zn, Fe and Ca). Grain amaranth markedly enhanced the nutrient content for cassava meal. It also generally enhanced nutrient content for maize, millet and rice albeit to a lower extent. This shows the value of incorporating grain amaranth in diets dominated by starchy staples. On the other hand, in sesame balls, grain amaranth incorporation was found to cause a reduction in the levels of all nutrients except protein. Generally the benefit of incorporating grain amaranth into oil seeds and pulses was lower that observed for starchy staples.

Sesame-peanut Paste, Bean-peanut Snack, Sesame balls are exceptional products to such a child because they contribute to at least 20% of RDA for all the nutrients in just one serving. Sesame balls among the snacks have the highest nutrient contribution for all the nutrients.

Peanut sauce gives the highest contribution towards energy, protein and fat while sesame balls have the highest contribution towards zinc, iron and calcium. This is an indicator to show that when such recipes are adopted and practiced in favor of these children, deficiencies of the nutrients may significantly reduce.

CHAPTER SIX
6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The current nutrition and food security status of rural households in Kamuli, Apac and Nakasongola is rather poor and require attention. The factors associated with malnutrition in these districts included; consumption of monotonous and unvaried diets lacking in most of the critical micronutrients, insufficient knowledge on how to prepare nutritious/balanced meals more especially children(6-59 months), Inadequate dietary intakes and high disease burden.

The study showed that amaranth could be combined with a variety of locally available foods to make highly acceptable products containing enhanced levels of Ca, Zn, Fe, etc, nutrients identified to be low in diets for people in Kamuli, Nakasongola and Apac districts.

In addition to this, the study demonstrated that grain amaranth has potential to contribute to the alleviation of malnutrition because the recipes developed through this study were found to contain enhanced levels of the nutrients previously reported to be inadequate in the diets of the 3 study districts. These recipes have not only been able to fill the nutritional gaps but were found to be highly acceptable to the farmers in the rural households of Kamuli, Apac and Nakasongola. Once widely disseminated and adopted, these recipes are likely to markedly contribute to improved nutrition in the three districts.

This is a clear testimony to Uganda's understanding that tackling nutrition problems will contribute to the attainment of its broader development goals. The prevalence of malnutrition across a predominantly agrarian country like Uganda and its potential economic implications indicate the importance of understanding the link between agricultural productivity and nutrient intake. Such an understanding will highlight the importance of different nutrients (and nutrient rich foods like grain amaranth) available across Uganda, thus guiding policymakers in prioritizing and developing appropriate programs to tackle malnutrition and improve agricultural productivity.

Generally, the study showed that there is a positive potential benefit of incorporating grain amaranth in the diets of rural households in Kamuli, Apac, Nakasongola Districts and Uganda as a whole because it significantly contributed to improvement in nutrition and food security.

5.2 Recommendations

Production of grain amaranth should be encouraged by MAAIF, MOH, and NAADS among others because of its nutritional values and income generation potential. It requires small plots of land, implying that the "landless" can afford to grow it. There is need to promote farmers′ access to grain amaranth markets in order to increase the returns on investment, which in turn will motivate farmers to expand on production and promote local food-grain amaranth recipes.

The dietary diversity of indigenous African leafy vegetables(including grain amaranth), in addition to providing essential nutrients and micronutrients, may also offer broad health benefits due to inherent benefits of dietary diversity, reinforcing food cultures, and functional properties of leafy greens.

The documentation and dissemination of more recipes will not only help diversify diets but will also give others a chance to enjoy other people's foods. A number of recipes are on the verge of being lost as cultural erosion continues.

Many local foods in Uganda have the potential for commercialization but this potential is only realized (unlocked) after promotion. Promotion of grain amaranth consumption within the communities by local leaders and village health teams, Community nutrition and health workers is required for significant nutritional benefits to be recorded.

Programmers that aim to reduce malnutrition in the rural communities should focus on improving IYCF practices, hygiene & sanitation practices, and reducing disease burden. These factors can negatively affect food intake which eventually affects nutrition even when nutrient rich foods like G.A have been promoted. They should also advocate for increased resources for scaling up nutrition interventions to address the needs of young children and mothers and to create awareness among the general population of the human, social, and economic costs of malnutrition.

There should be more practical ways of improving diet diversity and increasing the energy and nutrient density of local diets. Both food-based approaches and micronutrient-specific interventions will be needed. The scope of such programming must seek to integrate nutrition, gender and livelihood activities, targeting households in rural settings where undernutrition is higher. Increasing the target populations' consumption of diverse nutritious foods should be done by increasing the production of and access to micronutrient-rich foods like grain amaranth at the household and community levels

The WFP has been identified as support for food supplementation to IDP'S in northern Uganda, refugees in northern and western Uganda and to the food-insecure Karamoja. The study therefore recommends that it (WFP) designs a new strategy to include a preventive community nutrition component like supplementing their diets with nutrient rich foods such as grain amaranth

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APPENDICES

APPENDIX 1: Questionnaire for Determining the Current Nutrient Intake and Nutrition Related Knowledge and Practices among House Holds of Farmers

Date……

Consent form

This baseline survey is aimed at **determining the current nutrient intake and nutrition related knowledge and practices**. This is an initiative which will be aimed at alleviating malnutrition, food insecurity and poverty of resource poor farmers in the districts of Apac, Kamuli and Nakasongola. Makerere University in collaboration with Volunteer Efforts for Development Concerns (VEDCO), National Agricultural Research Organization (NARO), and district authorities is implementing this project.

This questionnaire is meant for **farmers** in various farmer groups in the districts of Kamuli, Apac and Nakasongola where the grain amaranth project (09-517) is in operation to promote production and utilization of grain amaranth for improved nutrition and health in Uganda.

You have been randomly selected among farmers to give us information about the current nutrient intake and nutrition knowledge and practices at your household where the project will be implemented. Information collected will help us to better design the Project activities for households in this area. Your answers will be kept confidential and your participation is voluntary.

At this point, do you have any questions about the study? Also, in case you have additional questions after we leave this area, you can contact any of the following numbers: +256-414-533865, +256-753481481, +256-701684241

May I begin the interview now? Signature of respondent……..
Name of farmer group…….Interviewer's Name: ……..
Interviewer's Contact: ……

SECTION ONE: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Characteristic	**Options(please circle the correct option)**
Operational area: 1.0: District 1.1:Sub-county 1.2:Parish 1.3:Village	 …… …… …… ……
1.4: Name of respondent	……
1.5Sex of the respondent:	1. Male 2. Female
1.6: Age of Respondents (years)	……
1.7:Physiological state of the respondent	1. Expectant/pregnant mother 2. Lactating/breast feeding mother 3. Expectant and lactating mother. 4. None of the above.
1.8: Maximum Education level attained	1. None 2. Primary 3. Secondary 4. Tertiary
1.9: Main Occupation	1. Trader 2. Salaries worker 3. Subsistence farmer 4. Others (specify)…….
1.10: Marital status	1. Single 2. Married 3. Divorced/separated 4. Widowed
1.11: Household size	……(people)
1.12: Respondent's position in the house hold	1. Mother 2. Grand mother

	3. Daughter/son 4. House help 5 .Other (specify)…….
1.13: Relationship of the respondent to the child (under five years)	1. Mother 2. Grand mother 3. Sister 4. House help 5.Other (specify)……

SECTION TWO

2.0 FOOD INTAKE (FOOD FREQUENCY & HOUSEHOLD DIETARY DIVERSITY)- FOR WOMEN TO BE GIVEN FIRST PRIORITY.

Please narrate everything that your **house hold members** ate yesterday during the day or night, at home.

a. Think about when ***you*** first woke up yesterday. Did ***you*** eat anything at that time? *If yes*: Please tell me everything ***you*** ate at that time. ***Probe****:* Anything else? *Until respondent says nothing else. If no, continue to Question b).*

b. What did **you** do after that? Did **you** eat anything at that time?

c. If yes: Please tell me everything **you** ate at that time. **Probe**: Anything else? *Until respondent says nothing else.* Repeat question b) above until respondent says the whole household went to sleep until the next day. If respondent mentions mixed dishes like a porridge, sauce or stew, **probe:**

d. What ingredients were in that **(*Mixed Dish*)**? Probe: Anything else? *Until respondent says nothing else*. As the respondent recalls foods, underline the corresponding food and circle '1' in the column of **YES** under Last 24 hours.

If the food is not listed in any of the food groups below, write the food in the box labeled 'other foods'. If foods are used in small amounts for seasoning or as a condiment, include them under the **MISCELLANEOUS** food group.

Once the respondent finishes recalling foods eaten, read each food group where '1' was not circled, ask the following question Yesterday during the day or night, did ***you*** drink/eat any ***(FOOD GROUP ITEMS)****?*

And Circle **'1'** *if respondent says YES fill in the columns for food measure* and '**2**' *if NO. For the columns of food frequency;* **D**=*Daily,* **W**=*Weekly,* **M**=*Monthly,* **O**=*Occasionally. Assign* **4, 3, 2, 1respectively**. **Score 0** *if no item from the food group is mentioned,* **Score 1** *if any item from the*

food group is mentioned Could you please tell me how many days in the **past one week** (seven days) your household has eaten the following foods-read out the whole list of foods provided on the questionnaire (write 0 for items not eaten over the last 7 days) your whole household

2(a)Number of meals eaten in your house hold (yesterday) ……times

2(b)

			Last 24 hrs			FOOD MEASURE		FOOD FREQUENCY				Last7 days
FOOD GROUP	**NO.**	**FOOD GROUP ITEMS**	**SCORE**	**YES**	**NO**	**QTY EATEN**	**UNIT**	**D**	**W**	**M**	**O**	*No. Of days Eaten last 7 days*
	ENERGY GIVING FOODS											
A	**CEREALS**											
	1	Maize meal*(ugali)*		1	2		Kg	4	3	2	1	
	2	**Wheat products:**	**A….**									
	2.1	Chapatti		1	2		Pieces	4	3	2	1	
	2.2	biscuit		1	2		Pieces	4	3	2	1	
	2.3	cookies		1	2		Pieces	4	3	2	1	
	2.4	cakes		1	2		Pieces	4	3	2	1	
	2.5	Doughnut,		1	2		Pieces	4	3	2	1	
	2.6	Spaghetti/macaroni		1	2		Packets	4	3	2	1	
	3	Rice, boiled		1	2		Kg	4	3	2	1	
	4	Millet ugali (*Kaalo*)		1	2		Kg	4	3	2	1	
	5	Sorghum ugali		1	2		Kg	4	3	2	1	
B	**ROOTS ,TUBERS & BANANAS**											
	6	Irish Potatoes	**B….**	1	2		Stem tubers	4	3	2	1	
	7	Orange-fleshed sweet potato (*owa kipapali)*		1	2		Root tubers	4	3	2	1	
	8	Cassava		1	2		Root tubers	4	3	2	1	
	9	Yams*(Amayuni)*		1	2		Root tubers	4	3	2	1	
	10	White fleshed Sweet Potatoes		1	2		Root tubers	4	3	2	1	
	11	Matooke		1	2		Clusters	4	3	2	1	
	PROTECTIVE FOODS											

	(VITAMINS AND MINERALS)											
C		**VEGETABLES**										
	12	Dark Green leafy vegetables (of any kind) *(enva endiirwa)*	**C….**	1	2		Bundles	4	3	2	1	
	13	Egg plants (*Biringanya*)		1	2		Whole vegetables	4	3	2	1	
	14	Bitter tomato (*Entula*)		1	2		Whole vegetables	4	3	2	1	
	15	Pumpkin *(ensujju)*		1	2		Whole pumpkin	4	3	2	1	
	16	Tomatoes		1	2		Whole tomatoes	4	3	2	1	
	17	Onion		1	2		Whole onions	4	3	2	1	
	18	Green pepper		1	2		Whole pepper	4	3	2	1	
	19	Cabbage		1	2		Whole cabbage	4	3	2	1	
	20	Mushrooms		1	2		cups	4	3	2	1	
	21	Carrots		1	2		Whole carrots	4	3	2	1	
D		**FRUITS**										
	22	Mango	**D….**	1	2		Whole fruits	4	3	2	1	
	23	Passion fruits		1	2		Whole fruits	4	3	2	1	
	24	Tangerines (*Mangadda)*		1	2		Whole fruits	4	3	2	1	
	25	Jackfruit (*ffene*)		1	2		Whole fruits	4	3	2	1	
	26	Pineapples		1	2		Whole fruits	4	3	2	1	
	27	Pawpaw		1	2		Whole fruits	4	3	2	1	
	28	Apples		1	2		Whole fruits	4	3	2	1	
	29	Pears		1	2		Whole fruits	4	3	2	1	
	30	Guavas		1	2		Whole fruits	4	3	2	1	
	31	Oranges		1	2		Whole fruits	4	3	2	1	
	32	Water melon		1	2		Whole fruits	4	3	2	1	

	33	Banana (*Ndiizi, Bogoya*).		1	2		clusters	4	3	2	1	
	34	Avocado		1	2		Whole fruits	4	3	2	1	
	BODY BUILDING FOODS (PROTEINS)											
E	**MEAT, POULTRY, OFFALS & INSECTS**											
	35	Beef		1	2		Kg	4	3	2	1	
	36	Goat		1	2		Kg	4	3	2	1	
	37	Mutton		1	2		Kg	4	3	2	1	
	38	Pork		1	2		Kg	4	3	2	1	
	39	Chicken		1	2		pieces	4	3	2	1	
	40	Turkey	**E….**	1	2		pieces	4	3	2	1	
	41	Any kind of liver *(ekibumba)*		1	2		Kg	4	3	2	1	
	42	Offal's		1	2		Kg	4	3	2	1	
	43	Blood (cow, goat, sheep)		1	2		Liters	4	3	2	1	
	44	White ants		1	2		tablespoons	4	3	2	1	
	45	Grass hoppers		1	2		tablespoons	4	3	2	1	
F	**EGGS**											
	46	Eggs (hens, ducks)	**F….**	1	2		Whole eggs	4	3	2	1	
G	**FISH & SEA FOODS**											
	47	Nile perch		1	2		Kg	4	3	2	1	
	48	Tilapia		1	2		Kg	4	3	2	1	
	49	Mukene	**G….**	1	2		Kg	4	3	2	1	
	50	Nkejje		1	2		Kg	4	3	2	1	
	51	Cat fish		1	2		Kg	4	3	2	1	
H	**PULSES,LEGUMES AND NUTS**											
	52	Beans (all kinds)		1	2		Kg	4	3	2	1	
	53	Peas(all kinds)	**H….**	1	2		Kg	4	3	2	1	
	54	Groundnut		1	2		Kg	4	3	2	1	
	55	Simsim		1	2		tablespoons	4	3	2	1	
I												

	MILK & MILK PRODUCTS											
	56	Cow-milk/goat milk(powdered/condensed, liquid)		1	2		*tumpeco*	4	3	2	1	
	57	Yoghurt*(bongo, ekiviguto)*		1	2		*tumpeco*	4	3	2	1	
	58	Cheese	**I….**	1	2		tablespoons	4	3	2	1	
	59	Butter		1	2		tablespoons	4	3	2	1	
	60	Ghee		1	2		tablespoons	4	3	2	1	
	61	Soy milk		1	2		*tumpeco*	4	3	2	1	
	LIPIDS											
J	**FATS AND OILS**											
	62	Oils(Liquid) - any kind (e.g. Ufuta, Mukwano)	**J….**	1	2		tablespoons	4	3	2	1	
	63	Fats(Solids)– any kind(Kimbo, Cowboy, Blue band)		1	2		tablespoons	4	3	2	1	
K		**SUGAR & HONEY**										
	64	Sugar	**K….**	1	2		Kg	4	3	2	1	
	65	Honey		1	2		tablespoons	4	3	2	1	
	OTHERS											
L		**MISCELLENIOUS**										
	66	Tea		1	2		*tumpeco*	4	3	2	1	
	67	Coffee		1	2		*tumpeco*	4	3	2	1	
	68	Cocoa	**L….**	1	2		*tumpeco*	4	3	2	1	
	69	Soda		1	2		*bottles*	4	3	2	1	
	70	*Busheera*		1	2		*tumpeco*	4	3	2	1	
M		**GRAINAMARANTH (G.A)**										
	71	G.A Porridge		1	2		*tumpeco*	4	3	2	1	

	72	G.A meals	**M….**	1	2		*tumpeco*	4	3	2	1	
	73	G.A paste		1	2		*tablespoon*	4	3	2	1	
	74	G.A snack		1	2		*handfuls*	4	3	2	1	
	75	G.A sauce		1	2		*ladles*	4	3	2	1	

OTHER FOODS: *PLEASE WRITE DOWN OTHER FOODS IN THESE SPACES THAT RESPONDENT MENTIONED BUT ARE NOT IN THE LIST ABOVE:…… …… …… ……*

HDDS for the house hold is……/ 13

2(c) which food taboos do you follow most in your area? .....

SECTION THREE

3.0 ASSESSMENT OF INFANT AND YOUNG CHILD (6-59MONTHS) FEEDING

PRACTICES & ANTHROPOMETRY IN THE HOUSE HOLD- This section is meant for the youngest child in the household who is below 5years but is above 6 months.

1	I would like to ask you some questions about ***(NAME)***.In what month and year was ***(NAME)*** born? What is his/her birthday? *If the respondent does not know the exact birth date ask:* Does ***(NAME)*** have a health/vaccination card with the birth date recorded? *If the health/vaccination card is shown and the respondent confirms the information is correct, record the date of birth as documented on the card*	DAY.....|___|___| *If day is not known, enter '98'* MONTH.....|___|___| YEAR..... |___|___||___|___| ***(NAME)*** is**…….**months/years Old	

2	Was ***(NAME)*** breastfed yesterday during the day or at night on addition to other complementary food?	YES..... 1 NO..... 2 DON'T KNOW 8	

NO	**INTERACTIVE 24 HOUR FOOD RECALL FOR CHILDREN 6-59 MONTHS**				
3	Please describe everything that ***(NAME)*** ate yesterday during the day or night, whether at home or outside the home. a) Think about when ***(NAME)*** first woke up yesterday. Did ***(NAME)*** eat anything at that time? *If yes*: Please tell me everything ***(NAME)*** ate at that time. *Probe:* Anything else? U*ntil respondent says nothing else.* I*f no, continue to Question b).* b) What did ***(NAME)*** do after that? Did ***(NAME)*** eat anything at that time? *If yes:* Please tell me everything ***(NAME)*** ate at that time. *Probe:* Anything else? U*ntil respondent says nothing else*. *Repeat question b) above until respondent says the child went to sleep until the next day.* *if respondent mentions mixed dishes like a porridge, sauce or stew, probe:* c) What ingredients were in that ***(MIXED DISH)***? *Probe:* Anything else? *Until respondent says nothing else.* *As the respondent recalls foods, underline the corresponding food and circle '1' in the column next to the food group. If the food is not listed in any of the food groups below, write the food in the box labeled 'other foods'. If foods are used in small amounts for seasoning or as a condiment, include them under the condiments food group.* *Once the respondent finishes recalling foods eaten, read each food group where '1' was not circled, ask the following question and Circle '1' if respondent says yes, '2' if no and '8' if don't know:* Yesterday during the day or night, did ***(NAME)*** drink/eat any ***(FOOD GROUP ITEMS)***?				
	OTHER FOODS: *PLEASE WRITE DOWN OTHER FOODS IN THIS BOX THAT RESPONDENT MENTIONED BUT ARE NOT IN THE LIST BELOW:* …….. …….. …….. …….. …… ……..				
	QUESTIONS& FILTERS	**CODING CATEGORIES**			
	Food group(underline the mentioned food item)				
A	**GRAINS, ROOTS OR TUBERS**		**YES**	**NO**	**DK**
	Porridge, bread, rice, noodles, or other foods made from grains White potatoes, white yams, manioc, cassava, or any other	**A….**	**1**	**2**	**8**

	foods made from roots				
B	**VITAMIN A RICH PLANT FOODS**				
	Pumpkin, carrots, squash, or sweet potatoes that are yellow or orange inside Any dark green leafy vegetables Ripe mangoes, ripe papayas, or (**insert other local vitamin** A-**rich fruits**)	**B….**	1	2	8
C	**OTHER FRUITS OR VEGETABLES**				
	Bananas, passion fruits, goose berries etc	**C….**	1	2	8
D	MEAT,POULTRY,FISH,SEAFOOD				
	Liver, kidney, heart, or other organ meats Any meat, such as beef, pork, lamb, goat, chicken, or duck Fresh or dried fish, shellfish, or seafood	**D….**	1	2	8
E	**EGGS**				
	Eggs (Ducks, hens)	**E….**	1	2	8
F	**PULSES/LEGUMES/NUTS**				
	Any foods made from beans, peas, lentils, nuts, or seeds	**F….**	1	2	8
G	**MILK AND MILK PRODUCTS**				
	Cheese, yogurt, or other milk products	**G….**	1	2	8
H	**FOODS COOKED IN OIL/FAT**				
	Any oil, fats, or butter, or foods made with any of these	**H…**	1	2	8
I	**GRAIN AMARANTH (ANY PRODUCT)**	**I….**	1	2	8

IDDS for the child is ……. /9

4	How many times did ***(NAME)*** eat solid, semi-solid, or soft foods other than liquids yesterday during the day or at night?	NUMBER OF TIMES..... |___|___| DON'T KNOW..... 98	

5. Is the child's food prepared separately from the family meal?	1. Prepared separately 2. Taken from family meal
If food is prepared separately:	

6. Which foods and drinks do you serve the child separately?	**Food**	**Qty**	**drinks**	**Qty**
	1.		1.	
	2.		2.	
	3.		3.	
	4.		4.	

If food comes from the family meal:		
7. Does the child eat from his/her own plate?	1. Yes 2. No	
8.How many main meals (solid or semi-solid food or porridge) did the child eat yesterday (day and night)	**( )**	
9. How many times did the child eat snack food of any type in between the main meals yesterday?	**( )**	
10. What time does the child normally eat his/her last meal?	1. Early evening (6-8pm) alone or with other children but separately from adults 2. Late evening (after 8pm) with the rest of the family	
11. Do you feed your child on porridge?	1. Yes 2. No	
	12. If yes, which ingredients do you use? Ingredient	Quantity
	1…… 2…… 3…… 4…… 5……	…… …… …… …… ……

13. Have you heard of ‘kitobero” as applied to special preparation of children’s food?	1. Yes 2. No				
14. If yes have you prepared kitobero for your child?	1. Yes 2. No				
15. If yes, How many times in the last seven days did you prepare ‘kitobero’ for your child?	1. Once 2. 2-3 times 3. More than four times				
16. If you did not prepare kitobero for the child in the last seven days, please give reasons why.	1. I do not know how to prepare it 2. I can’t get the ingredients 3. It takes too much time to prepare 4. What I give is enough for the child 5. No particular reason 6. Other (specify)				
17. If you have prepared kitobero in the last seven days can you list ingredients for three different types of kitobero		1st ingredient	2nd ingredient	3rd ingredient	4th ingredient
	1				
	2				
	3				

ANTHROPOMETRY (FOR CHILDREN 6-59 MONTHS)-All children under five years but above six months in the house

Qn 17. Qn18. MUAC Tape Color (tick right color)

CHILDREN	MUAC Measurement(cm)	☐ Red	☐ Yellow	☐ Green
Child1				
Child2				
Child3				
Child4				
Child5				
Child6				
Child7				
Child8				
Child9				

Qn19. For children with MUAC Measurement is <11.5cm take:

Weight (kg)……Height (cm) …… W/H Z score ……

Qn 20.

Does child have	YES	NO
Diarrhea		
Vomiting		
Fever		

4.0: FOOD SECURITY

Use this table to give information about any 3 of the foods you consider major to you.

4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11	4.12	4.13
Last food harvest & storage								**Food purchase made last month**			**H/h Food Consumption Patterns**	
Food	Acreage(tenths)	Total No. of bags **16**harvested	Bags currently in storage	Bags sold	Bags used for brewing	Bags used for eating	Food supply **17**(weeks)	Purchased food last month? 1.yes (>>4.10) 2.No (>>4.12)	Kilos purchased	How many days did you depend on purchased food in the last 30 days	In the month after the harvest, how many major meals does your family usually eat per day	Weeks last year in which you had only one major meal per day

16. *Probe to establish the average amount of food stuff that makes a bag where necessary*

17. *Food supply means the time a particular type of food stuff takes to get exhausted from the time of harvest*

5. HOUSEHOLD ASSETS

5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1
Asset Ownership			**Animal &Poultry Ownership**			**Land Ownership**			**Land Usage**	
Asset	Owned? 1…Yes (>>5.3) 2…No (>>5.4)	Qty	Animal & Poultry	Owned? 1.Yes (>>5.6) 2…No (>>5.7)	Qty	Total No. c acres (Tenths[13])	Type of Ownership 1.Communal 2.Customary 3.Free Hold 4.Lease 5.Kibanja 6.Other-Specify	Acres rented or family Use (Tenths)	Use	Acres (Tenths)
Radio			Milk Cows						Grain Amaranth	
TV										
Bicycle			Other Cows							
Motorcycle									Perennial [14]crops	
Car/truck			Bulls							
Hoes										
Ploughs			Oxen						Seasonal [15]crops	
Wheelbarrow										
Pumps/sprays			Sheep/ Goats							
Storage shade									Other(specify)	
Animal buildings			Pigs							
Building for h/h business			Chicken							
Other(specify)			Turkeys							
			Others (Specify)							

13*Tenths, i.e., to one decimal place (e.g., 1.5)* ***14****The distinction between perennial and seasonal crops is useful because the asset value for land with trees is likely to be higher than the value for the other land. Perennial crops (e.g. tea, coffee, fruits, etc.)* ***15****seasonal crops (e.g., maize, cassava, sweet potatoes, cotton etc)*

APPENDIX 2: Questionnaire for the Baseline Recipe Collection

INDIVIDUAL INTERVIEWS ON PARTICIPATORY DEVELOPMENT AND DOCUMENTATION OF GRAIN AMARANTH BASED RECIPES WITH EXPERIENCED WOMEN FARMERS

District……
Sub-county……

Information:
You have been purposefully selected as an experienced woman farmer (in the area of grain amaranth preparation/ cooking) to participate voluntarily in the development of G.A based recipes. Information collected will help us to design and document the recipes and protocols.
We all know that grain amaranth has the potential to contribute to the improvement of the nutritional status of vulnerable populations such as children and the sick. By developing recipes of a variety of amaranth-based products, consumption of grain amaranth can be increased beyond non-producing communities. Later on Promotion of the value-added products can also contribute to expanding the market for amaranth. Your co-operation is highly needed.
Feel free to air out your views on how you actually prepare the grain amaranth (popping, roasting, sprouting, and milling) and eventually how you make your soups, porridge, paste, pops, stiff porridge among others. Clearly stating the names and amounts of ingredients you use, the type of fuel used, how many minutes it takes you to prepare and cook the dishes mentioned. You are also requested to tell us how many people can be served from your dish and how much of that dish can be served to an individual at your house hold.

In case of any questions contact any of the following numbers: +256-414-533865, +256-753481481 or +256-701684241

Table: G.A product codes:

G.A PRODUCT	CODE
1. Gruels (porridge)	1
2.Meal/Bread/stiff porridge	2
3.Amaranth Sauce	3
4.Amaranth snack	5
5.Medicinal Amaranth	6
6.Amaranth paste	7

RECIPE NAME: ……

RECIPE CODE: ……

INGREDIENTS USED	UNIT	QUANTITY
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Makes: ……
Preparation time: ……..
Cooking time: ……
Fuel: ……
Number of H/H Members served: ……

<u>Preparation/cooking method:</u>

……
……
……
……

Thanks for your information

APPENDIX 2.1

Table: PARTICULARS OF RESPONDENTS (BASELINE RECIPE COLLECTION):

No.	Farmer's Name	Farmer's Name	Farmer's Name
	Kamuli	Nakasongola	Apac
1	Saabi Jane	Nalweyiso Janet	Easter Ogwal
2	Ngonzi Tappy	Namwenje Harriet	Anna kongor
3	Mugoberezi Betty	Namiramu Edissa	Michael Wontwoni
4	Nabirye Robinah Kinabeya	Nattimba Margaret	Lillian Ogwang
5	Nabiryo Suzan	Nakalema Jane	Adoch Bito
6	Sodo Irene	Nansubuga Mary	Sophia Omara Aporo
7	Mugalagala Josephine	Nabukenya Cate	Margaret Akello
8	Namugaya Hanifah	Namirimo Editha	David Eyee
9	Waideno Mebra	Nambuusi Alice	Lucy Oceng
10	Ntogona Margaret	Nalweyiso Stephania	Mango Ayoo
11	Twiino Miriam	Nakiligya Beatrice	Erimalina Opodo
12	Mutalaga Irene	Kyamujoli Carol	Shelli Oruru
13	Isabirye Florence	Nanyombi Josephine	Acen Evaline
14	kyatte Sarah	Namaganda Betty Nalongo	Omach Geoffrey
15	Nampala Zeulensi	Nakivumbi Sarah	Semmy Adoko
16	Tinka Rose	Namuwonge Damalie	Ketty Oceng
17	Nangobi Christina		Okello Cosmas
18	Bujuni Rose		Rose Ococh
19	Wambi Beatrice		Rose Oruru
20	0uma Monica		Lilian Tapi
21	Nakiwala Margaret		
22	Kasubo Naima		
23	Timugibwa		
24	Namabiro Suzan		
25	Musowanire Jessica		
26	Namugaya Mangarita		
27	Nakawoma Florence		
28	Namia Rose		
29	Kauma Tappy		
30	Sipiyoza Tibiwa		
31	Kateme Samalie		
32	Isabirye Mary		
33	Nankwanga Monica		
34	Nakayiima Ruth		

APPENDIX 3: Questionnaires for Sensory Evaluation of the Developed Products

3.1 Questionnaire for Sensory Evaluation of Chapatti.

Name of Panelist: ……Age…….sex…….Date: ……

Instructions:

You are provided with 2 coded samples (804,840) of **Chapatti**. Assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code attribute	Texture	Flavor	Appearance	Odor
804				
840				

For any other comments, please note the sample codes.

……

……

Thank you for your participation

3.2 Questionnaire for Sensory Evaluation of Sesame Balls.

Name of Panelist: ……Age……sex……..Date: ……

Instructions:

You are provided with four coded samples (801,180) of **Sesame Balls**. Assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	**Texture**	**Flavor**	**Appearance**	**Odor**
801				
180				

For any other comments, please note the sample codes.

……

……

Thank you for your participation

3.3 Questionnaire for Sensory Evaluation of Baggia.

Name of Panelist: ……Age…….sex…….Date: ……

Instructions:

You are provided with two coded samples (802,820) of **Baggia**. Assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code attribute	Texture	Flavor	Appearance	Odor
802				
820				

For any other comments, please note the sample codes.

……

……

……

Thank you for your participation

3.4 Sensory Evaluation questionnaire for Pancakes.

Name of Panelist: ……Age……sex……..Date: ……

Instructions:

You are provided with two coded samples (380,830) of **Pancakes.** Assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
380				
830				

……
……
……

For any other comments, please note the sample codes.

Thank you for your participation

3.5 Sensory Evaluation questionnaire for Peanut Sauce

House Hold Number…… Date: ……

Instructions:

You are provided with two coded samples (901,910) of **Peanut powder**. You are request to prepare the samples and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this sauce.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
901				
910				

For any other comments, please note the sample codes.

……

……

……

Thank you for your participation

3.6 Sensory Evaluation questionnaire for Bean Sauce

House Hold Number…… Date: ……

Instructions:

You are provided with two coded samples (902,920) of **bean Sauce**. You are request to prepare the samples and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this sauce.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
902				
920				

For any other comments, please note the sample codes.

……

……

Thank you for your participation

3.7 Questionnaire for Sensory Evaluation of Sesame Instant Porridge.

House Hold Number…… Date: ……

Instructions:

You are provided with two coded samples (604,640) of **Sesame Instant Porridge**. You are request to prepare the samples and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this porridge.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
604				
640				

For any other comments, please note the sample codes.

……

……

Thank you for your participation

3.8 Questionnaire for Sensory Evaluation of–Millet Porridge.

House Hold Number…… Date: ……

Instructions:

You are provided with three coded samples (106,160,610) of **Millet Porridge Flour**. You are request to prepare the samples and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this porridge.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
106				
160				
610				

For any other comments, please note the sample codes.

……

……

Thank you for your participation

3.9 Questionnaire for Sensory Evaluation of Maize Porridge

House Hold Number…… Date: ……

Instructions:

You are provided with three coded samples (603,360,630) of **Maize Porridge Flour**. You are request to prepare the samples and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this Porridge.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
603				
360				
630				

For any other comments, please note the sample codes.

Thank you for your participation

3.10 Questionnaire for Sensory Evaluation of Rice Porridge

House Hold Number…… Date: ……

Instructions:

You are provided with three coded samples (602,260,620) of **Rice Porridge Flour**. You are request to prepare the samples and assess texture, flavor, appearance and odor for basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this Porridge.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
602				
260				
620				

For any other comments, please note the sample codes.

……

……

……

Thank you for your participation

3.11 Questionnaire for Sensory Evaluation of Cassava Meal.

House Hold Number…… Date: ……

Instructions:

You are provided with three coded samples (703,370,730) of **Cassava flour**. You are request to prepare the samples (follow instructions attached) and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this Meal.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code attribute	Texture	Flavor	Appearance	Odor
703				
370				
730				

For any other comments, please note the sample codes.

……

……

……

Thank you for your participation

3.12 Questionnaire for Sensory Evaluation of Millet cassava meal

House Hold Number…… Date: ……

Instructions:

You are provided with three coded samples (701, 170,710) of **Millet-cassava meal flour**. You are request to prepare the samples and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this Meal.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
701				
170				
710				

For any other comments, please note the sample codes.

……

……

……

Thank you for your participation

3.13 Questionnaire for Sensory evaluation of Rice Meal.

House Hold Number…… Date: ……

Instructions:

You are provided with two coded samples (702,720) of **Rice Meal**. You are request to prepare the samples and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please remember to rinse your mouth with water provided before testing the next sample. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare this Meal.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
702				
720				

For any other comments, please note the sample codes.

……

……

Thank you for your participation

3.14 Sensory Evaluation questionnaire for Ginger tea Masala.

Name of Panelist: ……Age…….sex…….Date: ……

Instructions:

You are provided 2 coded samples (301,310) of **Ginger tea Masala**. Follow the preparation instructions and assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please feel free to give any comments about any of the samples.

Note: Attached are instructions on how to prepare the Tea.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
301				
310				

For any other comments, please note the sample codes.

……

……

Thank you for your participation

3.15 Sensory Evaluation questionnaire for Paste

Name of Panelist: ……Age…….sex…….Date: ……

Instructions:

You are provided with two samples of **Paste**. Assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please feel free to give any comments about any of the samples.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	**Texture**	**Flavor**	**Appearance**	**Odor**
501				
510				

For any other comments, please note the sample codes.

……

……

……

Thank you for your participation

3.16 Sensory Evaluation questionnaire for bean snack

Name of Panelist: ……Age…….sex……..Date: ……

Instructions:

You are provided with 2 samples of **the bean-peanut Snack**. Assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please feel free to give any comments about the sample.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	Texture	Flavor	Appearance	Odor
401				
104				

For any other comments

……

……

Thank you for your participation

3.17 Sensory Evaluation questionnaire for grain amaranth soup

Name of Panelist: ……Age…….sex…….Date: ……

Instructions:

You are provided with 3 samples of **soup**. Assess for texture, flavor, appearance and odor basing on the scale given below. Write the figure that corresponds to your response in the box below the attribute under test. Please feel free to give any comments about any of the samples.

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither Like nor dislike	like slightly	like moderately	like very much	like extremely

Sample Code Attribute	**Texture**	**Flavor**	**Appearance**	**Odor**
678				
768				
876				

For any other comments, please note the sample codes.

……

Thank you for your participation

APPENDIX 4: Grain Amaranth (G.A) Recipes For Trials And Evaluation By Farmer Groups

PRODUCTS	INGREDIENTS/ group
Chapatti	3 leveled Tumpeco cups (1400g) of wheat Flour (Preferably Azam)
	600g (5 heaped table spoons + half kilo)of Popped Grain Amaranth flour
	½ Liter (1 Tumpeco cup) Oil
	2 finely grated medium size carrots(156g)
	2 finely grated medium size onions(86g)
	2 Tumpeco cups of hot water (1000mls)
	15g (1 tablespoon) of salt
	Optional: spices (1teaspoon /7g pilau Masala)
Baggia	Half a kilo (500g) cassava flour
	Quarter a kilo+$2^1/_2$ tablespoons (300g) roasted soy bean flour
	Ten heaped tablespoons (200g) popped Grain amaranth flour
	1 Liter of Cooking oil (2 Tumpeco cups)
	1 finely ground medium size onion(43g)
	$1^1/_2$ Tumpeco cups of cold water(1500mls)
	15g (1 tablespoon) of salt
	Optional: spices (1 teaspoon /7g ground ginger)
Pancakes	Half a kilo (500g) cassava flour
	Quarter a kilo (250g) popped Grain amaranth flour
	7 Big sweet bananas (560g)
	2Tumpecos of Cooking oil (1 liter)
	1 leveled tablespoon of fresh finely ground ginger (17g)
Balls	Quarter kilo (250g) of sesame seeds
	Quarter kilo (250g) of popped amaranth grains
	Quarter kilo (250g) of sugar
Soup	1 Nice cup (345g) of roasted/ toasted amaranth grains
	7 Nice cups (3248ml) of water,
	2 heaped teaspoon(14g) of salt,
	2 tablespoon (72g) of margarine
	1 teaspoon (6g) freshly ground ginger
	Tomato puree from 2 big tomatoes(184g)

	□ 1 finely grated/chopped onion (40g).
sesame Instant porridge	□ Half Tumpeco cup boiling water(250ml)
	□ Half Tumpeco cup of fresh whole milk(250ml)
	□ 3 tablespoons of the instant flour- ***made from:***
	roasted sesame kernels (1/2kg or 500g)
	popped G.A Grains(1kg or 1000g)
	sugar(1/4kg or 250g)
	□ Optional: Sugar
Rice-GA Porridge	□ 5 heaped table spoons mixed flour- ***made from:***
	Rice Flour [250g (1/4kg)]
	Popped G.A flour [250g (1/4kg) of G.A]
	□ 1 liters (2 Tumpeco) Fresh water
	□ 500 mls (1 Tumpeco) Milk (optional)
	□ 125 g(half of 1/4kg) sugar
	□
Maize-GA Porridge	□ 5 heaped table spoons mixed flour **- *made from:***
	Maize Flour [250g (1/4kg)]
	Roasted G.A flour [250g (1/4kg) of G.A]
	□ 1 liters (2 Tumpeco) Fresh water
	□ 500 mls (1 Tumpeco) Milk (optional)
	□ 125 g(half of 1/4kg) sugar
Millet-GA Porridge	□ 5 heaped table spoons mixed flour **- *made from:***
	Millet Flour [250g (1/4kg)]
	Roasted G.A flour [250g (1/4kg) of G.A]
	□ 1 liters (2 Tumpeco) Fresh water
	□ 500 mls (1 Tumpeco) Milk (optional)
	□ 125 g **(half of 1/4kg)** sugar
G.A-Peanut sauce	□ 20 g (1 table spoon) G.A leaf powder
	□ 100g (5 table spoons) pounded peanut
	□ ¼ teaspoon salt (2g)
	□ ¾ nice cup clean water
Convenient Bean sauce	□ 800g of soaked fresh beans
	□ Five tablespoons (100g) of Popped G.A powder

	Two table spoons table Salt(30g)
	2 Liters Water(4 Tumpeco cups)
	1 finely grated onion(44g)
	2 Teaspoons of curry powder
	½ teaspoon of pilau Masala (2g) (optional spice)
	1tablespoon of ground ginger (17g)
Instant rice-G.A Meal	Half a kilo of raw grain amaranth (500g)
	1tablespoon of ground ginger (17g)
	½ teaspoonful salt (4g)
	Half a kilo of rice kernels (500g)
	Water (2Liters/4 Tumpeco cups)
Cassava meal	250g(**1/4kg**) Cassava flour
	250g (**1/4kg**) roasted Grain Amaranth flour
	1 liter of water (2 Tumpeco cups)
Millet-cassava-G.A Meal	500g(**1/2kg**) Millet flour
	250g (**1/4kg**)Cassava flour
	250g(**1/4kg**) Roasted G.A flour
	2litersWater(4 Tumpeco cups)
Ginger-G.A Masala	300g(slightly more than 1/4kg) of Ginger (fresh, peeled, ungrounded)
	100g(5 table spoons) Popped Grain Amaranth flour
	20 g /3 teaspoons Pilau Masala (optional)
Paste	1kg sesame seeds(1000g)
	1/2kg Peanut seeds(500g)
	1/4kg popped Grain amaranth flour(250g)
Bean-peanut-G.A Snack	100g popped Grain Amaranth flour
	300g Peanuts/groundnuts seeds
	100g beans
	Cooking oil (1 liter)
	2 tablespoons of salt (30g)
	Water (3 liters)
	1 finely grated onion (43g)
	2 Teaspoons of curry powder (3.5g)

	□	½ teaspoon of pilau Masala (2g)
	□	1tablespoon of ginger (17g)

INSTRUCTIONS:

1. Chapatti

- Make Popped G.A Flour locally ***(As follows :)***
  - Pre-heat a large pan using an open fire
  - Put clean seeds on a pre-heated pan
  - Stir the seeds constantly while popping to prevent them from burning and to allow most of them to pop until the majority are
  - Pound in a motor
  - Sieve the flour to get the finest powder- ***now you have your popped GA flour***
- Sift wheat and popped grain amaranth flour; this is done to incorporate air into the flour.
- Mix the two flours and salt very well
- In a large bowl, add together flour, carrots, onions and 3 tablespoons of oil. Adding a little bit of hot water at a time, mix the ingredients together to form dough.
- Knead the dough for 10 minutes or until it does not stick to your hands. The secret to really soft Chapattis lies in the kneading and use of hot water. The dough must be smooth and just the right softness - medium.
- Divide the dough into equal portions, roughly the size of a golf ball. Roll between your palms, applying a gentle pressure, till the balls are smooth and without cracks. Once completed, lightly brush each piece of dough with oil and then sprinkle a pinch of flour on top.
- Sprinkle flour over the table where you will be rolling the chapattis out. Use your rolling pin to push the dough into round flat circles about 5 inches wide. Flip the dough as you roll and make sure you add flour if it is sticking to the table or the rolling pin.

Figure a: How to roll the Chapatti dough

- Heat a pan on a medium flame and put one tablespoon of oil in the pan. Put the rolled out Chapatti on it to cook. Use your hands to stretch the chapatti to the width of the pan so that the chapatti is as thin as possible.

- Take either a spatula or an empty flour bag and fold it down from the top to the bottom. Slowly press down on the chapatti as you turn it.

- The Chapatti is ready for its first flip when you begin to see raised bumps on its surface. Use a spatula to turn it on to its other side. Remove from the pan when both sides appear golden in color as shown in figure b below.

Figure b: The ready golden brown chapatti

- Place on a clean paper to absorb excess oil.
- Place in a polythene paper to keep them soft.

2. Baggia

- Sift cassava, soybean and popped grain amaranth flour; this is done to incorporate air into the flour.
- Mix the three flours and salt very well in a large bowl, add together flour and onions. Adding a little bit of water at a time, mix the ingredients together to form a thick paste.
- Place the paste in a Baggia machine or perforated cup or grater machine holes.
- Exert pressure on the dough from the top so that it can go through the perforations into the hot oil for a few minutes.

Figure c: Cold extrusion of the Baggia paste with grater

- Deep fry until Baggia is light golden brown and with firm sound when touched with a spoon.
- Remove the ready baggia from oil using a perforated spoon(with holes) and place on a clean paper to absorb excess oil until they are cold and with no visible oil.
- Seal in a polythene paper to keep them crunchy as shown below.

Figure d: the sealed Baggia

3. Pancakes

- Make popped G.A Flour(follow instructions)
- Obtain cassava flour locally
- Mix the two flours in a ratio of 1:2 respectively(see ingredients' quantities for direction)
- Sift flour (cassava + popped G.A).
- Remove ¼ of the flour and keep aside for dusting the dough and the board
- Peel the bananas and place them in the remaining ¾ of the sifted flour.
- Mash the bananas and ground ginger into the ¾ of the flour.
- Once fully mashed, knead to make big round dough.
- Add 3 tablespoons (21mls) of oil when the dough is sticky.
- Dust the rolling stick and board (whenever necessary) with the flour that had been kept aside
- Roll out the dough and cut out into small round shapes as shown below.

Figure e: Cutting out of the pancake dough

- Place the cut out dough into hot oil in a frying pan.
- Deep fry until golden brown on both sides.
- Place on a clear paper to absorb oil.
- Place them in a polythene bag so that they remain soft.

4. G.A-Sesame balls

- Sort sesame to remove visible stones/dirt
- Wash the sesame twice in fresh clean water
- Allow it to settle so that the remaining stones settle at the bottom for easy separation

- Drain(remove the water from) the Sesame on a big sieve
- Roast the sesame over low fire(remember not to salt it) until it begins to pop giving off sweet aroma(it should be firm when pressed)
- Pour the roasted sesame in a large pan once it's ready
- Pop G.A. (***as in the instruction for chapatti)***
- Mix the two (roasted sesame and popped G.A grains) and place them in a dish.
- Melt sugar in a separate pan.
- Add the mixture (sesame+ G.A) to the melted sugar.
- Stir quickly and mould into tiny balls using your hands.
- Seal the balls in polythene (***as shown below***) or in a container with a tight fitting lid.

Figure f: the sealed sesame balls

5. G.A Soup

- Roast G.A at low fire until golden brown(see figure below) to acquire a nutty flavor

Figure g: The golden brown roasted/ toasted G.A grains

- Soak the roasted G.A in cold water of seven times its weight for one hour.
- To this mixture, add salt, ground ginger, chopped tomatoes and finely ground onion and mix with a wooden spoon.
- Boil uncovered for 5 minutes over high open fire.
- Cover the sauce pan with a tight fitting lid and place the contents over low fire on the charcoal stove (with ash on top of the charcoal) for 20 minutes.
- At this point, Most of the water has soaked and the amaranth grains are puffed up.
- Gently stir the mixture and remove the cover to allow some of the water to evaporate for 60 minutes.
- When the mixture is a little thick add the margarine and allow it to melt.

- Strain the contents through a sieve (to get a thick clear soup) into a clean dish ready for consumption.

6. Sesame-G.A instant porridge

- Sort sesame to remove visible stones/dirt
- Wash it twice in fresh clean water
- Allow it to settle so that the remaining stones settle at the bottom for easy separation
- Drain(remove the water from) the Sesame on a big sieve
- Roast the sesame over low fire(remember not to salt it) until it begins to pop giving off sweet aroma(it should be firm when pressed)
- Pour the roasted sesame in a large pan once it's ready
- Pop the amaranth
- Pour all the popped amaranth in the pan with the roasted sesame
- Add the sugar into this very pan
- Stir continuously at low heat
- Let the sugar melt but do not let it caramelize (turn brown). At this point the melted sugar will bind the sesame and G.A.
- Remove the contents from fire but continue to stir until they have cooled
- Transfer the contents into a motor and pound with a pestle until a powder is formed
- Sieve the powder to get a finer powder
- Seal in a polythene bag or a clean dry container with a tight fitting lid (***in order to make the instant porridge :)***
- Boil clean water and milk in a clean pan
- Put the flour into a clean container
- Add the boiling water/milk mixture while stirring
- Add sugar to taste if it's not enough

7. G.A-Rice porridge

- Mill the rice kernels to get flour
- Make Popped G.A flour (***as in the instruction for chapatti)***
- Mix the two flours (rice and popped G.A) in a ratio of 1:1 (250g ($^1/_4$kg) rice to 250g ($^1/_4$kg) of G.A)

  then in order to make the porridge
- Boil clean water in a clean saucepan
- Put the flour into a clean plastic container
- Add cold water to the flour and stir to make a light paste using a spoon
- Add the paste to the boiling water while stirring and boil for 15 minutes
- Add milk to a desired consistence and continue boiling for 10 minutes
- Add sugar to taste and serve in cups

8. G.A –Maize porridge

- Mill the maize grains to get flour
- Make Popped G.A flour (***as in the instruction for chapatti)***
- Mix the flours (G.A, Maize) in a ratio of 1:1 (250g ($^1/_4$kg) maize to 250g ($^1/_4$kg) of G.A)

  then in order to make the porridge
- Boil clean water in a clean saucepan
- Put the flour into a clean plastic container
- Add cold water to the flour and stir to make a light paste using a spoon
- Add the paste to the boiling water while stirring and boil for 15 minutes
- Add milk to a desired consistence and continue boiling for 10 minutes (optional)
- Add sugar to taste and serve in cups

9. G.A-Millet porridge

- Roast the millet for a short time
- Grind the millet to obtain flour
- Roast G.A until golden brown(***see figure for roasted grains in making the soup***)
- Make roasted/ toasted G.A flour by pounding in a motor and sieving to obtain a fine flour
- Mix the 2 flours (G.A& Millet) in a ratio of 1:1 (250g ($^1/_4$kg) millet to 250g ($^1/_4$kg) of G.A))

  then in order to make the porridge
- Boil clean water in a clean saucepan
- Put the flour into a clean plastic container
- Add cold water to the flour and stir to make a light paste using a spoon
- Add the paste to the boiling water while stirring and boil for 15 minutes
- Add milk to a desired consistence and continue boiling for 10 minutes (optional)
- Add sugar to taste and serve in cups

10. G.A Leaf powder-Peanut sauce

- Pick G.A leaves from the garden.
- Clean them thoroughly to remove dirt and worms.
- Wash them in running water.
- Place the clean leaves in a sauce pan with a tight fitting lid.
- Steam the leaves for 15- minutes.
- Remove the sauce pan from the fire but keep the lid on until the contents are cold.
- Remove the leaves from the sauce pan and dry them under direct sun shine on a clean drying stand.
- Cover with a transparent polythene to prevent contamination from flies.
- Continuously turn the leaves until all have dried and fragile.
- Place the leaves into a motor and pound them into powder using a pestle.

- Sieve the powder to get the finest powder.
- Seal in polythene or store in a dry container with a tight fitting lid.
- Roast the Peanut over low fire

Then in order to make the sauce

- Mix the G.A leaf powder with the pounded peanut in a ratio of 1:5(***see ingredients***)
- Add water and boil to form a thick stew while stirring for 30 minutes.
- Add salt to taste.
- Serve.

11. Convenient bean sauce

- Soak beans overnight
- Make popped G.A Flour (***as in the instruction for chapatti)***
- Remove testas from the beans and half them(divide each bean into two)
- Pour the beans in a saucepan and add water to a level just slightly above the beans
- Add salt, curry powder pilau Masala, ginger and onion to the beans, stir and put a lid
- Put the beans on fire
- Boil and continuously add water to maintain its level (*always make sure that the beans do not get mashed*)until beans are ready
- Remove the excess water, cool it and pour in the G.A flour to make dough
- Shape the dough in tiny little attractive pieces which can easily dry
- Sundry the beans and G.A pieces for 3-5 days until they are all dry as seen in the figure below

Figure h: The sundried beans-G.A Pieces

- Seal in polythene or container with tight fitting lid

Then in order to make the sauce:

- Soak the beans and G.A pieces overnight
- Boil for 20 minutes
- Add salt to taste
- Serve

12. Convenient rice-G.A meal

- Soak raw G.A grains in water for 2 hours
- Add half of the salt to the soaked G.A and boil until ready(***remember to keep stirring to prevent burning on)***
- Place rice in a clean saucepan
- Add the other half of salt, ground ginger and water to the rice
- Boil over low fire until its ready
- Mix the ready rice and G.A and spread on the tray
- Sundry until all is dry/ crispy
- Seal in polythene (***as shown below)*** or in a container with a tight fitting lid

Figure i: Sealed G.A-Rice instant meal

Then in order to cook the meal:

- Add clean water to slightly above the level of the rice-G.A mixture
- Boil the G.A-Rice mixture for 20 minutes
- Add salt to taste(if it's not enough for you)
- Serve

13. G.A-Cassava meal

- Make roasted G.A Flour (***follow instructions as in G.A Millet porridge above***)
- Obtain cassava flour locally
- Mix the two flours in a ratio of 1:1(*see ingredients*)
- Boil a liter of clean fresh water
- Fold in the flour: little at a time, until you reach a desired stiffness
- Mingle to make sure that all the flour is absorbed by the water
- Cover with a lid for about 5 minute so that it can cook then mingle again (repeat this step 3 times)
- Invert the saucepan onto a plate or a tray
- Keep the pan on until you are ready to eat

14. G.A-Cassava-Millet meal

- Make roasted G.A Flour (***follow instructions as in G.A Millet porridge above***)

- Obtain cassava flour locally
- Roast millet and grind to make flour
- Mix the three flours in a ratio of 1:1:2 respectively(*see ingredients*)
- Boil the measured clean fresh water
- Fold in the flour: little at a time, until you reach a desired stiffness
- Mingle to make sure that all the flour is absorbed by the water
- Cover with a lid for about 10 minutes so that it can cook then mingle again (repeat this step 3 times)
- Invert the saucepan onto a plate or a tray
- Keep the pan on until you are ready to eat

15. G.A-Ginger Masala

- Peel the ginger
- Wash to remove dirt
- Pound to fineness
- Mix the Popped G.A flour with the grounded ginger so that its fluid will form paste with the G.A
- Mould into tiny flat pieces that can easily dry
- Dry the pieces until they can easily break
- Pound in a motor to form powder
- Sieve to get the finest powder
- Seal in polythene as shown below, or pack it in a clean dry container with a tight fitting lid

Figure j: the sealed G.A-Ginger Masala

Serving instructions

- Put 1 tea spoon of the powder
- Add tea leaves and sugar (your usual measure)
- Add hot water and stir
- Take while it's hot

16. G.A-Sesame-Groundnuts Paste

- Sort sesame and groundnuts to remove visible stones/dirt
- Wash the sesame twice in fresh clean water
- Allow it to settle so that the remaining stones settle at the bottom for easy separation
- Drain(remove the water from) the Sesame on a big sieve

- Roast the sesame over low fire(remember not to salt it) until it begins to pop giving off sweet aroma(it should be firm when pressed)
- Pour the roasted sesame in a large pan once it's ready
- Pop the amaranth and pound it to make flour(follow instruction above)
- Roast the sorted ground nuts over low fire
- Mix sesame, Groundnuts and popped G.A flour in a ratio of 4:2:1 respectively
- Pound continuously until you make a paste as shown below

Figure k: the ground paste

- Seal in polythene or a container (***like the one in the figure***) with a tight fitting lid

17. G.A-Peanut-Bean snack

- Soak beans overnight
- Roast groundnuts with salt over low heat until crispy
- Make popped G.A Flour (*follow instructions above*)
- Remove testas from the beans and half them
- Pour the beans in a saucepan and add water to a level just slightly above the beans
- Add salt, curry powder pilau Masala, ginger and onion to the beans, stir and put a lid
- Put the beans on fire
- Boil and continuously add water to maintain its level (always make sure that the beans do not get mashed)until beans are ready
- Remove the excess water, cool it and pour in the G.A flour to make dough
- Shape the dough in tiny little attractive pieces which can easily dry
- Sundry the beans and G.A pieces for 1 hour under very hot sun
- Deep fry the beans and G.A Pieces separately until they are crispy
- Add together the 3 commodities and mix them uniformly.
- Seal in polythene or container with tight fitting lid

APPENDIX 5: Questionnaire for the Farmer Group Interviews

DATE ……/……/……

DISTRICT …….. PARISH …….
NAME OF FARMER GROUP ……

	PRODUCTS	**QN 1.**	**QN 2.**	**QN 3.**	**Any other Comments from group members**
		What do you like about this recipe?	How would you rate this **recipe** in terms of acceptability?	How would you rate the **product** in terms of acceptability?	
1	**Chapatti**	☐☐☐	☐	☐	
2	**Baggia**	☐☐☐	☐	☐	
3	**Pancakes**	☐☐☐	☐	☐	
4	**Balls**	☐☐☐	☐	☐	
5	**Soup**	☐☐☐	☐	☐	
6	**sesame Instant porridge**	☐☐☐	☐	☐	
7	**Rice-GA Porridge**	☐☐☐	☐	☐	
8	**Maize-GA Porridge**	☐☐☐	☐	☐	
9	**Millet-GA Porridge**	☐☐☐	☐	☐	

10	**G.A-Peanut sauce**	☐☐☐	☐	☐	
11	**Convenient Bean sauce**	☐☐☐	☐	☐	
12	**Instant rice-G.A Meal**	☐☐☐	☐	☐	
13	**Cassava meal**	☐☐☐	☐	☐	
14	**Millet-cassava-G.A Meal**	☐☐☐	☐	☐	
15	**Ginger-G.A Masala**	☐☐☐	☐	☐	
16	**Paste**	☐☐☐	☐	☐	
17	**Bean-peanut-G.A Snack**	☐☐☐	☐	☐	

Key: To be used by the interviewer. (*The interviewer will clearly explain this table and take control of the group interview so that the views of the interviewees are within answers in the table below*.)

	1	**2**	**3**	**4**	**5**
QN 1.	Ingredients are easily available	It is a simple way of making this product (ease of processing)	It is **not** time consuming	None of these	
QN 2.	Extremely unacceptable	Moderately unacceptable	Neither acceptable nor unacceptable	Moderately acceptable	Extremely acceptable
QN 3.	Extremely unacceptable	Moderately unacceptable	Neither acceptable nor unacceptable	Moderately acceptable	Extremely acceptable

Appendix 6: The 21 farmer groups that participated in the Recipe trials and evaluation

KAMULI	NAKASONGOLA	APAC
Baligema kumunwa F.G	Kyabutaika F.G	Kong apor F.G
Tugezeku women F.G	Atakulaba F.G	Nya amii F.G
Bakuseka majja	Kiralamba integrated F.G	Wan opat F.G
Tibikoma F.G	Tusubira women's F.G	Ocan oyere F.G
Kamukamu F.G	Bakuseka majja F.G	Atana women's F.G
Babigumira F.G	Twekembe F.G	Odongi cen F.G
Bakyala kwelandiza F.G	Okola baseke F.G	Can opwonya F.G

F.G=Farmer Group

Appendix 7: Main ingredients used in the theoretical recipe formulation

CODE	MAIN INGREDIENTS OF PRODUCTS	Wt (g)	**Energy (Kcals)**	**Protein (g)**	**Total lipid (fat) (g)**	**Ca(mg)**	**Fe(mg)**	**Zn(mg)**
A	Beans, yellow, mature seeds, cooked, boiled, with salt	100	144	9.16	1.08	62	2.48	1.06
B	Peanuts, all types, dry-roasted, without salt	100	585	23.68	49.66	54	2.26	3.31
C	Seeds, sesame butter, tahini, from roasted and toasted kernels (most common type)	100	565	16.96	48	989	14.76	7.16
D	Millet flour	100	373	10.75	4.25	14	3.94	2.63
E	Corn flour, whole-grain, white	100	361	6.93	3.86	7	2.38	1.73
F	Cassava, raw	100	160	1.36	0.28	16	0.27	0.34
G	Rice flour, white	100	366	5.95	1.42	10	0.35	0.8
H	Grain amaranths	100	371	13.56	7.02	159	7.61	2.87
I	Soy flour, full-fat, roasted	100	441	34.8	21.86	188	5.82	3.58
J	Wheat flour, white, all-purpose, unenriched	100	364	10.33	0.98	15	1.17	0.7
k	ginger	100	335	8.98	4.24	114	19.8	3.64
L	Sugar	100	387	0	0	1	0.05	0.01
m	blue band	100	604	0.2	70	0	0	0

Source: USDA Nutrient Data Base

Appendix: 8 Age group Vs Nutrient requirement

Age group	Nutrient Requirement					
	Calcium(mg)	**iron(mg)**	**Zinc(mg)**	**Protein(g)**	**Energy(Kcals)**	**Fat(g)**
Infants(7-12)	270	11	3	11	999	30
Children (1-3 years)	500	7	5	13	1404	ND
children (4-8 years)	800	10	8	19	1789	65
9-13 years	1300	8	11	34	2265	65
14-18 years(Male)	1300	11	9	52	2840	65
14-18 years(Female)	1300	15	11	46	2000	65
19-30years(Male)	1000	8	8	56	2818	65
19-30years(Female)	1000	18	8	46	2000	65
31-50 years(Male)	1000	8	11	56	2554	65
31-50 years(Female)	1000	18	8	46	2000	65
51-70 years(female)	1200	8	8	46	2000	65
Pregnant(≤18 years)	1300	27	13	71	2500	65
Pregnant(18-50 years)	1000	27	11	71	2500	65
lactating (≤18 years)	1300	10	14	71	2700	65
Lactating (18-50 years)	1000	9	12	71	2700	65

Source: 1999 - 2002 Dietary Reference Intakes, Institutes of Medicine 2005 Dietary Guidelines
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