EFFICACY OF SORGHUM PEANUT BLEND IN THE TREATMENT OF MODERATE ACUTE MALNUTRITION IN CHILDREN AGED 6 - 59 MONTHS IN KARAMOJA SUB-REGION, UGANDA

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A RESEARCH THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOHPY IN FOOD, NUTRITION AND DIETETICS IN THE SCHOOL OF APPLIED HUMAN SCIENCES OF KENYATTA UNIVERSITY

APRIL 2015

DECLARATION

This thesis is my original work and has not been presented for a degree in any other university or any other award.

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DEDICATION

This thesis is dedicated to my wife Lillian Amegovu, daughter Barbara Tabea Amegovu and sons Brian AnzoAmegovu, Peter Amegovu and Paul for the patience, prayers and encouragement they provided.

ACKNOWLEDGEMENT

I want to deeply acknowledge the power of the Almighty God for having given me good health, knowledge and wisdom to carry out this research and all the successes in my education career. To my supervisors Dr. Sophie Ochola and Dr. Patrick Ogwok, I am forever grateful for the guidance and advice you tirelessly provided. I am grateful to the data analysts, Raymond Musyoka, Irumba Joseph, Stewart Kiwanuka, and Paul Mbaka for their statistical input.My sincere thanks also goes to World Food Program Uganda, Nakapiripirit Sub-office for their support especially in ensuring the availability of corn soya blend (CSB) for this study; and to Andre Food Consult for playing a great role in the coordination of the study. Many thanks to the District Health Officer Dr. Anguzu John of Nakapiripirit district for having allowed the study to be conducted at the health centres of Namalu and Kakamangole. My gratitude also goes to the research team: Emma Mutenyo, Peter Yiga, Juliana Mandha, Diane Achanda and Robert Vudiga for the services they rendered in ensuring successful completion of the study. I am also indebted to the mothers of those children for their mutual consent and participation in this study and the village health team volunteers (VHTs) and the health centre focal persons for their respective roles during the study.

Lastly, thanks to the Uganda National Council of Science and Technology (UNCST) for the approval of research proposal, without which the study would have not been possible.

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ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
CSB+	Corn Soy Blend plus
DHO	Director of Health Services
FAO	Food and Agriculture Organization
FBFs	Fortified blended foods
FGD	Focus Group Discussion
MAM	Moderate Acute Malnutrition
MOH	Ministry of Health
MUAC	Mid Upper Arm Circumference
NGO	Non-governmental organizations
RTUFs	Ready- to- use foods
SFP	Supplementary Feeding Programme
SPB	Sorghum Peanut Blend with Honey and Ghee
UNICEF	United Nations Children Emergency Fund
WFP	World Food Program
WHO	World Health Organization
W/A	Weight for age
W/H	Weight for height

OPERATIONAL DEFINITION OF TERMS

Acceptability is the measure of the extent to which participants or caregivers of selected children liked the use, appearance and taste of the food product.

Effectiveness is a measure of the extent to which a programme or intervention achieves its objectives in programme (rather than controlled) setting.

Efficacy is a measure of the extent to which a programme or intervention achieves its objectives in programme in scientifically controlled settings. For the purpose of this study it refers to the potential of locally developed food supplement, Sorghum Peanut Blend with Honey and Ghee (SPB) to yield acceptable level of recovery in treating moderate acute malnutrition (Sphere Standards, 2004) in comparison to standard corn soya blend plus (CSB+).

Moderate Acute **Malnutrition (MAM)** refers to children aged 6 to 59 months whose MUAC was between 115mm-125 mm. It was also defined by weight-for-height between -3 and -2 Z score of the WHO child growth standard.

Standard CSB+ was the comparator, approved by the United States Drug administration (USDA) as authentic therapeutic food and is currently being used in Karamoja, Northern Uganda to treat moderate malnutrition.

ABSTRACT

Moderate acute malnutrition (MAM) is estimated to affect 11% of children worldwide. In Sub-Saharan Africa, 239 million people are malnourished with 48 million of these being children. Karamoja region has the highest cases of acute malnutrition in Uganda. Corn Soya Blend Plus (CSB+) is the traditional treatment for moderate acute malnutrition (MAM) in children 6-59 months. CSB+ was introduced as a substitute for CSB but does not provide a sustainable treatment for moderate acute malnutrition (MAM) due to unavailability to local communities and its high cost. Despite the availability of local foods to constitute dietary supplements for children that are relatively cheaper than CSB+ and with greater potential to provide a more sustainable solution to treat MAM, they are not widely promoted. There is need therefore to formulate food supplements from locally grown foods and to test their efficacy in treating MAM among children 6-59 months of age. The study was conducted in Karamoja region, Northern Eastern Uganda. The study was conducted in two phases: phase I involved formulating a test food supplement from sorghum and peanut, mixed with honey and ghee (SPB) along with assessing its nutritional and anti- nutrient profile. Phase II comprised the intervention, in which the acceptability and efficacy of SPB versus CSB+ in treating MAM was tested. The sample size for efficacy study was 440 children, 220 for each study arms; SPB and CSB+. A randomised single-blind parallel cluster trial was conducted in which two health centres were assigned on a 1:1 ratio by computer to the two study groups. Each child received a daily ration of 269g of either SPB or CSB+ for a maximum period of 3 months. Anthropometric measurements were taken on a bi-weekly basis. The primary outcomes were the recovery rate and the mean length of stay in the programme before full recovery. Data was analysed using (SPSS version 17). Levels of macronutrients, CSB+ had significantly higher amounts of protein and carbohydrates whereas SPB had significantly higher amounts of fat and crude fibre. There was no significant difference in terms of energy content in SPB and CSB+. Proximate components, beta-carotene, iron, zinc, calcium, magnesium, phosphorus, potassium, manganese and sodium amounts were available in adequate amounts in both products. Vitamin A level was higher in CSB+ than SPB. Levels of anti- nutrients; condensed tannin, phytates, and trypsin inhibitors were significantly higher in SPB but were in amounts lower than the acceptable limits. Aflatoxins were also below the 20ppb upper limits by FDA. The two food supplements were acceptable to the study participants in terms of all the sensory attributes. The recovery rates were not significantly different (91.4%) in the SPB and 87.1% in the CSB+ group (Chi-square test; P=0.193). Duration of recovery was significantly shorter for CSB+ group; median 43 days compared to 57 days in the SPB (Kaplan-Meir Survival test). The recovery rate and the duration of stay in the programme for those children fed on CSB+ and those on SPB were all within the acceptable Sphere Standards 2004 (≥75% and ≤90 days) respectively. The cost of SPB was much lower than the CSB+ if transportation costs are considered. SPB has the potential to become a cost-effective, sustainable locally-available home-based food supplement for treatment of MAM in the study community and other similar circumstances.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

More than one third of all child deaths are attributed to under-nutrition worldwide. Malnutrition continues to be the world's most serious health problem. It is the biggest contributor to child mortality with 3.1 million child deaths per year. Children weakened by all forms of malnutrition often die from diseases which are both preventable and easy-to-treat such as diarrhoea and pneumonia. Malnutrition also reduces human capital through compromised cognitive development and physical health, which in turn reduces economic growth and development at a community and national level (WHO 2013).

Globally, approximately 33 million children under five years of age are affected by moderate acute malnutrition (MAM), defined as a weight-for-height in z-score (WHZ) between -2 and -3, and at least 19 million children under five by severe acute malnutrition (SAM), defined as a WHZ in z-score <-3 . For children with SAM, the risk of death is approximately 10-fold higher compared to children with a z-score ≥ – 1. Based on an analysis by UNICEF, WHO and the World Bank, 32 out of the 134 countries for which there was data on prevalence of acute malnutrition (WHZ <-2) had a prevalence of 10% or more – a threshold that represents a "public health emergency" requiring immediate intervention.

Moderate acute malnutrition (Weight-for-Height < -2 to ≥ -3 in z-scores) is highly prevalent in low-income countries (Black et al., 2008; FAO, 2010). South Asia and Sub-

Saharan Africa (SSA) is the most hit region in the world. In Sub-Saharan Africa it's estimated that239 million people are being malnourished with 48 million being children under the age of five years (Black et al., 2008). A child suffering from acute malnutrition has low immunity and is likely to die from common childhood ailments. Acute malnutrition causes low appetite, mal-absorption of nutrients and increased nutritional requirement in children (Golden, 2009). It is estimated that 3.5 million children under the age of five years die annually from acute malnutrition and other childhood related illnesses (Black et al., 2008; WHO, 2007). Acute malnutrition alone (severe and moderate combined) accounts for 11% of the disease burden and mortality among children below five years of age. Generally, a malnourished child experiences slow physical and cognitive development and stands a greater risk of morbidity and death than their normal counterparts (Black et al., 2008).

In Uganda, malnutrition is still highly prevalent with over 2 million children below the age of five years estimated to be under weight (Acham, Kikafunda, Tylleskar, & Malde, 2012). It is reported that up to 60% of child mortality in Uganda is directly linked to malnutrition. According to Uganda Demographic and Health Survey(UDHS, 2011), 33% of children in Uganda are chronically undernourished, 5% are acutely undernourished or wasted and 14% have low weight for their age (underweight). North Eastern Uganda in particular Karamoja sub-region is the most affected with stunting standing at 45%, wasting at 7.1% and underweight at 31.9%.

All children with moderate wasting, or with moderate or severe stunting, have in common a higher risk of dying and the need for special nutritional support. In contrast to children suffering from life-threatening severe acute malnutrition, there is no need to feed these children with highly fortified therapeutic foods designed to replace the family diet. Their dietary management should be based on improving the existing diets by nutritional counselling and if needed, by the provision of adapted food supplements providing nutrients that cannot be easily provided by local foods. Children with growth faltering would also benefit from the same approach. Dietary management of children suffering from acute malnutrition results in recovery which reduces the risk of morbidity (Ramdath & Golden, 1989). Fortified blended flours (FBFs), mainly corn-soy blend (CSB) and of recent CSB+ mixed with sugar and vegetable oil are the most common food supplements used for treating moderate acute malnutrition (MAM) especially in humanitarian emergencies(de Pee & Bloem, 2009; Marchione, 2002). The supplementary product CSB+ is fortified with vitamin A and iron. It is supplied to a targeted number of beneficiaries as a dry ration consumed in porridge form. These food supplements (CSB old form and CSB+ new form) are effective in treating MAM but are a short term rather than a sustainable intervention for management of re-current malnutrition in poverty stricken countries because of their high cost (de Pee & Bloem, 2009). A study by Chang et al., (2013) showed that children who recovered from MAM still remain at risk of malnutrition and death in the subsequent year after recovery.

Formulations using local food materials have been proposed as a means of averting nutrient deficiency among young children in developing countries (Ashworth & Ferguson, 2009). At the household level, optimal utilization of locally accessible nutrient-dense foods has been demonstrated to be effective in dietary management of MAM. Local food materials are of low cost and yet provide essential nutrients required for successful recovery of children with MAM. A food product designed from local food materials would therefore be appropriate to address sustainability gaps.

1.2Problem statement

Karamoja region located in North Eastern Uganda is a semi-arid region with only one agricultural season usually a short rainy season, April to August. The single harvest is predominantly of sorghum which is the main staple food of the Karamajongs. The unpredictable rainfall pattern often results in crop failures and sometimes death of livestock (FAO, 2010). The effect of the prolonged droughts on the livestock and crop is evidenced by household food insecurity and constant high global acute malnutrition (GAM) levels of above 15% for the past five years. Since independence in 1962, the region has been depending on relief aid from the World Food Programme to avert human suffering from hunger resulting from cyclic drought.

According to (UDHS, 2011), stunting rate in Karamoja stands at 45%, wasting at 7.1% and underweight at 31.9%. Among the under-fives' who suffer from acute malnutrition, MAM accounts the highest proportion. Currently, moderately malnourished children in Karamoja region are treated with corn soy blend plus (CSB+) premix with sugar and oil provided by the World Food Program (WFP) as opposed to traditional CSB.

In 2008, the World Health Organization (WHO) expert consultation on moderate acute malnutrition (MAM) recognized that the traditional CSB is not the most appropriate food supplement to treat moderate malnutrition in children because it does not contain all the required nutrients in adequate amounts. It contains relatively large amounts of anti-nutrients which inhibit the absorption of proteins, vitamins and minerals. In addition CSB does not provide enough energy per serving and has too much fibre and its essential amino acid content is low (WHO, 2008). This inadequate nutrient level of CSB to treat moderate acute malnutrition has initiated a search for a better alternative treatment such as addition of milk powders to CSB to improve its nutrient bioavailability, now known as CSB+ (Brinkman, de Pee, Sanogo, Subran, & Bloem, 2010). Other studies have also pointed out additional challenges that include infrequent food distribution due to break down in pipeline, long transport routes and fluctuating cure rates between 25%-95%. Others challenges includes unfamiliarity of the CSB+ to the consumers, short shelf life due to the addition of oil in the mix, lack of knowledge of appropriate storage conditions, high transportation cost, sustainability challenges among others. It is also important to note that the foreign nature of the CSB+ makes its formulation a challenge to local communities and poses a sustainability question whenever food aid is discontinued.

Most studies have focused on the improvement of standard food supplements such as CSB and current CSB+ and not on development of local alternative food supplements. The potential of food supplements from locally available foods in Karamoja such as sorghum, peanut, honey and cow's ghee, could be cheaper in terms of production, sustainability and familiarity to beneficiaries compared to the current CSB+. In view of the apparent supply related bottlenecks, sustainability question, and lack of formula knowledge by local communities, there is need to examine the viability of an appropriate alternative food supplement to local communities. Furthermore, studies addressing the nutritional appropriateness and economic viability of local food supplements are limited. The lack of rigorous and systematic tests of the nutritional efficacy of locally blended food supplements to treat moderate acute malnutrition therefore constitutes a gap this study proposes to address. Consequently, this study is aimed at developing a food supplement based on locally available materials and testing of developed food supplement to treat moderate acute malnutrition (MAM) in under-fives compared with CSB+.

1.3 Purpose of the study

The purpose of the study was to develop a supplementary food product based on sorghum, peanut mixed with cow ghee and honey and comparing of the developed product with that of corn soy blend mixed with sugar and vegetable oil (CSB+) in treating moderate acute malnutrition in children aged 6-59 months in Karamoja, Uganda.

1.4 Specific objectives

The specific objectives of the study were:

1. To develop a food supplement from sorghum peanut blend mixed with honey and Ghee (SPB)for treating MAM in children aged 6–59months using locally available food varieties in Karamoja;
2. To determine the nutrient and anti-nutrient profile of SPBand that of CSB+;
3. To determine the acceptability of SPB compared with that of CSB+ among moderately malnourished children and caregivers in Karamoja;
4. To compare the efficacy of SPB to CSB+ in treating MAM in children 6-59months of age in Karamoja; and
5. To compare the costs of the SPB and CSB+

1.5 Hypotheses

$H_0$1: There is no significant difference in the levels of nutrients and anti-nutrients in SPB and CSB+.

$H_0$2: There is no significant difference in acceptability of SPB and CSB+ to MAM children and caregivers.

$H_0$3: There is no significant difference in efficacy of SPB and CSB+ in treating MAM in children aged 6-59 months of age in Karamoja, Uganda.

$H_0$4: There is no significant difference in the costs of the food supplements SPB and CSB+.

1.6 Significance of the study

This study will contribute to - and - add onto the existing information which will be of great importance to the government (ministry of health) and humanitarian agencies like UNWFP,UNICEF, WHO and NGOs in decision making regarding Scaling up of Nutrition (SUN) interventions using home grown supplements formulated using locally available food varieties. These findings contribute knowledge to the on-going research efforts to identify and develop cheaper and appropriate food supplement to treat moderate acute malnutrition.

1.7 Study limitations

The limitations of the study were:

- At baseline children in the CSB+ group were significantly more undernourished than those in SPB in terms of wasting and underweight though they were all moderately malnourished. This however did not impact on cure rate because in multivariate analysis baseline nutrition status of the children did not predict the recovery rate of the children.

- Sharing of the product was not investigated; however a protection ration was given to minimize this practice.
- This study did not investigate the compliance to the product by children apart from self- reports by mothers/caregivers which indicated that children liked both products.
- The shelf-life of SPB was not studied due to financial constraints and also because the amount of ratio given at a time was supposed to last only 2 weeks and therefore there was less likelihood of product becoming contaminated. Besides, honey used in the formulation is a preservative.

1.8 Assumptions

There was minimal or negligible intra household sharing of food supplement since each study group was given a protection ration to cater for any sharing. Additionally, it was assumed that the beneficiaries would be rehabilitated from MAM within the 90 days as recommended by Sphere Standard (Sphere, 2004).

1.9 Conceptual framework of causes of malnutrition and flow-chart for management of acute malnutrition in children

1.9.1 Conceptual framework of causes of malnutrition

The UNICEF conceptual framework, developed in the 1990s shown below summarizes the causes of malnutrition.

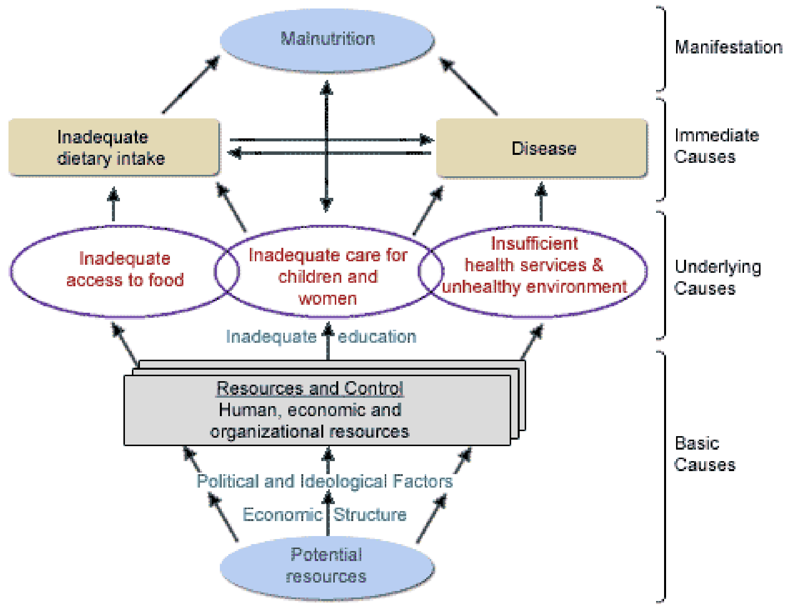

Figure 1.9.1 Conceptual framework of malnutrition (UNICEF, 1990)

This conceptual framework on the causes of malnutrition was developed in 1990 as part of the UNICEF nutrition strategy. The framework shows that causes of malnutrition are multi-sectoral, embracing food, health and caring practices. They are also classified as immediate, underlying, and basic, whereby factors at one level influence other levels. The framework is used at national, district and local levels, to help plan effective actions to improve nutrition. It serves as a guide in assessing and analysing the causes of the nutrition problem and helps in identifying the most appropriate mixture of actions.

According to this framework, developed by UNICEF, malnutrition occurs when dietary intake is inadequate and health is unsatisfactory, being the two immediate causes of malnutrition. In developing countries, infectious diseases, such as diarrhoeal diseases (DD) and acute respiratory diseases (ARI) are responsible for most nutrition-related health problems. Readily available food, appropriate health systems and a "healthy" environment are ineffective unless these resources are used effectively. As a result, the absence of proper care in households and communities is the third necessary element of the underlying causes of malnutrition.

Finally, this conceptual framework recognizes that human and environmental resources, economic systems and political and ideological factors are basic causes that contribute to malnutrition. This model relates the causal factors for under-nutrition with different social-organizational levels. The immediate causes affect individuals, the underlying causes relate to families, and the basic causes are related to the community and the nation.

The Food security and the malnutrition conceptual frameworks, which are the most commonly, used frameworks in this field, show significant differences. The food security framework emphasises an economic approach in which food as a commodity is a central focus. The malnutrition framework adopts a biological approach in which the human being is the starting point. However, both frameworks have in common the promotion of an inter-disciplinary approach to ensuring food and nutrition security.

1.9.2 Flow-chart for management of acute malnutrition in children

The recruitment of the study groups for the study was based on the Mid Upper Arm Circumference (MUAC) which has been widely recognized as an acceptable criterion for admission of children aged 6–59 months on to selective feeding programmes in management of acute malnutrition globally.

Supplementary foods for treating moderate acute malnutrition (MAM) must be energy dense and rich in micro-nutrients, culturally acceptable, easily digestible and palatable (tasty). Fortified blended foods such as CSB+, Unimix or Famix are normally used in treatment of MAM. In situations where cooking may not be feasible, ready to eat foods or locally made snacks can be substituted.

On-site wet feeding should provide from 500-700kcals (but 700 kcals are recommended to account for sharing with siblings). Dry take home rations, which are the most preferred, should provide from 1000 to 1200 Kcal per person per day and 35-45 grams of protein in order to account for sharing at home among children or adults in the household. Dry take home food supplements are normally provided in form of a premix to minimize mis-use and maximise benefits to the malnourished children(WHO, 2008).

Although CSB+ premix has been used to treat moderate acute malnutrition for decades it has been found to have a substantial amounts of anti-nutrients, unsustainable, with frequent pipe line breaks and high costs. There is therefore need to find an affordable, sustainable and suitable food supplement, easy to formulate at household level to manage MAM in drought stricken and chronically food insecure Karamoja region and other pastoral areas in East and Central Africa. SPB is a food supplement formulated from locally available food materials and has adequate amounts of energy required for treatment of moderate acute malnutrition in children 6-59months old, besides, it is easy to formulate and affordable to the households (Amegovu et al., 2013).The flow chart for management of acute malnutrition used in this study was adapted from (MSF, 1995).

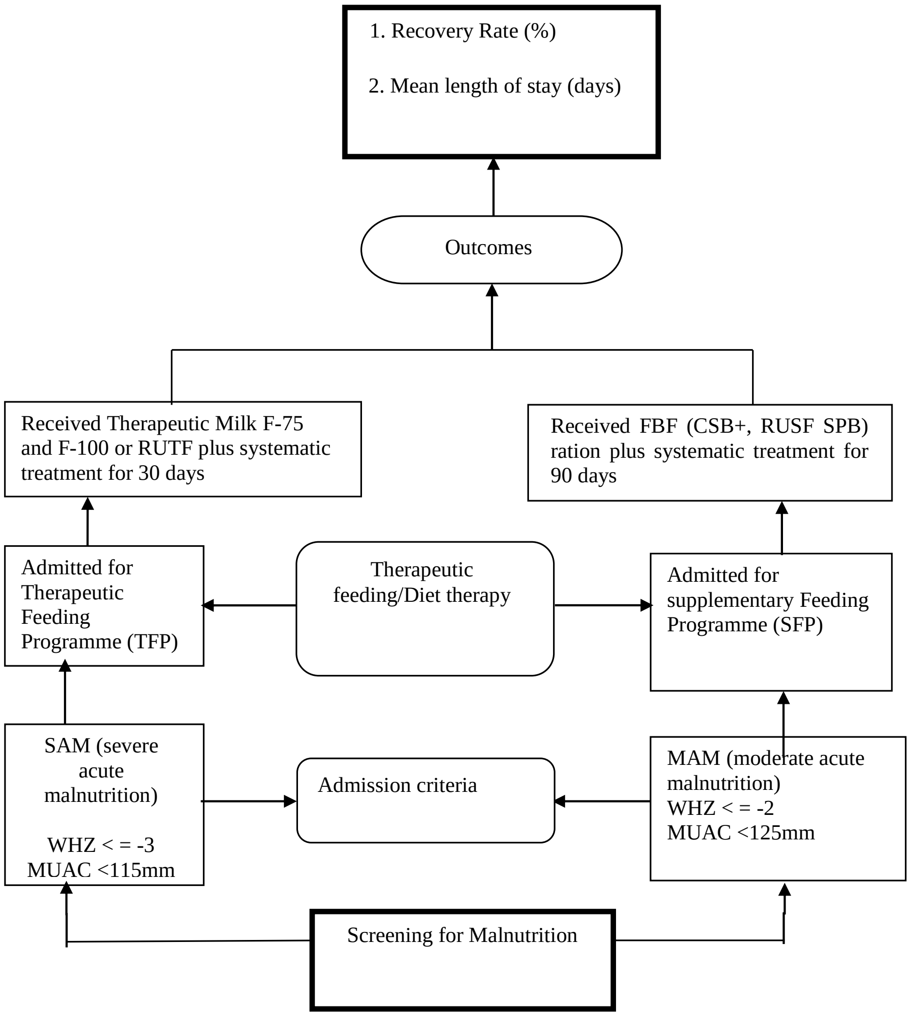

Figure 1.9.2 Conceptual Framework on management of Malnutrition. Adapted from MSF, 1995

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The term nutritional status has been identified as a measurement of how well the nutrients in one's diet meet the physiologic needs of the body (De Onis, Monteiro, Akré, & Clugston, 1993; UNICEF, 2009). Body measurements regularly used in field surveys include height, weight, mid-upper arm circumference, and measurements of skin folds. These measurements, together with the child's age and sex, are compared against a population reference or standard in order to create anthropometric indices that may reflect chronic or acute undernourishment (De Onis & Organization, 2006).

The term malnutrition according to (Benson & Shekar, 2006; Block, Masters, & Bhagowalia, 2010; Smith & Haddad, 2000; Victora et al., 2008) is a broad term for a range of conditions that hinder good health, caused by inadequate or unbalanced food intake or from poor absorption of food consumed. It refers to both under-nutrition (food deprivation) and over-nutrition (excessive food intake in relation to energy requirement). To understand the nutritional status of children or under-nutrition, measurements of body dimensions are commonly viewed as a gold standard measure of nutritional status and as they have been strongly linked to mortality outcomes (Pelletier, Frongillo Jr, Schroeder, & Habicht, 1995) as well as morbidity, cognitive development. In 2011, child malnutrition contributed to more than half of all deaths in children worldwide and 54% of children's deaths in developing countries (WFP, 2000; WHO & UNICEF, 2010).

Wasting and stunting are very different forms of malnutrition. Stunting is chronic and its causative factors are poorly understood. Stunting does not pose an immediate threat to life and is relatively common in many populations in less-developed countries. On the other hand, wasting results from an acute shortage of food, is reversible with interventions, and has a relatively high mortality rate. For these reasons, wasting is the highest priority form of malnutrition in humanitarian emergencies (WHO, UNICEF, & WFP, 2000).

2.2 Malnutrition in sub – Saharan Africa: burden, causes and consequences

According to the FAO hunger indicator, it is estimated that between 2010 and 2012, 870 million people (about 12.5% of global population) were undernourished. Majority of them from developing countries with 234 million being in sub-Saharan Africa [SSA](FAO, WFP, & IFAD, 2012). In sub-Saharan Africa (SSA) malnutrition accounts for over 4 million death in children < 5 years of age and about 67 million are estimated to be wasted (UNICEF, 2009). The increase in malnutrition causes has been linked to poverty, illiteracy, ignorance, big family size, climate change among other causes. Protein Energy Malnutrition (PEM) is associated with a number of co-morbidities such as lower; respiratory tract infections including tuberculosis, diarrhoea diseases, malaria and anaemia. These co-morbidities may prolong the duration of hospital stay and increased mortality among affected children (Bhutta et al., 2008; WHO & UNICEF, 2010).

2.3Malnutrition in Uganda and Karamoja

According to the Uganda Demographic Health Survey (UDHS) of 2011, North Eastern Uganda presents the highest cases/burden of malnutrition in the country. The nutritional status of children under five years of age in the Karamoja region is of serious concern as it has the highest estimate of stunting at 45%, underweight 31.7% while wasting is at 7.1% in the country (UDHS, 2011). The global acute malnutrition (GAM) and severe acute malnutrition (SAM) rates in children under five were 12.8 % and 2.8 % respectively and moderate acute malnutrition (MAM) was 10 % in half of the districts in the region. Analysis of the related nutrition and health indicators show high rates of disease burden among children 6-59 months of age. In terms of adequate feeding practices among the infants and young child, the coverage of exclusive breastfeeding, for example, is low as less than 30% of children are exclusively breastfed up to the age of 6 months. Complementary feeding practices are largely inadequate in terms of dietary diversity.

Malnutrition in Karamoja is largely due to insecurity, and constrained livelihood opportunities (Gray, 2012; Gray, Akol, & Sundal, 2009). Insecurity leads to displacement of people and disruptions of people’s livelihood activities and hence affecting food security and consequently normal feeding practices and child health care practices. High levels of malnutrition are also exacerbated by long dry spells that affects food production and forage for livestock (Sadler et al., 2012). Reduced rainfall results in reduced harvests and consequently recurrent famine in the region. Studies have shown high malnutrition rates during the hunger period of March to July depending on the harvests recorded the preceding year (Sadler et al., 2012).

When food insecurity is high, households diet may change from expensive- and nutrient- rich food- to calorie- rich and energy-dense foods (Barrett, 2010) which compromises the nutrient requirement of the body. In times of food scarcity, most households in Karamoja resort to detrimental coping strategies such as brewing. The adults consume the local brew called ***'ebutia'*** (made from sorghum) as their main meal while young children are given porridge made from beer residue locally called ***'adakai'*** as a complete meal whose nutritive value is low (Dancause, 2010).

2.4 Interventions to treat moderate acute malnutrition (MAM)

According to (WHO, 2003) MAM is defined as weight-for-height Z-score (WHZ) between -2 and -3 standard deviations (SD), weight-for-height (WFH) 70-80% of the National Centre for Health Statistics (NCHS) or WHO Child Growth Standards (2006) reference median or mid-upper arm circumference (MUAC) of 115-125mm. Acute malnutrition is associated with an increased risk of morbidity and mortality for the affected individuals. Therefore, when the prevalence of MAM is high, it is necessary to ensure access to services to correct and prevent under nutrition (Sphere Project, 2004).

Moderate acute malnutrition can be treated in a number of ways. In disaster situations, supplementary feeding is often the primary strategy for prevention and treatment of moderate acute malnutrition and prevention of severe acute malnutrition. Typically, moderately wasted children are treated with corn/soy blended flour (CSB) through targeted supplementary feeding programs. CSB is an expensive combination of a cereal and a legume fortified with micronutrients. A supply of CSB provides; 50% of a child's daily energy requirement (Matilsky *et al*, 2009). There is limited evidence, however, to suggest that CSB is an effective choice for wasted children (Matilsky *et al*, 2009). Although CSB is familiar and acceptable in the community, the inconsistency in outcomes in the treatment for moderate wasting raises questions about its effectiveness (Matilsky *et al*, 2009).

Since the early 2000s, the products used to deliver nutrients for management of SAM and MAM and the approaches used to target and deliver these products have been evolving rapidly. Innovations include new formulations and packaging and a shift from institutional to community-based management. Specially formulated foods are the cornerstone of treatment programs and include fortified blended foods (e.g. corn-soy blend (CSB, CSB+, CSB++) as well as ready-to-use-foods (RUFTs). RUFTs are nutrient-dense products that are formulated as lipid pastes, bars or biscuits that provide specified amounts high quality of protein, energy and micronutrients, depending on the target population (Greiner, 2010).

Typically, moderately wasted children are treated with corn/soy blended flour (CSB) through targeted supplementary feeding programs. CSB is an expensive combination of a cereal and a legume fortified with micronutrients. A supply of CSB provides; 50% of a child's daily energy requirement (Matilsky *et al*, 2009). There is limited evidence, however, to suggest that CSB is an effective choice for wasted children (Matilsky *et al*, 2009). Although CSB is familiar and acceptable in the community, the inconsistency in outcomes in the treatment for moderate wasting raises questions about its effectiveness (Matilsky *et al*, 2009).

Although widely used, there is little information concerning the efficacy of corn-soy blend (CSB) supplementation in treatment of moderate underweight African children (Thakwalakwa *et al.*, 2010). Traditionally, fortified blended foods such as corn-soy blend (and wheat-soy blend) are given to moderately malnourished children as a dry take-home supplement in the context of supplementary feeding programmes (SFPs). The effectiveness of SFPs has been questioned in both non-emergency and emergency settings (Owino, 2010). This is not only due to sub-standard monitoring methods used in such circumstances, but also the poor quality of corn soy blend/wheat soy blend (Owino, 2010). Recovery rates from MAM with the use of CSB remain at approximately 75%, a percentage that is lower than the rate achieved with peanut-based ready to use supplementary foods (RUSFs). There is increasing evidence that CSB cannot deliver the needs of vulnerable groups (infants, pregnant/lactating women) (Owino, 2010). CSB has low micronutrient content and bioavailability, low energy density, high fibre and anti-nutrient content may contribute to poor recovery rates which are as low as 24% in operation emergency setting (La Grone*et al.*, 2012).

World Food Program has recently attempted to bridge this gap with a revised CSB recipe, “CSB+” and even more recently “CSB++”. These two products are highly fortified with nutrients particularly micronutrients. CSB++ is more energy-dense from the added oil, sugar, and dried skim milk; increased phosphorus (28% greater), potassium (49%), vitamin B-6 (316%), vitamin B-12 (121%), zinc (43%), riboflavin (62%), vitamin C (141%) and vitamin D (115%); the addition of vitamin K and pantothenic acid; tighter specifications regarding aflatoxin and coliform contamination and a reduced anti-nutrient content through the inclusion of less soybeans and maize and the de-hulling of the soy beans. CSB++ is designed for targeted therapy of children with MAM and for feeding vulnerable children 6 months to 2 years of age. However the CSB++ is likely to be expensive because of its ingredients.

The introduction of RUTF in the 2000s expanded the range of treatment of MAM options considerably. RUTF contain very little water and require no cooking. RUTF are less susceptible to bacterial contamination and have an extended shelf life which allows them to be safely stored at home (Greiner, 2010). RUTF has allowed for the development of out-patient care services for children with SAM but no medical complications. The success of RUTF has led to the development of formulations of specialized lipid-based products meant to supplement usual diets.

The effects of locally formulated food supplements in the treatment of MAM have been understudied. A few studies conducted however show positive impact of such foods in the rehabilitation of malnourished children under five years of age. A study conducted in an informal settlement in Thika, Kenya (Okoth, 2014) demonstrated that a food product made from fermented and steeped-sorghum grains was effective in improving the nutritional status of children under five who were moderately malnourished. Another study also conducted in Thika, Kenya (Maoga, 2011) using *A.Hypochronicus* Grain to improve nutritional status of HIV-positive children showed the local grain to be efficacious in improving their nutritional status. There is therefore need for more studies to test the efficacy of local foods which are context-specific and that are likely to be cheaper and more sustainable than blended foods for the treatment of MAM among children.

2.5 Factors influencing the effectiveness of supplementary feeding programme

Globally, approximately 33 million children under five years of age are affected by moderate acute malnutrition (MAM). Based on an analysis by UNICEF, WHO and the World Bank, 32 of 134 countries for which there was data on prevalence of acute malnutrition (WHZ <-2) had a prevalence of 10% or more – a threshold that represents a "public health emergency requiring immediate intervention" (Greiner, 2010).

Energy density of the food products has direct influence on the effectiveness of the products used for SFP. Acute moderate malnutrition is treated by adding a nutrient rich supplemental food that provides the daily recommended dietary allowance of all micronutrients in addition to the child's habitual diet. The results indicate that the average body weight of children has substantially increased, particularly during the first and second months of the intervention. The increase could be attributed to the provision of supplemental food (Hartoyo, Hastuti, Briawan, Setiawan, & Yuliati, 2010). The increase of Z-score is directly influenced by nutritional status at the beginning of intervention, mother's participation in the intervention, level of consumption, and duration of illness. Meanwhile, child-care practices, socio-economic status of the family, and child characteristics are among the factors that indirectly affect the effectiveness of the intervention (Beaton & Ghassemi, 1982). It is recommended that supplementary feeding program should be simultaneously followed by nutrition and child-care education and health care programs to increase the effectiveness of supplementary feeding program. In conclusion, exploring local food supplements for treatment of moderate malnutrition in young children in the third world is the window of opportunity for sustainable SUN interventions

2.6 The nutrient and anti-nutrient profile of the proposed local food supplement

2.6.1 Sorghum grain and its nutritional benefits

Sorghum is a cereal crop which plays an important role as food security crop in semi-arid part of Africa (Lost Crops of Africa, 1996). In Uganda, sorghum is largely produced for home consumption and to a smaller extent for industrial beer production (FAO, 2013). Nutritionally sorghum can be compared to maize, although sorghum has higher percentage of protein (1-2%) than maize. However, the tannins and phytates in sorghum interfere with zinc and iron bio-availability and therefore its use for food supplement necessitate additional processing (FAO, 2013; Whole Grains Council, 2013).

2.6.2 Peanut and its nutritional benefits

Groundnut, sometimes referred to as peanut (*Arachishypogaea*) is a pulse, a member of the Leguminosae family. It originated in Brazil but is now extensively grown in warm climates around the world. In Uganda, groundnut is the second most important legume after beans (Kaaya & Warren, 2005). Groundnut seeds contain 40-50% fat, 20-30% protein and 10-20% carbohydrates (National Peanut Board, 2014). Its protein has a high biological value and contains all the essential amino acids except methionine. It also contains fibres and is rich in calcium and magnesium. Toxic components contained in groundnuts, aflatoxins, do not present a big threat since they are easily controlled by harvesting at maturity, drying pods quickly to less than 8% moisture, good storage practices and separation of contaminated seeds (Rudrappa, 2009)

2.6.3 Cow's Ghee and its nutritional benefits

Ghee is thought to originate from India and Egypt, and is produced from cows or buffalos milk fat. Ghee contains 99% fat and does not contain protein and carbohydrates. Ghee also contains about 2000 IU of vitamin A per 100g and traces of vitamin D. According to (Bille, Ozuuko, & Ngwira, 2002), ghee has good keeping qualities and is much used in tropical countries compared to butter. This is because butter easily goes rancid if kept unrefrigerated in warm temperatures while ghee can be kept at room temperature. Ghee enhances growth and boost immunity. Due to these properties, use of ghee as a component of food supplement could be used to accelerate recovery from malnutrition and reduce disease incidences in moderately malnourished under-fives (Sharma, Mann, & others, 2001)

2.6.4 Honey and its nutritional benefits

According to White & others (1975), honey is a food material made by honey bees from pollen grains of plants. According to White (1975) honey is composed of 17.1% water and 82.4% carbohydrates. The remaining 0.5% constitutes proteins, amino acids, vitamins and minerals. The predominant sugars in honey are fructose (38.5%) and glucose (31%). The remaining 12.9% of carbohydrates is made up of maltose, sucrose and other sugars. Honey contains a wide array of vitamins, minerals, antioxidants and amino acids found in trace amounts. The vitamins found in honey include niacin, riboflavin and pantothenic acid while the minerals present include calcium, copper, iron, magnesium, manganese, phosphorus, potassium and zinc. Just as the colour and flavour of honey varies by floral source, so does the vitamin, mineral, antioxidant and amino acid content (Ball, 2007).

Infants on a diet containing honey were found to have a better blood formation and higher weight gain than those given a diet without honey (Zumla & Lulat, 1989). In another study, infants on honey containing diet were shown to have a better weight increase and less disease incidence than infants fed normally. These positive effects of honey in infant diet are attributed mainly to the effects on the digestion process (Rivero-Urgell & Santamaria-Orleans, 2001).

In another study, rats which were given 500mg of honey showed a 25.5% to 33.6% increase in calcium absorption compared to the control group (Ariefdjohan, Martin, Lachcik, & Weaver, 2008)

2.6.5 Cost of food supplements

Several studies have shown that cost is not often the primary factor in selecting food commodity for interventions. Others factors such as food preference, availability, and potential disincentive effects often outweigh cost considerations (USAID, 2013). However, the cost effectiveness of food product which is the ratio of its cost to its nutritive or income value may help in determining whether it is cost effective for use as food aid. Calculating the cost-effectiveness of a desired food commodity in terms of cost per unit nutritional value or income transfer value in dollars to the recipient provides information about which commodities provide the most nutritional benefits or highest income at the lowest cost (Save the Children UK, 2009).

2.7 Summary of the literature review

Moderate acute malnutrition is very common in poor countries and mainly affects children below five years of age. In Uganda, Karamoja region has the highest malnutrition rates among children below five years. The traditional way of managing moderate acute malnutrition is by administering CSB+ and most recently the RUTFs. Studies have shown that although CSB+ is the most commonly used food supplement, it is not highly efficacious in the treatment of MAM. Furthermore, it has high anti-nutrient levels, high cost and sustainability concerns. More efforts have focused on improving CSB+ rather than seeking local alternatives for a replacement but this has been with limited success. There is, therefore, need for an alternative local, sustainable and cheaper food supplement to manage moderate acute malnutrition.

CHAPTER THREE: METHODOLOGY

3.1 Research Design

The study used a randomized cluster trial to compare the efficacy of SPB to that of CSB+ in treating moderate acute malnutrition among children 6-59 months of age. The study comprised of two phases: phase I consisted of identification of sorghum and peanut varieties, formulation (using nutri-survey software) and quality testing of the food supplement using requirements for safety of supplementary foods, and analysis of nutrient and anti-nutrient profiles of the developed food supplement. In phase II, the acceptability and efficacy of the developed food supplement in the treatment of moderate acute malnutrition were tested.

3.2 Location of the Study

The study was conducted in Nakapiripirit district, located in the Southern Karamoja, North Eastern Uganda. It was conducted in two sub-counties; Namalu and Kakamangole. The study targeted two health centres namely Namalu health centre III and Kakamongole health centre II respectively. The inhabitants of the catchment population of the two health centres selected are pre-dominantly agro-pastoralist. The region is largely food insecure and hunger and malnutrition is especially chronic among children (UDHS, 2011). The arid nature of the environment and low precipitation annually affects both the quantity and quality of water for human and livestock. There is generally low access to safe and clean drinking water drinking, poor hygiene and sanitation due to waste disposal largely in the bush surrounding the homesteads and hence a high morbidity due to diarrhoea diseases and ARI during the rainy seasons.

3.3 Variables

Table 3.1: Study Variables

Dependent Variables	Independent Variables
Nutritional status of children (WHZ scores)	• Consumption pattern of CSB+ and SPB • Parental socio-demographic characteristics • Existing and past children feeding practices
Recovery rate, mean length of stay in programme, defaulter rate, and morbidity prevalence	• Previous disease history and immunization status

3.4 PHASE I OF THE STUDY

Phase I of the study comprised of identification of Sorghum and peanut varieties, formulation of SPB, and determination of the nutritive and anti- nutritive composition using Association of Official Analytical Chemists (AOAC) standard procedures for food analysis.

3.4.1 Development of Sorghum peanut blend (SPB)

Raw materials used for formulation of SPB were locally obtained from north eastern region of Uganda. Sorghum variety (R8113), groundnuts variety (Sekado), ghee and honey were obtained from Nakapiripirit district, Karamoja region. The sorghum and groundnuts were sun dried for five days to moisture levels below 10%. Low density material, particularly leaf, damaged kernels and stalk in sorghum were removed by winnowing and thereafter sieved to remove small particle dirt. Dirt free sorghum was then milled using a hammer mill (Yang dong mill, China) into flour to pass through

250um mesh size and packed into gunny bags. Groundnuts were hand sorted to remove damaged kernels, foreign matter and the shrivelled kernels and the weighed. The groundnuts were dry roasted to a white roast for 30 minutes using a charcoal stove before grinding to a paste. Milk from Karamajong Zebu cows was traditionally processed by fermenting it for three days in pots. Fermented milk was churned in a jerrycan by hand until fat globules accumulated on top. Fat globules (butter) were scooped off, washed to remove the whey, and then matured for one week to develop the ghee flavour. The ghee was boiled using a charcoal stove for 30 minutes to concentrate the contents by removing remove excess water.

3.4.2 Product formulation of sorghum peanut blend (SPB)

Nutri-survey computer software, employing linear programming, was used for formulation of the local product (Erhardt, 2010). The quantity of each raw material was determined based on composition and the recommended daily allowances according to(Golden, 2009)for children between 6 to 59 months of age. Sorghum- peanut blend contained 55.2% sorghum, 18.6% peanut, 19.0% honey and 7.2% ghee. Chemical analyses were done to ascertain nutritional adequacy of the prototype.

3.5 Nutrient content analysis of SPB and CSB+

3.5.1 Determination of protein

The protein content of SPB and CSB+ was determined using Kjeldahl’s method according to AOAC (1999) method number 984.13. Samples were weighed (1g) and digested in concentrated sulphuric acid with one Kjeldahl tablet followed by distillation in 40% sodium hydroxide. The resulting solution was titrated with 0.1N hydrochloric acid using a mixed indicator (methyl red and bromocresol green).

The nitrogen content of the sample was calculated as shown by equation 3.1

Nitrogen in sample (%) = 100 (A*B/C*0.014-----------------→ Equation 3.1

Crude protein (%) = nitrogen in sample × 6.25

Where;

A = Hydrochloric acid used in titration (ml)

B = normality of HCL acid

C = weight of sample (g)

3.5.2 Determination of moisture content

The moisture of SPB and CSB+ was determined using the oven drying method as described by AOAC (2000) method number 925.40. Samples were weighed (5g) in dry petri-dishes and heated in an electric oven at 105^{o}Cfor 5 hours. Dried samples were cooled in desiccators, and the weight taken. The difference in weight was then obtained.

Moisture content (%) = 100 * (B – A) – (C – A) / (B – A)

Where;

A = weight of clean, dry petri-dish (g)

B = weight of petri-dish + wet sample (g)

C = weight of petri-dish + dry sample (g)

3.5.3 Determination of the ash content

The content of ash in SPB and CSB+ was determined according to AOAC (1999) method number 972.15. Samples were weighed (5g) in dry crucibles, carbonised on a hotplate, and heated in a muffle furnace model A-MF4 at 550^oC for 6 hours. The ash content was determined after cooling samples in the desiccators to ambient temperature.

Ash content (%) = 100 A – B/C

Where:

A = weight of crucible with sample (g)

B = weight of crucible with ash (g)

C = weight of sample (g)

3.5.4 Determination of crude fibre content

The crude fibre of SPB and CSB+ was determined according to the method outlined by Pearson (1976). Samples were weighed (1g) and transferred to a round bottom flask. One hundred millilitres of sulphuric acid (0.13M) was added and the mixture boiled under reflux for 45 minutes. The solutions were quickly filtered under suction and residues washed thoroughly with water until acid free. Residues were transferred back to flasks followed by addition of 100ml of NaOH (0.3M). The mixture was boiled under reflux for 45 minutes and quickly filtered under suction. Residues were washed with water until base free and then transferred to crucibles. They were dried to a constant weight in an oven at 105^oC for 1 hour, cooled in a desiccator and then weighed. The samples were then incinerated using an incinerator at 550^oC for 8 hours and reweighed. Percentage crude fibre was then computed.

Crude Fibre content (%) = 100 (A – B/C)

Where:

A = weight of crucible with dry residue (g)

B = weight of crucible with ash (g)

C = weight of sample (g)

3. 5.5 Determination of Crude Fat

The crude fat content of SPB and CSB+ was determined using AOAC (1999) method number 920.39. This involved using a soxhlet apparatus to extract the fat from 3g of the dried sample using 60ml of petroleum ether as the extraction solvent. The percentage fat was then obtained as the ratio of the extracted fat to the original sample weight.

Crude Fat content (%) = 100 (B – A/C)

Where;

A = weight of clean dry flask (g)

B = weight of flask with fat (g)

C = weight of sample (g)

3.5.6 Determination of carbohydrate and energy content

Carbohydrate concentration in SPB and CSB+ was determined by difference in ash, moisture, fat, crude fibre and protein while energy was calculated according to Golden, (2009).

3.5.7 Determination of beta-carotene

The Beta-carotene content in SPB and CSB+ was determined according to the method by (Rodriguez-Amaya & Kimura, 2004) using UV-visible spectrophotometer (PerkinElmer, Lambda Bio 20, USA).0.2 g of the samples were weighed and transferred into a mortar. Samples were mixed with 30mlacetone and the mixture filtered into a 50 mL volumetric flask. The extract was transferred into a 500mL separating funnel followed by addition of 30ml petroleum ether. Distilled water (300 mL) was added slowly along the walls of the separating funnel. The samples were left to stand at room temperature allowing the two phases to separate and the lower aqueous phase discarded. The mixture was washed four times to remove residual acetone. In the last washing, the lower phase was discarded and the petroleum ether phase collected in a 50mL volumetric flask through anhydrous sodium sulphate. The volume was then made to the mark with hexane and absorbance at 450mm using a pipette to take the measurement. A blank sample was taken to correct of the error.

3.5.8 Determination of mineral content

The mineral content of SPB and CSB+ was analysed using an atomic absorption spectrophotometer (Perkin Elmer, Norwalk, CT, USA) as described by (AOAC, 1990) method number 975.03. Samples (2 g) were digested in 3ml of concentrated nitric acid and hydrogen peroxide. Calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn), sodium (Na), potassium (K) were determined at wavelengths of 317.9 nm, 285.2 nm, 259.9 nm, 324.7 nm, 213.9 nm, 589.6 nm, and 766.5 nm, respectively, using an air-acetylene flame. Sodium chloride (NaCl) and potassium chloride (KCl) were used as standards for determination of Na and K. Standard solutions of magnesium oxide (MgO), calcium carbonate ($CaCO_3$) and ferrous ammonium sulphate ($Fe(NH_4)_2(SO_4)_2$) were used for determining concentrations of Mg, Ca and Fe. Phosphorus content of CSB+ and SPB were analyzed using Gravimetric method. The sample ash was dissolved in 2.5 mL of 4N HNO_3 and filtered with Whatman® filterpaper No. 541. The crucible was washed several times with distilled water and sample was diluted to 25 mL and 5 mL of the test solution was transferred into a 250 mL beaker. DI water was added to make the volume to 40 mL and boiled for 3 min, 10 mL conc. HNO_3 was added. The test solution was heated to boiling and swirled for 10 second. 50 mL ammonium molybdate solution was added and covered over with watch glass and swirled every 30 min for 2h.

The precipitate was left at room temperature overnight. Using a cleaned glass filter crucible with 95% ethanol and ether and the test solution was dried in a desiccator under vacuum for 1 h and weigh (W1). Quantitatively the precipitate was transferred from the beaker to the glass filter crucible and filtered using a vacuum pump and the beaker was rinsed with 5% NH_4NO_3. The precipitate was dried the precipitate in the desiccator under vacuum for 1h and weigh (W2).

Calculation:

P (mg /100g) = (W2-W1) x Y x 1559.4557

Weight of test sample (g)

Where W1: weight of dry glass filter (g)

W2: weight of glass filter with the precipitate (g)

P: phosphorus content

Y: dilution factor

3.5.9 Determination of dietary fibre content

Dietary fibre in SPB and CSB+ was determined using fibreanalyzer (Lanbconco, Missouri, USA) according to (AOAC, 2000) method number 973.18. Samples (1 g) were mixed with 100ml of acid detergent solution 2ml of dekalin. The mixture was boiled and refluxed for 45 min. Conditioned crucibles were weighed and the reflux mixture filtered into crucibles by increasing vacuum progressively. The crucibles were then placed in an oven (Hotbox oven, Gallencamp, UK) at 100^{o}C for 1 hour, cooled in desiccators for 30 min and then weighed to determine weight of dietary fibre. Samples were weighed to ±0.0001g.

Dietary fibre content (%) =100 (W_2/W_1)

Where:

W1 = weight of sample (g)

W2 = weight of residue (g)

3.5.10 Determination of vitamin A content (β-carotene)

Vitamin A content of SPB and CSB+ was determined according to (AOAC, 2005)method number 2001.13. Samples were weighed (10g) in 250mL amber glass flat bottom round flasks. 0.5g of Ascorbic acid and 50mls of 85% ethanol were added to the sample followed by addition of 4ml sodium sulphite solution 0.5M PH 7.6 and 10ml of 0.1NKOH solution were added. The samples were then saponified by boiling the solution under reflux for 30 minutes. After hydrolysis, 20ml of distilled water was added. The solutions were then cooled to ambient temperature under a stream of cold water. The samples were then transferred to 250 mL separation funnels. Flasks were rinsed with 10ml of distilled water and 50ml diethyl ether. The separating funnels containing the sample solution were swirled and left to stand to allow different phases to separate. The bottom water layer was collected in a flask while the diethyl ether phase was transferred to a separation funnel.

This extraction step with diethyl ether was repeated three times. The diethyl ether extracts were then washed with 50ml of distilled water by inverting the funnel 5 times without shaking to avoid formation of emulsion. The diethyl ether extracts were subsequently drained in a clean flask by filtering over anhydrous sodium sulphate followed by rinsing of filter paper with 20ml of diethyl ether. The sample filtrates were concentrated by drying in rotavapor at 40^{o}C and then dissolved in 10ml of n-hexane. The filtrates were then analyzed using thin layer chromatography (TLC Silica Gel F254 plate).

Retinol ester was used for preparing the standard solution. The standard solution contained 0.01 mg retinol/μl ester (3.3 International Units (IU) from which other esters were there in cyclohexane. The mobile phase consisted of a mixture of ether and cyclohexane (20:80 V/V) stabilized with butylatedhydroxytoluene (1 g/L). About 3 μl of each solution was spotted on the plate. Spots were examined in ultraviolet light at

254nm. A principal spot from test sample was confirmed by corresponding with that of retinol in the chromatogram of reference solution.

3.5.11 Determination of fatty acids profile

Fatty acids profile of SPB and CSB+ was determined using gas chromatography (GC) (PerkinElmer, Norwalk, USA) in accordance with (AOAC, 1990) method number Ce 1b-89. Ten grams of the samples were mixed with 100ml of chloroform for 2 minutes and followed by centrifuging at 2000 rpm for 5 minutes. The mixture was filtered over a filter paper of 1.5um with anhydrous sodium sulphate and evaporated (20mL) under a stream of nitrogen at 40^{o}C until only 20ml was left. Fat (0.5g) was dissolved in 2ml diethyl ether (2mL). A solution of 0.5ml of 1N potassium hydroxide (KOH) in 20ml ml methanol (MeOH) solution to dissolve the fat solution. To the soap solution, 2ml of water and 15ml of hexane were added.

The mixture was shaken and left to stand to allow phases to separate after which the top layer was decanted. The mixture was washed four times with water (2 mL) to remove residual hexane. Samples were dried using anhydrous sodium sulphate. Dried samples were transferred to a GC-auto sampler vial. Samples and standards were run on the GC. Percentages of peak areas obtained were divided by the relative molecular weight of respective fatty acid methyl esters to obtain moles percent of fatty acids (FA).

3.6 Analysis of Anti-nutrientcontent in SPB and CSB+

3.6.1 Determination of condensed tannins

The tannin content of SPB and CSB+ was determined using vanillin-hydrochloric acid method (Burns, 1963) modified by Price et al., (1978). Approximately 0.25 g of ground samples were weighed into Erlenmeyer flasks. Ten (10) ml of 4% HCl in methanol was pipetted into each of the flasks and closed with parafilm. The flasks were gently shaken for 20 min in a shaker (Model KS 250 basic, Germany) and the resulting extracts centrifuged for 10 min at 4500 rpm (Model H–2000C, Kokusan Corp., Tokyo, Japan). The supernatant aliquots were transferred to 25 ml volumetric flasks. Second extractions were done by adding 5 ml of 1% HCl in methanol to the residue from the first extraction and the extraction process repeated. The aliquots of the first and second extractions were combined and made up to 25 ml volume. Approximately 1 ml of each extract was pipetted to a corresponding labelled test tube. A set of catechin standard solutions was prepared ranging from 100 to 1000 ppm using methanol.

Approximately 1 ml of each respective standard and sample extract were pipetted into test tubes and 5 ml of freshly prepared vanillin-HCl reagent added. Sample blanks were prepared by adding 5 ml of 4% HCl in methanol to 1 ml of the aliquot extracts in test tubes. The absorbance of the standard solutions, sample extracts and blanks were read in a UV-VIS spectrophotometer (UV mini 1240 model, Shimadzu Corp., Kyoto Japan) at 500 nm 20 min after adding Vanillin-HCl reagent to the samples and standards. A standard curve was prepared from the readings of the catechin standard solutions.

The blank absorbance was subtracted from the samples absorbance and the corrected absorbance substituted into the regression equation ($y= 0.0004x$, $R=0.9972$) in order to calculate the concentration of the sample extracts. The concentration in μg per ml was converted in to mg catechin per ml. The percentcatechin equivalents (% CE) were calculated as follows:% CE = (CC × VM) / (VE × Wt) × 100

Where: CC = catechin concentration (mg/ml); VM = volume made up (25 ml); VE = volume of extract (1 ml); and Wt = weight of sample (250 mg).

3.6.2 Determination of phytates

This was done by HPLC method of phytic acid according to Camire and Clydesdale (1982). Approximately 50mg of sample was weighed into a 125 ml Erlenmeyer flask and 10 ml of 3% H2SO4 added. The flasks were placed on a shaker at a moderate speed for 30 min at room temperature and filtered using a fast filter paper (Shaker Model KS 250 basic, Germany).

The filtrate was transferred to a Boiling Water Bath (BWB) for 5 min and 3 ml of FeCl3 solution (6mg ferric iron per ml in 3% H2SO4) added. A second BWB heating was done for 45min to complete precipitation of the ferric phytate complex. Centrifugation followed at 2500 rpm for 10 min and the supernatant discarded (Centrifuge Model H–2000C, Shimadzu Corp., Kyoto, Japan).

The precipitate was washed with 30 ml distilled water, centrifuged and the supernatant discarded. Three (3) ml of 1.5 N NaOH were added to the residues and the volume brought to 30 ml with distilled water. Heating was done for 30 min in a BWB to precipitate the ferric hydroxide. Cooled samples were centrifuged and the supernatant transferred into a 50 ml volumetric flask. The precipitate was rinsed with 10 ml distilled water, centrifuged and the supernatant added to the contents of the volumetric flask.

Samples of 20 µl volume of the supernatant were injected into a HPLC (Model C-R7A plus, Shimadzu Corp.,Kyoto, Japan) fitted with a 50377 RP-18 (5 µm) column cartridge at an oven temperature of 30ºC and an RID detector (Model RID-6A, Shimadzu Corp., Kyoto, Japan) used for identification. The mobile phase was 0.005Nsodium acetate in distilled water, flowing at a flow rate of 0.5 µl min-1.A stock solution of the standard containing 10 mg/ml of sodium phytate (Inositol hexaphosphoric acid C6H6(OPO3Na2)6+H2O) in distilled water was prepared. Serial dilutions were made for the preparation of a standard curve.

Results of phytate content were obtained as per the calculations of Vohra et al. (1965). The equation of the standard curve line was obtained ($y = 263.13x$, $R= 0.9938$) and used for calculating the phytatevalues as follows; Phytate content (mg/g) = (y/b) *(dilution factor / weight of sample).Where y is the y intercept of obtained from the standard curve of phytates, and b is the peak area of the injected sample.

3.6.3 Determination of trypsin inhibitor content of SPB and CSB+

The casein digestion method was used for determining trypsin inhibitor content of SPB and CSB+ (Kakade, Simons, & Liener, 1969). Four grammes of samples were weighed, and defatted using petroleum ether. The defatted samples were weighed (1g) in Erlenmeyer flasks followed by addition of 20ml of phosphate buffer PH 8.2. The contents were shaken on a shaker for 1 hour followed by centrifuging at 5000 rpm for 5 min. 1ml of the supernatant was transferred to a 50 ml volumetric flask and diluted to volume with phosphate buffer of 0.05M PH 8.2 (molarity). Sample aliquots (0.5 ml) were transferred to test tubes and distilled water added to make 1ml. Subsequently trypsin concentration solution (1 ml) was added to each test tube and tubes placed in a water bath at 37^{o}C. Casein solution (2%, 1 ml) previously brought to 37^{o}C was then added and the test tubes containing the mixture incubated at 37^{o}C for 20 min. The reaction was then stopped by adding 6ml v/v of 5% trichloroacetic acid (TCA).

The suspensions were thoroughly mixed on a vortex mixer and left to stand at ambient temperature for 1 hour. The suspensions were filtered, and the absorbance of filtrate and trypsin standards measured at 280 nm using UV-Vis spectrophotometer (PerkinElmer, Norwalk, CT, USA).

3.7 Determination of aflatoxins

Aflatest Fluorometer (VICAM V1 #4, Watertown, MA, USA) was used for determining the presence of aflatoxin in accordance with AOAC (2001) aflatest method number 991.31. A mixture of 50gsample and 5g NaCl were placed in a blender jar, to which 100ml of methanol: water solution, 80:20 (100ml) was added followed by blending for 1 minute. The extract was then filtered through a fluted filter paper and 10ml of filtered extract transferred to a clean vessel, to which 20ml of purified water was added and then homogenized. The dilute extract was then filtered through a glass microfiber filter and 1 ml (equivalent to 0.167 g sample weight) of filtrate passed through aflatest-P-affinity column at a rate of 1 to 2 drops per second. The column was then eluted with 2ml purified water with 1ml at a time. Afterwards, the column was eluated with 1 ml HPLC grade methanol and the sample eluate collected in a glass cuvette. Aflatest developer solution (1 ml) was added to eluate followed by mixing and placing in a fluorometer to measure aflatoxin content.

3.8 Cost of food supplements

The costing of SPB was determined according to the prevailing local market food prices. Price of each raw material in local currency (Uganda shillings) was computed in relation to its proportion in the final product and summed up to obtain total cost of a kilogram of the food supplement. The price in local currency was then converted into United States (US) dollars. The USA dollar was rated at Ugandan shillings 2600. WFP (2013) FOB Kampala, Uganda food commodity price was used for CSB+.

3.9 PHASE II OF THE STUDY

This phase comprised the selection and recruitment of the study participants, testing of the acceptability of the food supplements and the intervention to test for the efficacy of SPB in comparison with CSB+ in treating moderately malnourished children.

3.9.1Target Population

The target population was children aged 6 - 59 months with weight -for -height between -3 and -2 Z scores of the WHO 2006 Child growth standards and MUAC of 115mm to 125mm without bilateral pitting edoema (SHPERE project, 2004).Respondents were the mothers or primary caregivers of the children who at the time of the study, were residing in Nakapiripirit district.

3.9.2 Inclusion Criteria

Parents whose children were to participate in the study had to be;

- Willing to participate with their children in the study.
- Willing to take their children to a designated health centre every two weeks.
- Intending to stay in the study area for a period of not less than four months from the commencement of the study.
- The children with MUAC of 115mm to 125mm without bilateral pitting oedema.

3.9.3 Exclusion criteria

- Children with chronic / complicated medical conditions as verified by medical personnel.
- Children with peanut, ghee or honey allergy. This was assessed by a clinician by giving small dose of supplement to the child and observed for at least one hour for any allergic reactions.
- Children already participating in other studies or interventions.

3.10 Selection and training of research assistants

Eight research assistants were recruited for the study. The Criterion for selection was a Bachelor’s Degree in Human Nutrition or Food Science with previous experience in nutritional surveys being an added advantage. The research assistants were trained for two weeks on the objectives of the study, understanding of the questions, interviewing skills, data tools, and how to take anthropometric measurements. Standardization of the anthropometric measurements was conducted to ensure validity of results. The training was conducted by the researcher through lectures, demonstrations, role plays and practice.

3.11 Acceptability study

3.11.1 Acceptability study design and data collection methods

An acceptability study was conducted on a sub-sample of the recruited study participants to determine acceptability of SPB before the intervention. Acceptability was defined as the extent to which participants or caregivers of selected children like the use, appearance and taste of the product. The acceptability study was conducted in Nakapiripirit town council on 42 caregivers and their children.

The study was conducted in two phases; the four days test *feeding trial* and a two weeks home-use trial. Test trials involved ranking the porridges by caregivers according to (Meilgaard, Carr, & Civille, 2006). During the feeding test trial the participants were introduced to the test while the subsequent days involved the actual sensory evaluation/tasting of the supplements.

During day 1, the caregivers were introduced to the various aspects of the food supplements including formulations, preparation methods, usage and handling and storage. In addition, cooking demonstrations, initial tasting of the porridge and completion of the questionnaire (hedonic scale) were conducted. Socio-economic and demographic data of participants was also collected and the final part of the test trial was child feeding. Caregivers prepared the porridges, tasted and fed the children at a central point. The colour, taste, aroma, mouth feel, consistency and overall acceptability of prepared porridges were evaluated based on a 5-point hedonic scale (Meilgaard et al., 2006).

By use of a cross-over design, children were initially randomised to receive one of the two study foods, SPB (n=21) and CSB+ (n=21) on the second day followed by a one-day washout after which they were switched to the second porridge on the fourth day. Each caregiver was provided with 300 mL of porridge in a graduated cup to feed the child. During this time, it was ensured that the child was awake, alert, and calm but not drowsy or crying. The actual time each child took to drink the porridge or refused further feeding was recorded. Likewise, the amount taken was recorded by noting the remaining amount of porridge in the cup.

Caregivers ranked the children's degree of liking basing on their perceptions. By dividing the amount of porridge taken by time, velocity of intake was ascertained. They also reported if the child vomited within the next hour or developed diarrhoea and any reaction to the test meal.

Phase two of acceptability study was the *home use trial* and it involved mothers taking home 2kg (packaged in daily ration of 269g of SPB and 269g of CSB+) of flour per visit at the outpost which was on a weekly basis. To avoid bias, food supplements were distributed randomly without putting into consideration caregivers' and child's preference if any. A qualitative and quantitative assessment of food supplement use and amount consumed were noted. Only participants who completed the test feeding phase were eligible for inclusion.

To ensure that beneficiaries consumed the entire daily ration, caretakers were advised to feed the children on the products three times a day. Caregivers were instructed to divide the daily ration into three portions, whereby one portion could be taken in the morning while the others would be taken in the afternoon and evening hours, respectively.

Proper storage conditions (clean and dry conditions, room temperature) and preparation methods were well explained to the participants. Village health team volunteers visited the participants on a daily basis to check on the amount of supplement consumed and to assess any difficulty encountered. After the end of the first week of supplementation, each participant was visited to check on the amount of supplement remaining and inquire about any illnesses (morbidity and any reaction).

At the end of the second week an exit interview was conducted to assess perceptions, utilization, and possible intra-household distribution of the product as well as ease and difficulty of providing the supplement more than once a day. Also, open-ended questions were asked at the exit interview to explore the caregivers' views about other characteristics of the food supplements.

3.11.2 Criteria for food supplement acceptability

A food supplement was deemed acceptable if a child consumed at least 75% of the serving and if less than 10% of adverse effect cases were reported (Valid International, 2006).

3.12 Efficacy study

3.12.1 Study design

This was conducted to test the effectiveness of SPB and CSB+ on MAM children after a maximum of 90 days of feeding trial. The study employed a single blinded, parallel controlled clinical trial that assessed the efficacy of treating MAM with SPB, for a period of ≤ 12 weeks, using CSB+ as the active comparator. The primary outcome of the intervention was a cure rate.

Children were defined as having recovered when they reached a WHZ ≥ -2; otherwise, they were categorized non-respondent as having continued MAM despite 12 weeks of therapy, had developed SAM (WHZ ,< -3 and/or pedal oedema), were transferred to outpatient or inpatient care, died, or defaulted (did not turn up for 2 consecutive visits). Secondary outcomes included duration of stay in the programme before full recovery and rate of weight gain. If the child was a twin, an additional supply of food was given to the caretaker to ensure that the child received a full ration and to cater for sharing between the twins.

3.12.2 Sample size calculation

Sample size was determined using procedure outlined by Lwanga et al. (1991)

$$n = \frac{[Z_{\alpha} + Z_{\beta}]^2 [2.\bar{p} (1-\bar{p})]}{\delta^2}$$

Where;

n= the number of beneficiaries receiving either of the food supplements for treatment of moderate acute malnutrition

δ^2 = difference to be detected, $(P_2 – P_1)$

$\bar{P}$ = mean proportion of success $(p_1+p_2)/2$

P_1 = Typical cure or recovery rate amongst beneficiaries using CSB/Oil/Sugar (Control) was found to be 65 % (Navarro-Colorado, 2007).

P_2 = Cure or recovery rate amongst the recipients of the Sorghum peanut powder / Cows ghee / Honey will be 85% i.e. Increase in δ=20%.

Z_α=value for alpha error

Z_β=value for beta error

To detect such increment an 80%power at β=0.20 and 5% level of significance was used and therefore substituting values in the formula, sample size of 172 children was obtained. The calculated sample size was inflated by 30% to cater for attrition. The final sample size was 220 per study group.

3.12.3 Randomisation process

Two health centres, 12 kilometres apart were randomly assigned on a 1:1 ratio by computer to the two study groups. The randomization was computer-generated using the Microsoft® Excel 2003 software package. Randomization was conducted by a bio-statistician who was not part of the research team.

Health centres rather than individual children and their mothers/caregivers were randomized to the study groups to prevent cross-over of the study groups and preventing sharing of the food supplements if close neighbours were assigned to the same study groups. The two health centres were randomly assigned to the two study groups.

A child and the mother/caretaker were assigned to the study groups based on their residence. The principal investigator assisted by the research assistants conducted the recruitment at baseline.

3.12.4 Blinding design

This was a single-blinded study. Only the investigator was aware of the treatment (the nature of the food supplement) given to the study groups. The hypotheses of the study were concealed from the participants, staff at the health centres and the research assistants who distributed the food and administered questionnaires.

3.12.5 Recruitment of study participants

Recruitment of the study children was done at baseline. Children of ages 6-59 months in the neighbourhood of the two randomly selected health centres were screened for moderate acute malnutrition by trained research assistants. All mothers/caretakers were mobilized by Village Health Teams (VHTs) to bring all children in their houses below five years of age for screening at the health centre.

Standard methods for anthropometrics measurements were used (Cogill, 2003). Weight was measured with an electronic scale (Seca scales) to the nearest 0.5kg, length/height was measured to the nearest 0.2 cm with a rigid height board, and MUAC was measured with a standard insertion tape to the nearest 0.2 cm. Oedematous malnutrition (kwashiorkor) was also assessed using bilateral pitting oedema criterion. The caregivers of children who met enrolment criteria gave a verbal and written consent before recruitment of their children into the intervention study. Prior to obtaining consent, caretakers were informed of the purpose of the study, potential benefits and the fact that the study posed no direct or indirect harm to them. Children were recruited in their respective health centres.

On enrolment, a baseline assessment was conducted to obtain information on the socio-economic characteristics of the participating children. Caregivers were administered the 9-item Household Food Insecurity Access Scale (HFIAS) tool to assess household access to food.[9] Nutrition and health education was provided to all caretakers.

3.12.6 Description of intervention

At after collecting baseline information, the 440 children recruited into the study were each given 4kg of each food supplement on a bi-weekly basis consisting of daily rations of 269g each of CSB+ and SPB. The daily ration was adequate to provide energy equivalent to 1000-1200kcal/day recommended for MAM children (WFP, 2000). Care givers were made aware of the purpose of the study and how to use the food supplement during the 90 days of the intervention. CSB+ was obtained from the community based supplementary feeding program of the United Nations World Food Program in Nakapiripirit district.

The SPB was prepared on a bi-weekly basis and distributed to the study participants on the same day that it was made. Information on the outcome indicators was collected during the bi-weekly visits by the research assistants. Program protocol such as the feeding of the supplement to the enrolled child only and using the supplement in addition to the usual diet were emphasized.

Other protocols given to the caregivers included how to store unfinished portions of the supplement and spacing out the use of the daily portions to last until the next biweekly distribution. Cooking instructions and demonstrations for example (using a ratio of 5 parts water to 1 part dry flour) to ensure adequate preparation of the supplements were well emphasized to caregivers. This information was universal across both study groups. Other activities conducted during the distribution of the food supplements included nutrition education on child feeding practices, hygiene and sanitation, and advice on risks of sharing food supplements. In order, to avoid leakage and sharing, caretakers were given a protection ratio (extra food) to cater for intra and inter-sharing at homes.

3.12.7 Data collection techniques

Baseline data was collected from households of the children recruited into the study. Data on demographic characteristics including age, sex, weight, height, and educational level of mothers and, socio - economic characteristics such as household assets was collected. Likewise, nutritional status, morbidity patterns, food consumption score, hygienic practices and sanitations were assessed. Birth certificates and age calendars were used to verify the age of children.

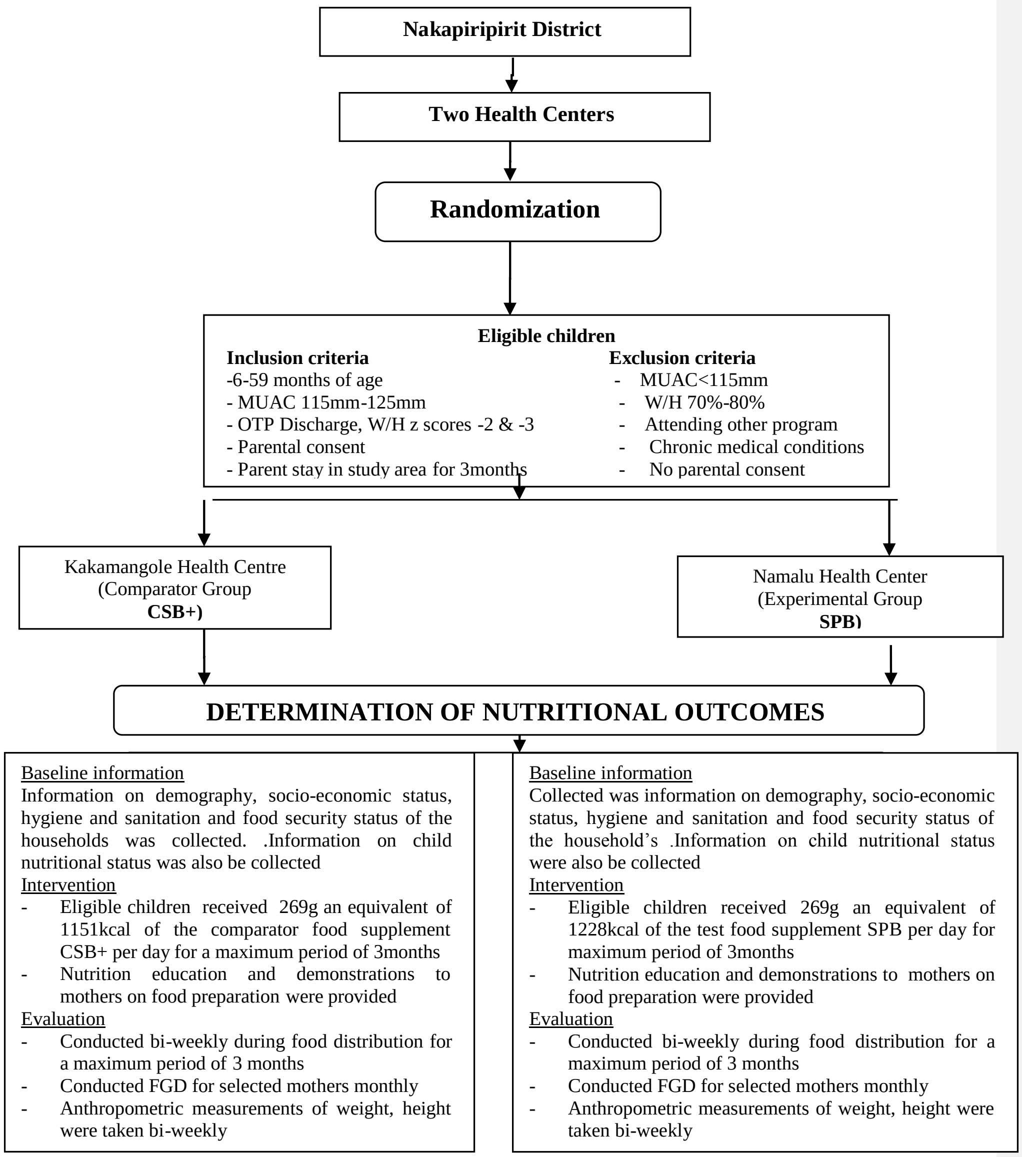

Figure 3.1: Schematic Diagram of study design, interventions and follow up

3.13 Research instruments

Researcher-administered questionnaires(Appendix C)containing baseline information such as age, sex, education level of mothers, household assets, food consumption scores etc. and that of anthropometric measures such as weight, height ,mean length of stay were used in the study in addition to FGD tool (Appendix D)was developed, pre-tested and administered to the two different study groups. Analysis of the nutritive, anti-nutritive value profiles of the test food and that of physical parameters were standard and internationally recognized. Details of outcome indicators resulting from the intake of the two food groups were also recorded in special designed forms.

3.13.1Pre-testing of instruments

The pre-testing was conducted in Moroto district on 20 pairs of children and caregivers/mothers to establish accuracy of questions and clarity and to determine the length of interviews. During pre-testing an effort was made to check for consistency in the interpretation of questions and to identify any ambiguous items. After review of the instruments all suggested revisions were made before being administered in the actual study.

3.13.2 Validity

To ascertain the degree to which the data collection instruments measured what they were supposed to measure, the instruments are validated by a group of nutrition professionals from the department of Food, Nutrition and Dietetics Kenyatta University, WFP/UNICEF and Ministry of Health Kampala. The data collection instruments were reviewed based on the feedback from the professionals.

3.13.3 Reliability

The Test-retest method was used to test the consistency of the questionnaire in producing the same results. Ten caregivers from Moroto district, with similar characteristics to the study area were interviewed two times (with a span of one week between the interviews) using the same questionnaire. A comparison was then made between the answers obtained from both interviews. Correlation coefficient was determined using Cronbach correlation formula by (Cronbach & Shavelson, 2004) which yielded a correlation coefficient of 0.7 which was acceptable. The pre-test subjects were allowed to make comments and give suggestions concerning the questionnaire.

3.14 Data quality control measures

Data quality was controlled by conducting the experimental analysis in triplicates and training all research assistants how to carry out accurate measurements. In addition, equipment used for the study was frequently calibrated. The researcher checked a 10% random sub-sample of all the interviews in addition to checking filled questionnaires for completeness and accuracy of recording of responses.

3.15 Data analysis and presentation

Data were analysed using the statistical software package SPSS version 17. Anthropometric indices were based on the WHO 2006 Child Growth Standards, computed using WHO ANTHRO version 3.1. Cure rate was based on the weight for height/length Z scores index (wasting). Weight gain (g/kg/day), relative to the enrolment weight, was calculated for the children over the 12 weeks or less if discharged earlier. Chi-square test was used to check relationships between categorical variables and student's t-test for differences in continuous variables. Differences in recovery time were assessed by Kaplan Meir Survival analysis and by Accelerated Failure Time (AFT) model.

The predictors of cure rate were determined by Cox Hazard Ratio. Differences between means of nutrients, anti-nutrients and sensory parameters; color, aroma, taste, mouth feel, consistency, overall acceptability and children's' degree of liking were tested for significance using the least significance difference (LSD) at 95% confidence level ($p<0.05$). Mothers' comments from the focus group discussions for the acceptability study were recorded verbatim and organized into themes.

3.16 Logistical and ethical Considerations

Authority to conduct the study was granted by the graduate school of Kenyatta University (Appendix B) and Uganda National Council of Science and Technology (Appendix A) and Ethical clearance was sought from the vector control division ministry of health of Uganda (Appendix A). Caregivers signed or thumb printed an informed consent form signifying they willingness to participate in the study. Prior to obtaining consent, caretakers or mothers were duly informed of the purpose of the study, potential benefits and the fact that the study poses no direct or indirect harm to them. The study trial presented zero risk as most of the components of the food product were already being used as food in these communities.

CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter presents the findings of the nutrient profiles of the food product developed, SPB and that of CSB+ for whose efficacy in treating moderate acute malnutrition was the major hypothesis of the study. The overall acceptability among the respondents and the efficacy of sorghum peanut blend (SPB) for treating moderate acute malnutrition (MAM) in children 6-59 months of age in Karamoja sub-region is also presented in this chapter.

FINDINGS OF PHASE I OF THE STUDY

Phase one of the study involved formulation of the food product; sorghum peanut blend (SPB). The content of the food product in terms of nutrients and anti-nutrients were analysed and compared to corn soy blend plus (CSB+), the standard treatment for moderate acute malnutrition.

4.2 Nutritive and Anti-nutrient content of the food supplements (CSB+ and the SPB)

4.2.1 Macro-nutrient contents

The macronutrient content of SPB and CSB+ are shown in table 4.1. Both SPB and CSB+ contained substantial proportions of protein and fat. The amount of protein per 1 in CSB+(16.8g per 100g dry weight) was significantly higher than that in SPB (14.6g per 100 dry weight) ($p = 0.027$). The amount of carbohydrates was also significantly higher in the CSB+ (63.60%±0.25) than in the SPB (51.88%±0.19) (t-test; P<0.001). In contrast, the amount of fat in SPB, 18.2g/100gdry weight was significantly higher than in the CSB+ 10.69±0.08 (p-value=0.014). Similarly, the amount of ash in the CSB+ was significantly higher than in the SPB (p<0.001). The moisture content was also higher in the SPB than in the CSB+ (p=0.033). The total energy level; kcal/100g which plays a major role in recovery from malnutrition was not significantly different in the SPB (421.23 Kcal/100g), compared to CSB+ (430.37 Kcal/100g) (t-test; p =0.060) as shown in Table 4.1. Although SPB contained higher amount of fibre than CSB+, the difference was not significant (p=0.113).

Table 4.1: Proximate composition of CSB+ and SPB

Parameter	**CSB+**	**SPB**	**t-test p value**	**Recommended levels for MAM**
Moisture (%)	5.06±0.53	8.48±0.09	0.033	10
Protein (%)	16.81±0.41	14.57±0.31	0.027	14
Fat (%)	10.69±0.08	18.15±0.13	0.014	6
Ash (%)	2.59±0.00	1.95±0.02	<0.01	
Crude fibre (%)	1.25±0.17	1.98±0.12	0.031	5
Carbohydrate (%)	63.60±0.25	51.88±0.19	<0.01	
Total energy (kcal/100g)	421.23±3.09	430.37±0.99	0.060	380
Dietary fibre (%)	4.36±1.61	7.85±0.07	0.113	11g/1000kcal

Results are expressed on dry basis except those of dietary fibre. Rows with bolded values are significantly different (*p<0.05*). Values are means of three replicates ± standard deviation

4.2.2 Micro-nutrient content of the supplementary food products

In terms of the mineral content of the two food products, CSB+ contained higher levels of iron, calcium, zinc, phosphorous and potassium as indicated in table 4.2 Nonetheless, the differences were not significant except for zinc and potassium. CSB+ and SPB had16.67 mg/100g±1.44 and 12.08±1.90 mg/100g iron (t-test, p=0.128), respectively as shown Table 4.2. The amounts of iron in both products were within recommended levels (9mg/1000kcal) for local diets formulated for malnourished children(Golden, 2009). For calcium, CSB+ contained 891.6mg±4.39 and SPB 737.5mg ±6.96 (p=0.118) respectively, again the amounts in the two products were higher than what is recommended for local diets formulated for treatment of moderate acutely malnourished children. Despite the fact that CSB+ contained significantly higher amount of zinc than SPB, the amounts contained in both the food products were lower than what is recommended for treatment of moderate acute malnutrition. The same was true for potassium (Table 4.2).

SPB had higher amounts of magnesium than CSB+ although the difference was insignificant. The amounts of magnesium in each of the two products were within what is recommended for treatment of moderate acute malnutrition. The same was true for sodium and manganese where both products had amounts within recommended levels for treatment of moderate acute malnutrition.

Table 4.2: Mineral contents of corn soy blend plus and sorghum peanut blend premix

Minerals (mg/100g)	**CSB+**	**SPB**	**p value t-test**	**Recommended levels for MAM (mg/1000kcal)***	
				Food-based	Complement based
Iron	16.67±1.44	12.08±1.90	0.128	9	18
Calcium	891.6±4.39	737.5±6.96	0.118	600	840
Magnesium	71.83±1.23	86.83±1.91	0.324	200	300
Sodium	27.50±2.16	30.41±4.73	0.539	550	550
Manganese	0.73±0.06[a]	2.14±0.75	0.091	1.2	1.2
Zinc	4.15±0.19	1.74±0.27	0.012	13	20
Phosphorous	485±21.21	380±14.14	0.149	600	900
Potassium	626.67±30.2	371.67±19.38	0.013	1400	1600

CSB+: Corn soy blend; SPB: Sorghum peanut blend; *Golden (2009). Rows with bolded values are significantly different (P<0.05). Values are averages of three replicates ± standard deviation.

4.2.3 Vitamin A and β-carotene content of CSB and SPB

The vitamin A and β-carotene content (per dry weight) and fatty acid profile of SPB and CSB+ (per dry weight) are shown in table 4.3.

SPB had lower vitamin A level (204 IU/100g) than CSB+ (2,200 IU/100g). The high amounts of vitamin A in CSB+ premix is a result of fortification while that in SPB is largely contributed by ghee. A retinal density of 1900µg/1000kcal is recommended for a fortified food meant for management of MAM in children less than five years of age (Golden, 2009).

4.2.4: Fatty acid profile of CSB and SPB

In terms of the fatty acid profile; Palmitic (16:0), oleic (18:1, n-9), cis- 11-eicosenoic acid (20:1), erucic (22:1, n-9) and arachidic (20:0) acids (Table 3) were the predominant fatty acids (FA) in CSB+ and SPB. Myristic (14:0), stearic (18:0), linoleic (18:2, n-6), linolenic (18:3, n-6) and lignoceric (24:0) acids were also in detectable amounts. No significant differences were observed in the proportions of the fatty acids in the two food supplements. The total polyunsaturated fatty acid (PUFA) in SPB was 0.79% and 0.43% in CSB+ (Table 4.3). The predominant PUFA were linoleic acid (0.35% and 0.15% for SPB and CSB+, respectively) and gamma- linolenic acid (0.3 - 0.45%), respectively. No significant difference was found in PUFA levels between the products, even in the two individual predominant PUFA. Omega-6-FA was found in respective levels of 0.45% and 0.31% for SPB and CSB+. Omega-3- FA was less than 0.5% for both supplementary foods.

Levels of mono-unsaturated fatty acids (MUFA) were in substantial amounts with values of 68.94% for CSB+ and 65.06% for SPB. Oleic (29.60% in CSB+ and 24.95% in SPB), cis-11-eicosenoic (33.60% in CSB+ and 31.85% in SPB) and erucic acids (8.25% in SPB and 5.9% in CSB+) were the most abundant MUFA. Saturated fatty acids (SFA) were relatively high with values of 34.14% for SPB and 30.50% for CSB+. Stearic, myristic, palmitic and arachidic acids were the most predominant SFA present in both foods.

Table 4.3: Amounts of vitamin A, beta-carotene and fatty acids (%) in CSB+ and SPB

Parameter	**CSB+**	**SPB**	**t-test, *p value***
Vitamin A (IU/100g)	2244.00±569.93	204±0.00	0.124
Beta-carotene (mg/100g)	3.47±0.53	3.13±0.41	0.142
Myristic acid	0.3±0.14	0.45±0.21	0.205
Palmitic acid	3.75±3.61	5.75±1.34	0.430
Stearic acid	0.65±0.49	1.05±0.21	0.295
Oleic acid	29.60±4.24	24.95±1.34	0.448
Linoleic acid	0.15±0.07	0.35±0.07	0.295
Gamma-linolenic acid	0.30±0.28	0.45±0.70	0.500
Arachidic acid	24.70±1.27	25.1±4.81	0.899
Cis-11-eicosenoic acid	33.60±3.39	31.85±3.04	0.776
Erucic acid	5.90±3.11	8.25±0.49	0.526
Lignoceric acid	0.30±0.28	0.50±0.00	0.500
Saturated fatty acids	30.50±4.33	34.14±4.02	0.649
Mono-unsaturated fatty acids	68.94±4.74	65.06±3.92	0.641
Poly-unsaturated fatty acids	0.43±0.23	0.79±0.11	0.364
Omega-6-fatty acids	0.31±0.26	0.45±0.03	0.541
Omega-3-fatty acids	< 0.001	< 0.001	NQ
Trans-fatty acids	<0-001	< 0.001	NQ
Omega-9-fatty acids	35.45±1.14	33.24±0.87	0.364

CSB+: Corn-soy blend; SPB: Sorghum-peanut blend; NQ: Not quantified. Values are averages of three replicates ± standard deviation.

4.2.3 Anti-nutrientcontent of CSB+ and SPB

SPB Table 4.4 represents the results for anti-nutrient content of CSB+ and SPB per 100g of the dry weight. Sorghum-peanut blend had higher content (25.69 mg/g) of condensed tannins compared to CSB+ (3.14 mg/g) (p = 0.001).Similarly, the Sorghum-peanut blend had a significantly higher content of phytate (1.53 mg/g) compared to (0.49 mg/g) in CSB+ (p=0.008). Levels of trypsin inhibitors for both products were relatively high. SPB had a significantly higher content (37.54mg/g) of trypsin inhibitors than that (29.58mg/g) of CSB+ (Table 4.4)

Table 4.4: Anti-nutrient content of corn soy blend plus and sorghum peanut blend

Parameter	**CSB+**	**SPB t-test,**	***p value***
Condensed tannins (mg CE/g)	3.14±0.14	25.69±1.41	0.001
Phytates (mg/g)	0.49±0.25	1.53±0.32	0.008
Trypsin inhibitors (mg/g)	29.58±2.19	37.54±0.58	0.023

CSB+: Corn soy blend plus; SPB: Sorghum peanut blend; Values bolded are significantly different ($p<0.05$). Values are averages of three replicates ± standard deviation. Condensed tannins expressed in mg Catechin Equivalent (CE)/g.

4.3Aflatoxin content of the food products

Sorghum-peanut blend had aflatoxin levels of 15ppb compared with 4.5ppb for CSB+. These amounts were below limits 20ppb stipulated by FDA and Codex Alimenterius Commission (CODEX, 1981).

FINDINGS OF PHASE II OF THE STUDY

4.4Acceptability of CSB+ and SPB products

Forty two 42) caregiver-child pairs were recruited from Nakapiripirit Town Council for the SPB acceptability test. The children comprised of 57.1% boys and 42.9% girls. All the children in the sample were moderately malnourished with an average MUAC of 12.1cm.The mean age of children was 34.8 months while that of caregivers was 28.9 years as shown in Table 4.6. Majority of the caregivers had either no formal education or had attained only primary education (90.5%)

Table 4.5: Demographic characteristics of the children and their mothers for the acceptability study conducted in Nakapiripirit Town Council

	Mean ± SD	**N=440**	**%**
Mean Age of children (months)	34.80±9.65		
Mean MUAC (cm)	12.1±0.34		
Average age of respondents/caregivers (years)	28.9±6.60		
Sex of children			
Male		251	57.1
Female		189	42.9
Respondents/caregivers relationship to children			
Mother		378	85.7
Others		62	14.3
Education level of mothers/ caregivers			
No formal education			57.2
Primary level			33.3
Secondary level			9.5
Tertiary level			0

4.4.1 Sensory evaluation of the food supplements by care givers/respondents

Overall, based on sensory preferences, CSB+ and SPB were acceptable to mothers/ caregivers. CSB+ was ranked higher in terms of taste compared to SPB (Table 4.6). With the exception of taste, which varied significantly (p=0.009), there were no significant differences in the other attributes such as colour, aroma, mouthfeel and child's degree of liking between the porridges made from the two food products.

Table 4.6: Sensory evaluation of the products' porridge by respondents/caregivers

Attributes	**CSB+**	**SPB**	**p-Value**
Colour	4.76±0.43	4.57±0.59	0.258
Aroma	4.33±0.48	4.29±0.64	0.815
Taste	4.81±0.40	4.33±0.73	0.009
Mouth feel	4.28±0.46	4.38±0.66	0.605
Consistency	4.24±0.44	4.05±1.36	0.493
Overall acceptability	4.71±0.46	4.48±0.51	0.649
Child's degree of liking	4.76±0.43	4.57±0.59	0.258

*Values which are bolded are significantly different ($p<0.05$), N=42

4.4.2 Consumption pattern of CSB+ and SPB by the children

Consumer intents for both products were assessed using a 5-point rating scale. Majority of the mothers reported that they fed their children on supplements thrice a day while a few indicated they did so to at least twice a day. The products were *'liked a lot'* or generally *'liked'* by the children as indicated by the quantities consumed in a short time (Table 4.7). Sensory preference evaluation is related to normal feeding.

Table 4.7: Consumption of corn soy blend plus and sorghum peanut blend by the children

Attributes	**CSB+**	**SPB**	***t-test, p*-Value***
Quantity consumed of 300ML			
Day 2 (mL)‡	297.38±3.75	295.48±3.80	0.88
Day 4 (mL)	296.90±3.70	297.14±4.05	0.833
Pooled (mL)	297.14±3.67	296.31±3.99	0.291
Feeding duration			
Day 2 (min)‡	8.19±1.50	8.33±1.59	0.379
Day 4 (min)	8.09±1.51	8.14±1.52	0.815
Pooled (min)	8.14±1.50	8.24±1.54	0.456
Velocity of food intake			
Day 2 (mL min^{-1})‡	37.15±8.27	37.44±7.98	0.247
Day 4 (mL min^{-1})	37.85±8.03	38.07±7.91	0.058
Pooled (mL min^{-1})	37.51±8.09	37.76±7.86	0.660

CSB+: Corn soy blend plus. SPB: Sorghum peanut blend. *Results of day 1 are not since it was to allow mothers and children adjust to the study protocol and the new environment. The level of significance for all tests is $p < 0.05$. ‡Mean (95% confidence interval)

The quantities of food products (CSB+ and SPB) consumed by the children over the two-week period acceptability test period are shown in Figure 4.1.

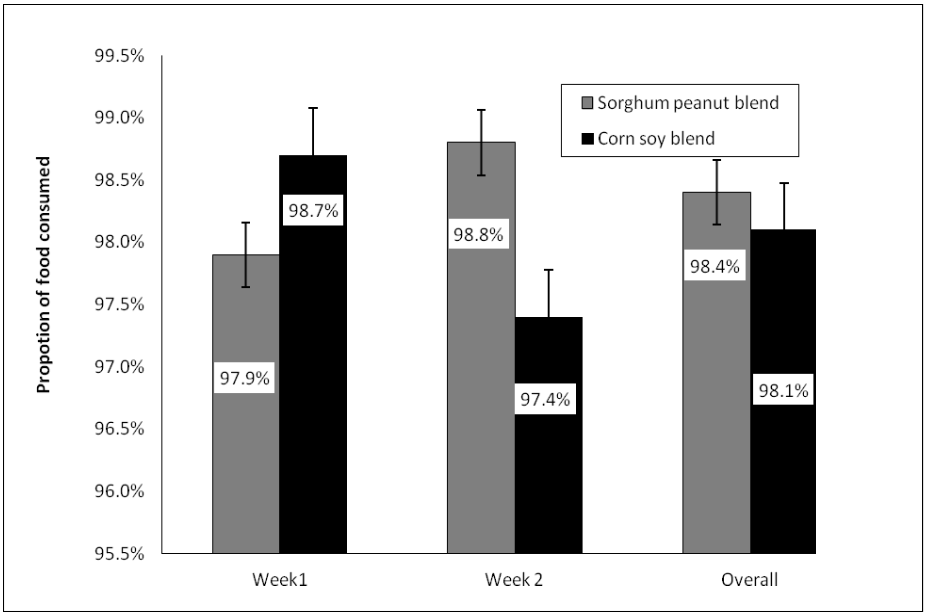

Figure4.1: Percentage of food ration consumed over the two weeks home use trial in relation to the given ration

4.4.3 Morbidity levels and side effects experienced by participants during the two-week home use trial) acceptability test

During the two-week feeding trial, no side effects relating to consumption of the food supplements were reported. A substantial number of respondents/caregivers reported that their children suffered from diarrhoea, fever and acute respiratory infections (ARIs). The highest prevalence of illnesses was reported for ARIs but this was not related to the food supplements.

4.4.4 Respondents'/caregivers' post-testing perceptions on the food supplements at exit interview and focus group discussions

Details concerning the responses to the exit interview after the home use trial are presented in Table 4.9. Majority of the caregivers, over 80% across both food supplements reported feeding children on the porridge three times a day while a few did so twice. Most of them (90%) reported that they freshly prepared the porridge at the feeding times while some prepared the porridge once a day and kept the porridge in thermos flasks. All the caregivers considered both food supplements beneficial to their children and were willing to continue feeding them to their children if they were provided with the supplements. All the caregivers (100%) did not have issues with the porridge preparation methods which they reported were time saving and very easy to learn.

The caregivers considered the supplements beneficial because the weight of their children increased upon supplement consumption. One mother remarked, "My child's health status has improved after recovering from fever due to feeding him with this porridge; he is now more energetic and plays a lot". Another reason why the food supplements were liked was that no side effects were associated with the food supplement. Furthermore, the caregivers reported that they and the children liked the aroma and taste sensory attributes of the SPB; and the familiarity of raw materials used. The following statement by a mother illustrates this point; "My child likes this food product because it is sweet and has butter like aroma. In addition, it is very easy to prepare the porridge; it takes just a few minutes to do so”. All the caregivers who participated in this study indicated that, if they were empowered to practice bee farming and trained on how to formulate SPB, the product would provide a home-based solution to malnutrition in Karamoja.

Consumer intent of both products was also assessed using a 5-action rating scale. Majority of the mothers reported that based on the rate at which their children were consuming the supplement; they would continue to feed the children on the product thrice a day while a few indicated that they would feed their children at twice a day depending on the food security situation in the household. On average, consumption intent of greater than 4 was recorded.

Table 4.8: Participants perceptions towards CSB+ and SPB

Response	**SPB (N=21)**		**CSB+ (N=21)**	
	n	**%**	**n**	**%**
Feeding Frequency				
Once				
Twice	4	19.0	2	9.5
Thrice	17	81.0	19	90.5
Views regarding preparation method				
Easy	21	100.0	21	100.0
Difficult				
Willingness to continue feeding the child				
No				
Yes	21	100.0	21	100.0
Supplement beneficial to the child				
No				
Yes	21	100.0	21	100.0
Negative and adverse effects				
No	21	100.0	21	100.0
Yes				

4.5 Efficacy of SPB and CSB+ in curing Moderate Acute Malnutrition (MAM)

4.5.1 Enrolment of study participants into the study

A total of 1600 children aged 6-59 months were screened for acute malnutrition, of which 464 had MUAC readings between 11.5 to 12.5cm and WHZ, < -2 to ≥ -3 Z-scores without bipedal oedema and hence were classified as moderately malnourished. Of the total children with MAM (N=464), 440 children were recruited into the study; 220 each for the two study arms (Figure 4.3). There were no households with two children enrolled into the study. Overall, a total of 392 children completed the study, 198 (90%) in SPB group and 194 (88.2%) in CSB+ group. A total of 48 children, 22 SPB and 26 CSB+ dropped out of the study because either the caregivers moved out of the study area or withdrew consent to participate in the study without indicating the reason. Those who moved out of the study site could probably be attributed to the nomadic lifestyle of the population in search for pasture and water. Karamoja is a semi-arid region thus people are usually on the move in search for pasture and water for their livestock.

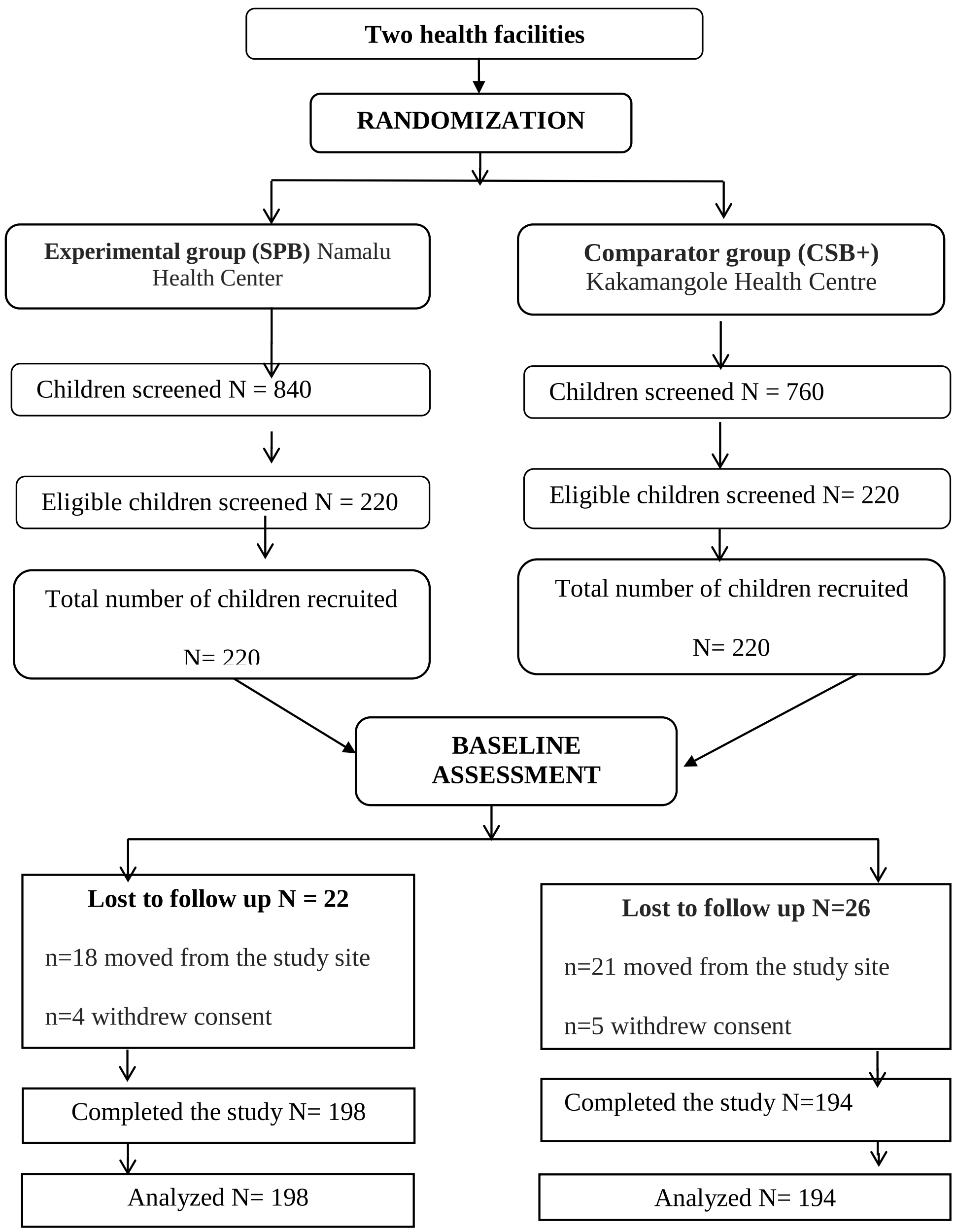

Figure 4.2: Schematic presentation of enrolment and completion of study participants

4.5.2 Comparison of the study groups at baseline

4.5.2.1 Comparison of socio-demographic characteristics of the study population by study groups at baseline

Equal numbers (220) of moderately malnourished children aged 6-59 months were recruited into each of the two study groups (The proximate/ nutrient analysis Table 4.1). There were significantly more male children in the SPB group (55.5%) compared to the 43.6% in the CSB+ group (chi-square test; p=0.013). The majority of the respondents (about 95.0%) in each of the study groups were mothers of the index children. Most (over 92.0%) of the respondents had no formal education and this was not significantly different between the study groups (chi-square test; p=0.759). The majority of the respondents, 74.5% in the CSB+ group and 81.4% in the SPB group, were in the age category 15 – 34 years with no significant differences between the groups (Chi-square test; p= 0.179). Large proportion of children in both groups 65.5% in the CSB+ and 55.9% in the SPB groups, suffered from fever in the two weeks before recruitment into the study although the difference between the groups was insignificant (Chi-square test; p=0.068).

In regards to waste disposal, majority of the households disposed faeces in private or community latrines; 71.8% in the CSB+ and 69.1% from the SPB group (Chi-square test; p=0.531). Slightly over half of the households in both the study groups treated drinking water, 55.9% in the CSB+ group and 56.8% in the SPB group(Chi-square test; p =0.390). The majority of the children (78.2% from the CSB+ group and 76.8% in the

SPB group) slept under insecticide treated bed-nets (Chi-square test; p=0.732). About half of the households in each of the groups; 45.0% and 49.5% in the CSB+ and the SPB groups respectively had acceptable food consumption scores, indicating that they were food secure (Chi-square test; p=0.572).

Table 4.9: Socio-demographic and anthropometrics characteristics of participants

Characteristics	**CSB+** (N = 220)	**SPB** (N = 220)	**(Chi-square p value)**
	n (%)	n (%)	
Respondent relationship to children			
Mother	209(95.0)	210(95.5)	0.8230
Caregiver	11(5.0)	10(4.5)	
Education level of respondents			
Non formal education	207(94.1)	204(92.7)	0.7590
Primary	12(5.5)	14(6.3)	
Secondary	0(0.0)	1(0.5)	
Tertiary	1(0.5)	1(0.5)	
Age of respondents (years)			
15 – 34	164(74.5)	179(81.4)	0.1790
35 – 44	44(20.0)	28(12.7)	
45 and above	12(5.5)	12(5.5)	
Sex of children			
Male	96(43.6)	122(55.5)	0.0130
Female	124(56.4)	98(44.5)	
Mean age of children (months)	30 ± 9.1	31 ± 8.8	
Morbidity based on 2 week recall			
Fever	144(65.5)	118(55.9)	0.0680
ARI*/Cough	11(5.0)	15(6.8)	
Diarrhoea	20(9.1)	5(2.3)	
Disposal of faeces			
Private/community latrine	158(71.8)	152(69.1)	0.5310
Bush/open air	62(28.2)	68(30.1)	
Treatment of drinking water			
Yes	123(55.9)	125(56.8)	0.3900
No	92(41.8)	95(43.2)	
Children sleeping under ITN**			
Yes	172(78.2)	169(76.8)	0.7320
No	48(21.8)	51(23.2)	
Food consumption scores			
Poor consumption	46(20.9)	39(17.7)	0.5720
Borderline Consumption	75(34.1)	72(32.7)	
Acceptable consumption	99(45.0)	109(49.5)	

*ARI = Acute Respiratory Infections; **ITN = Insecticide treated bed-nets

4.5.2.2 Comparison of the anthropometric measurements and nutritional status of the children at baseline by study groups

The mean weight of the children in the CSB+ group was 9.8 ±1.9 kg and 10.1 ±2.0 kg in the SPB group (Table 4.11). This difference was not statistically significant (t-test; p=0.135). The mean height measurement in the CSB+ was 86.3 ±8.5 cm and in the SPB group it was 86.3±9.0cmand again this difference was not significant (t-test; p=0.992). MUAC measurements for the children in the two study groups were not significantly different (CSB+ 12.1 ±0.35 and SPB 12.1 0.30; t-test; p=0.470). Similarly, the mean height for age Z score were not significantly different in the two groups; CSB+ -1.51±1.48 and SPB -1.57±1.45; t-test p=0.672 (Table 4.11). In contrast, the mean weight for- height and weight for age Z scores were significantly different in the study groups. In the CSB+ group, the mean weight for height Z scores was -2.35±0.29 whereas in the SPB group it was -2.09±0.12; t test; p<0.001. The mean weight for age Z score in the CSB+ was -2.44±0.89 and in the SPB it was -2.27±0.82; t test; p=0.027).

Table 4.10: Baseline anthropometric characteristics of study children

Anthropometric	CSB+ N=220 (Mean ± SD)	SPB N=220 (Mean ± SD)	t-test p-Value
Weight (Kg)	9.8 ± 1.8	10.1 ± 2.0	0.135
Height (cm)	86.3 ± 8.5	86.3 ± 9.9	0.992
MUAC (cm)	12.1 ± 0.35	12.1 ± 0.3	0.470
Weight for height, Z score	-2.35 ± 0.29	-2.09 ± 0.12	<0.001
Weight for age, Z score	-2.44 ± 0.89	-2.27 ± 0.82	0.027
Height for age, Z score	-1.51 ± 1.48	-1.57 ± 1.45	0.672

Values are means ± SD, Weight-for-height Z- score, p>0.05 no significant difference and values which are bolded are significantly different.

4. 5.3 Impact of the intervention on nutrition performance and nutrition indicators

The efficacy of SPB in the treatment of MAM compared to the traditional CSB+ was measured using recovery rate, mean length of stay on the treatment before recovery, defaulter rates, death rates and morbidity prevalence as the performance indicators

The proportion of children who recovered from MAM in the SPB group was 91.4% compared with 87.1%in the CSB+ group although this difference was not statistically significant (Chi-square test; p=0.193). Non-response rates/those who did not recover from MAM was 8.6% in the SPB group and 12.9% in the CSB+ group (Table 4.12). The non-response rate observed for the CSB+ group was higher than the 10% acceptable level. Meanwhile the defaulter rate was 10% in the SPB group and 11.8% in the CSB+ group. The mean weight for height Z scores at discharge for children in SPB was significantly higher (-0.88±0.34) implying better nutritional status of children) compared to -1.149±0.43 in the CSB+ group. No death was recorded among the children during the intervention. The morbidity rates were significantly lower in both study groups at the end of the intervention but were not significantly different between the study groups (Table 4.11).

Table 4.11: Impact of the interventions on programme performance and nutrition indicators

Outcome	**SPB (N = 198)**		**CSB+ (N = 194)**		**Chi-square; t-test p value**
	Mean ± SD	n (%)	Mean ± SD	n (%)	
Recovered		181(91.4)		169(87.1)	0.193
Not recovered		17(8.6)		25(12.9)	
Defaulters		22 (10)		26 (11.8)	
Mean WHZ at discharge	-0.88±0.33		-1.149±0.43		<0.001*
Mean HAZ at discharge	-1.6 ± 1.45		-1.6 ± 1.48		0.969
Diarrhoea		8(3.6)		8(3.6)	
Vomiting		4(1.8)		1(0.45)	
ARI		12(5.5)		10(4.5)	

WHZ = weight-for-height Z score; HAZ= height-for-age z score, Values are means ± SD or n (%); bolded values are significantly difference at $p<0.05$

Although recovery rate was higher among SPB group, those on CSB+ recorded a faster recovery. Children in the CSB+ group recovered significantly faster (median 43 days) than those in the SPB group whose median recovery duration was a median 57 days Kaplan-Meir Survival analysis in Figure 4.3.

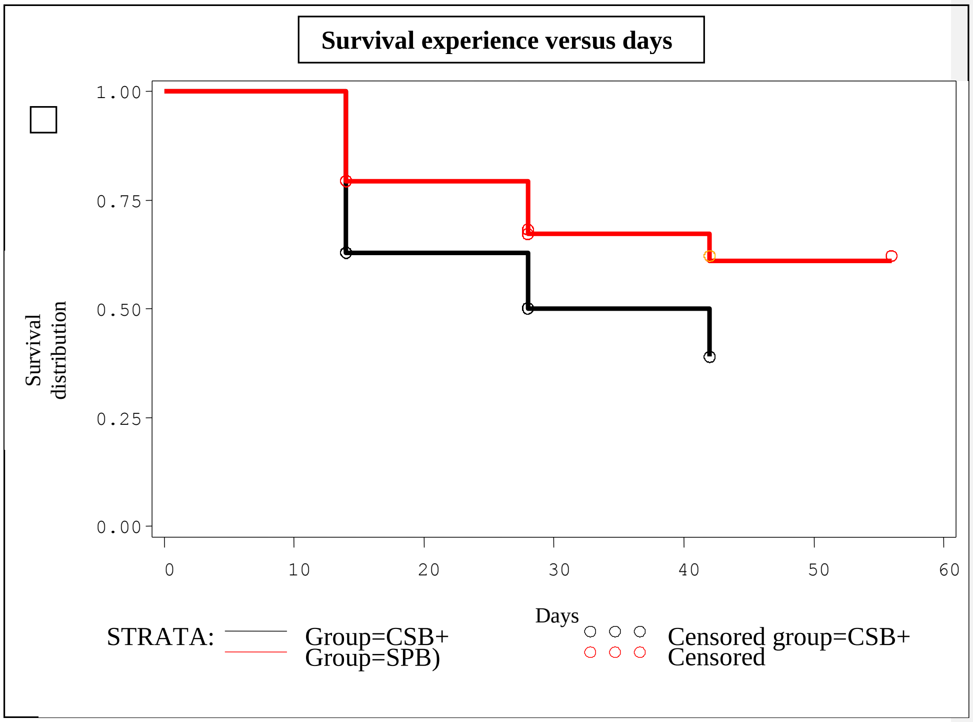

Figure 4.3 : A comparison of Recovery trend of children on the two food supplements

4.5.4 Predictors of recovery time

A pooled multivariate accelerated failure time (AFT) analysis of the two study groups showed that baseline age and type of food supplement received predicted recovery time; p<0.001 and p=0.021 respectively (Table 4. 13). There was no significant difference observed in recovery rate on the basis of sex (p = 0.287) and the baseline weight-for-height status (p= 0.568).

Table 4.12: Predictors of recovery time

AFT -Model

No. of subjects=427				LR chi2(4)=263.64	
Log likelihood=84.964				Prob> chi2=0.000	
T	Time ratio	Coef.	Std. Err.	z	P>z
Age at admission	0.985	-0.015	0.006	-2.300	0.021
Sex					
Female	1.000	0.000			
Male	0.887	-0.120	0.113	-1.060	0.287
Food item (Treatment)					
SPB	1.000	0.000			
CSB+	12.57	2.531	0.185	13.680	0.000
Baseline weight-for-height	0.851	-0.162	0.283	-0.570	0.568
Constant		-12.659	0.964	-13.140	0.000

4.6Cost analysis of the formulated food product

The cost of the food products SPB was calculated based on price of 1kg of the food items and the proportion of the amount of the food item in the formulated product. One kilogram of sorghum costs 500 Uganda shillings; 1kg of groundnut costs 2000 Uganda shillings, 1 litre of ghee cost 7000 Uganda shillings and 1litre of honey cost 5000 Uganda shillings and the proportion of the food stuffs in 1kg of supplement formula is 40g honey, 20g ghee, 44g of peanut and 160g of sorghum respectively, the weight on each component multiplied by price per gram a total cost of US$ 0.81/kg was obtained for SPB while the cost of CSB+ is US$ 0.83/kg (WFP, Uganda FOB price, 2013). No significant difference was noted between the costs of the two products. The project implementation cost for distribution of CSB+ to beneficiaries would be the major factor in cost differences. This may be very costly when transportation and other subsidies are considered. Accordingly, CSB+ and other blended infant foods are 2 to 3 times as expensive as basic staple foods when transportation and other subsidies are considered. Sorghum and peanut are staple foods in most parts of Uganda particularly Karamoja sub region. Ghee at US$1.92/kg and honey at US$ 2.69/kg were the most expensive raw materials in the local market but are common household commodities in Uganda.

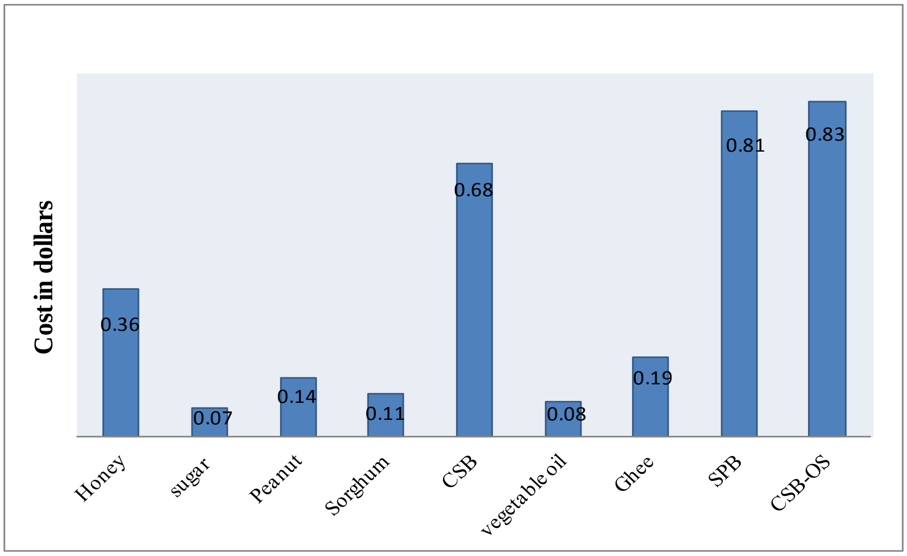

Figure 4.4: Costing of SPB and CSB+ in dollars per kilogram

CHAPTER FIVE: DISCUSSION

5.1 Introduction

In this chapter, the results of the study on nutrients and anti-nutrient content, acceptability, efficacy and cost of SPB and CSB+ are discussed in relation the study objectives, hypotheses and findings/results.

5.2 Nutritive and anti-nutritive contents of the CSB+ and SPB food supplements

5.2.1 Macro-nutrient contents of the product

In terms of protein content, CSB+ and SPB contained substantial proportions of protein. The amount of protein in CSB+ was significantly higher ($p<0.05$) than that in SPB but the amount were within the minimum recommended levels of 14% by CODEX (1981) for management of MAM. Accordingly, protein contents of the two supplementary food products provides for recommended daily intakes (RDI) (26g/1000kcal, 10.4% protein energy) for children of 6 to 59 months of age who are moderately malnourished (Golden, 2009). Protein recommendation by FAO/WHO and Institute of Medicine (IOM) for normal children is set at 21g/1000kcal (WHO, 2007). A diet containing 24g of protein per 1000kcal has also been recommended (Golden, 2009) for recovery of children suffering from moderate acute malnutrition. Peanuts contain high proportion of protein of high biological value. It has almost all essential amino acids particularly leucine and alanine save for methionine. SPB has adequate quantity (14.56%) and quality of protein required for management of MAM among children.

Levels of moisture in corn-soy blend plus (CSB+) and sorghum-peanut blend (SPB) were within the range recommended (<10%) for proper storage of dehydrated foodstuff

(Alimentarius, 1981). High moisture levels (above 10%) accelerate spoilage by promoting microbial activity and chemical reactions that reduces product shelf life. Sufficient drying of raw materials is critical for proper storage of supplementary foods.

The fat content in SPB was significantly higher compared to that in CSB+. The fat content of both products were above the prescribed minimum levels of 6% specified by (Alimentarius, 1981) for treating moderate malnutrition in children. Ghee and peanut contributes to the high amounts of fat in SPB. A child suffering from MAM has high energy needs requiring a diet of sufficient fat content. Fat is also needed in the absorption of vitamins A and E(Malnutrition Forum, 2015). Vitamins A and E are vital for immediate recovery from acute malnutrition to reduce disease incidences in children. Milk-based products have been demonstrated to boost children's growth and immunity associated with fat-soluble vitamins(Dossou, Ndour, Briend, Wade, & others, 2003). It is desirable that supplementary diets contain high fat content to provide the required energy to the malnourished child.

CSB+ contained significantly higher level of carbohydrate than SPB. Carbohydrates (sugars and starches) provide energy to cells in the body, particularly the brain. The recommended dietary allowance (RDA) for carbohydrate is set at 130 g/d for children aged 6–59months (IOM, 2005). Carbohydrates in the prototype (SPB) are mainly derived from honey and sorghum. About 95% of dry matter in honey is composed of carbohydrates, mainly fructose and glucose (Bogdanov, Jurendic, Sieber, & Gallmann, 2008). A high percentage of carbohydrates in honey comprises of simple sugars that are easily absorbed (Bogdanov et al., 2008; White & others, 1975). Levels of carbohydrates in CSB+ and SPB were adequate to provide sufficient energy for a child to recover from moderate malnutrition.

The total energy in SPB was higher than that in CSB+ although this was not significant. Energy density is an important quality of diets formulated for moderately wasted children given their increased energy need (King & Garza, 2007). The energy contents of SPB and CSB+ were above the minimum value of 380kcal for fortified blended foods (FBF) specified by technical specifications of (United Nations University & WHO, 2004).

Corn-soy blend plus and SPB contained low dietary fibre although the amount was significantly higher in the SPB. Dietary fibre plays vital physiological and biochemical roles in digestion. Particularly, soluble fibre imparts prebiotic properties while insoluble fibre prevents constipation. According to (King & Garza, 2007), constipation is not a major issue in malnourished children. This dictates low amount of insoluble fibre in the diets while that of the soluble should be high. Unfortunately, because of limited evidence on problems caused by insoluble fibre in children, no limits have been set. Based on extrapolation, a total dietary intake of 11g/1000kcal is recommended in formulations of supplementary foods (Golden, 2009). A lower value of 0.5 g/kg body weight has been proposed. A further reference intake suggested for children 3 years and above for dietary fibre intake is 5 g plus 1 g for each year of age (Dwyer, 1995).

(Williams & Mills, 1970)recommend that children older than 2years of age consume a minimum amount of dietary fibre equivalent to age plus 5 g/d. A safe range of dietary fibre intake for children is between age plus 5 and age plus 10 g/d. This range of dietary fibre intake is considered to be safe for normal laxation, and helps prevent future chronic illnesses. In general, the “age plus 5” rule may be useful when determining the appropriate amounts of dietary fibre in diets for children. Based on the above recommendations, amounts of dietary fibre in CSB+ and the prototype remain within healthy levels for MAM children.

5.2.2 Micro-nutrient contents of the product

5.2.2.1 Mineral content

The amount of ash in SPB was lower than in CSB+.CSB+ is fortified with minerals and is therefore expected to have higher mineral contents than SPB. Sorghum contains reasonable amounts of mineral, close to that found in SPB (Gassem & Osman, 2003). The level of iron in SPB was lower than in CSB+. The amounts of iron in both products were within recommended levels (9mg/1000kcal) for local diets formulated for malnourished children (Golden, 2009). In most malnourished children, storage levels of iron increases and may not decrease even in cases of severe anaemia. Anaemia is linked to multi-micronutrient disorders rather than iron deficiency alone. For example, it is has been associated with malaria and intestinal parasites. Iron nutrient density should therefore not be high but rather modest in diets formulated for malnourished children. Diets high in iron have been found to increase mortality rates (Ramdath & Golden, 1989). Iron supplements may therefore be recommended for other functions other than that of anaemia. It is a vital part of haemoglobin required in sizeable amounts in children (King & Garza, 2007). This enhances oxidation of food components to provide energy which is highly required in children.

Levels of sodium in the two products were not statistically different. Sodium is the main electrolyte in extracellular fluids. Total sodium in the body, instead of decreasing, increases considerably during malnutrition. This increase stems from the slowing down of the sodium pump and potassium diminution therefore increasing intracellular sodium (Patrick, 1978). Diets that contain high sodium concentrations would then be detrimental arising from toxicity. Accordingly, requirements for moderately malnourished children have been set at a far lower level than that for normal children. Levels of sodium in SPB and CSB+ do not exceed the maximum recommended amount of 550mg/1000kcal set by Golden (2009).

Corn-soy blend plus contained significantly higher amounts of zinc than SPB. Zinc helps in preventing diarrhoea in malnourished children. It is also essential for growth and synthesis and maintenance of lean body mass (King & Garza, 2007). Zinc is often the limiting growth nutrient in diets of populations with high prevalence of malnutrition. During weight loss, large amount of zinc is liberated from the tissue as a result of catabolism (Fell et al., 1973). Consequently, in moderate acute malnutrition muscle zinc concentration falls from 81 to 64mg/kg (Cheek, Hill, Cordano, & Graham, 1970). Zinc amount in CSB+ was close to the range of 4.25 to 5.75mg/100g recommended by WFP (2002). The level of zinc in SPB was lower than the prescribed value. According to (Williams & Mills, 1970), a diet with lower levels of zinc results in anorexia hence sufficient amounts have to be availed through complementary sources to support normal growth. Golden (2009) has recommended a nutrient density for zinc in local food-based diets of 13 mg/1000 kcal for moderately malnourished children. However, according to

(King & Garza, 2007) formulations using local foods may not attain these recommendations except through fortification.

The levels of potassium in both products were within the value (1400mg/100kcal) recommended by Golden (2009) for moderately malnourished children. Depletion of potassium takes place in all malnourished children. Supplementary diets should contain sufficient potassium to maintain a renal excretion of 27mg/kg/day and a faecal excretion of 39mg/kg/day (Golden, 2009). Based on these considerations, the concentration of potassium present in SPB could repair tissue deficit of potassium in about three days for children.

The amount of magnesium in SPB was not statistically different from that in CSB+. Both products met the recommended levels of 200 mg/1000 kcal (Golden, 2009). Magnesium is a growth nutrient and deficiency has a negative influence on growth since its deficiency interferes with protein utilization. Magnesium is particularly important for stunted children who need to grow.

No significant difference was observed in calcium levels of both products. It is recommended that, diets should contain adequate amounts of calcium to avoid osteoporosis (Garn, Rohmann, Behar, Viteri, & Guzman, 1964). In developing countries, even in cases of normal children, calcium levels are very low in most diets (Prentice, Laskey, Shaw, Cole, & Fraser, 1990). It is necessary that diets have sufficient calcium for normal bone density to be restored and maintained. In addition, according to (Golden, 2009), the calcium: phosphorous ratio should be maintained within the range of

0.7 to 1.3 for all children above 6 months of age. Golden (2009) has recommended levels of 840mg/1000kcal if the formulation is to be fortified and 600mg/1000kcal if it's based on local foods. Levels of calcium in SPB and CSB+ were adequate for rehabilitating a malnourished child.

Corn-soy blend plus contained low amounts of manganese significantly lower than in SPB. Manganese is required during iron metabolism and its deficiency is associated with anaemia and skin lesions (Golden, 2009). Epilepsy in humans is also linked to low levels of manganese in the body (Carl et al., 1986). Malnourished children are shown to have lower levels of manganese compared to their normal (García-Aranda, Meza-Camacho, & Pandzich-Arapov, 1990). Diets for malnourished children should therefore be rich in manganese to make-up for the deficiency. Levels of Manganese in SPB are above the 1.2mg/1000kcal recommended by (Institute of Medicine, 2002) for management of malnutrition among children.

Phosphorus content was significantly higher in SPB than CSB+. In ill health, phosphate plays a critical role as a major acid-base buffer of the body and is critical for renal excretion of the acid generated. In moderately malnourished children, rickets is associated with phosphorous deficiency. Phosphorous is likely to be a limiting nutrient in treatment of MAM (King & Garza, 2007). The amounts of phosphorus present in SPB meets the minimum amounts of 600mg/1000kcal recommended by Golden (2009) for diets formulated from only local foods.

5.2.2.2 Vitamin A and β-carotene

The amounts of β-carotene, a pro-vitamin A, was at 3.47mg/100g and 3.13mg/100g in CSB+ and SPB respectively. The high amounts of vitamin A in CSB+ premix is a result of fortification while that in SPB is solely contributed by ghee. A retinol density of 1900µg/1000kcal is recommended for a fortified food meant for management of MAM in children less than five years of age (Golden, 2009). For a diet formulated from local food materials, a retinol density of 960µg/1000kcal is considered adequate (Golden, 2009). However, if Vitamin A capsule distribution is in place with a verified wide coverage, then FAO/WHO (2001) recommends a retinol density of 600µg/1000kcal for a local food formula. Vitamin A coverage distribution in Karamoja sub-region is above the 90% FAO/WHO recommended levels (UDHS, 2011). Therefore, the vitamin A levels present in SPB can sustain MAM recovery for the majority of children in this area. The concentration of β-carotene, a pro-vitamin A, was at 3.47mg/100g and 3.13mg/100g in CSB+ and SPB, respectively. The high level of beta-carotene in SPB makes it vital for supplementary feeding.

5.2.3 Fatty acid profile

No significant difference ($p<0.05$) existed in the proportion of EFAs in the two food supplements. Essential fatty acids (EFA) are required for brain and neural tissue development. Malnourished children have low levels of essential fatty acids (EFA), particularly omega-3 FA (Hansen and Wiese, 1954). Moderately malnourished children have a dry, flaky skin resulting from the deficiency of EFA (Hansen, 1954). A diet comprising of 5g/1000kcal omega-6-FA and 0.85g/1000kcal omega-3 FA is recommended for rehabilitating malnourished children. The amounts present in both food supplements were substantial albeit lower than recommendations.

5.2.4 Levels of anti-nutrients in the food supplements

Sorghum-peanut blend had significantly higher anti-nutrient content than CSB+. The level of tannins in SPB was close to those reported by (Waniska, 2000)for sorghum. Condensed tannins even at a low level possess an astringent taste which contributes to a decreased intake of foods. Additionally, condensed tannins inhibit enzymatic digestion of protein by forming complexes with large quantities of proteins but this only occurs when present in high amounts. Levels of tannins in SPB pose no nutritional problems given that amounts were low.

The phytate content of SPB was higher than that of CSB+ however both values are lower than the values in some edible fruits and legumes. The high levels of phytates in SPB could be due to high levels of phytates in sorghum and peanut (Waniska, 2000). A diet containing substantial amounts of phytates reduces bioavailability of minerals particularly iron, calcium, magnesium and zinc which are important in treatment of MAM (King & Garza, 2007).

Sorghum and peanuts contain high levels of trypsin inhibitors (Gassem & Osman, 2003). This explains the high levels of trypsin inhibitors in SPB. The high trypsin inhibitor levels in CSB+ are contributed largely by soy being the most concentrated source of trypsin inhibitors among all foods. But soy forms a small percentage (about 21%) of the formulation. The extrusion process used in CSB+ reduces levels of trypsin inhibitors explaining its low content. High levels of trypsin inhibitors may result in increased size of the pancreas and inhibition of child growth (Golden, 2009). Trypsin inhibitors can have a negative effect on growth but there is lack of data for malnourished children (J. C. King & Garza, 2007). Thermal processing reduces the activity of trypsin inhibitor. Traditional methods such as roasting also inactivate trypsin (Hotz & Gibson, 2007). The low levels of trypsin inhibitors in SPB could be a result of processing of the raw materials.

5.2.4 Aflatoxin content

Aflatoxin amounts reported were below the upper limits (20ppb) stipulated by Food and Drug Authority (FDA) and Codex Alimenterius (1981). Aflatoxin intake has been associated with growth retardation, immune suppressing abilities and synergistic effects with infectious diseases like malaria and HIV in children. According to (J. C. King & Garza, 2007)and Golden (2009), it is not possible to completely avoid this toxin and the goal is to reduce it to levels below limits 20ppb.

5.3 Acceptability of SPB and CSB+

Sensory attributes of food products strongly correlates with level of acceptance (Saba, Moneta, Nardo, & Sinesio, 1998). All sensory attribute means for CSB+ and SPB porridges were above 4.0 with no evidence of allergic reactions. This signifies a general liking for the two food supplements. Appearance is important in the choice and rejection of a food product. Humans perceive aroma and taste of a food product basing on its colour. SPB had an appealing colour stemming from the red colour of sorghum coupled with the glossy appearance of honey. This could have improved SPB's acceptability. It is also likely that the subjects were already used to the raw food materials being their staples. The yellow appearance of CSB+ powder was generally acceptable to the subjects. Sensory attributes of corn soy blend plus (CSB+) and sorghum peanut blend (SPB) were acceptable by mothers and caregivers.

The mothers preferred the taste of CSB+ to SPB although this did not affect the consumption of SPB. The appearance, aroma, taste and mouth feel of food products strongly correlates with the level of acceptance (Saba et al., 1998).

Food consistency score (>4) of porridges prepared from CSB+ and SPB were appropriate for complementary (supplementary) foods for infants and children (Brown, Dewey, & Allen, 1998). Consistency of complementary foods has been demonstrated to have a direct correlation with preference among children (Parker, Schroeder, Begin, & Hurtado, 1998). A thick porridge would require more effort to swallow limiting its intake by young children (J. King & Ashworth, 1987). On the other hand, a thin porridge means low energy density which is also undesirable. A semi-liquid porridge is appropriate for feeding infants and children on cereal-based foods (Codex, 1981). Mouth feel ratings of SPB and CSB+ were acceptable. Mouth feel is an important attribute in a child's feeding and determines the quantity of food consumed. A young child swallows a smooth gruel at ease compared to a coarse product and the ranking of coarseness of SPB in comparison to CSB+ by mothers is all very high on the hedonic scale.

Sweet taste has been demonstrated to have a positive effect on food product acceptability by children (Owino, Sinkala, Amadi, Tomkins, & Filteau, 2007; Pérez, Dalix, Guy-Grand, & Bellisle, 1994). This is supported by the fact that humans are born with innate preferences for sweet taste (Kern, McPhee, Fisher, Johnson, & Birch, 1993). CSB+ had a better taste score than SPB. Sugar is used in the formulation of CSB+ while SPB contained honey. Formulations of complementary foods with addition of sugars are shown to be better preferred by young children than those products without (Muhimbula, Issa-Zacharia, & Kinabo, 2011). This could be a strong point for the preference of CSB+ by infants over SPB. The taste of SPB and CSB+ were both within the acceptable range (4-5). Honey contains over 80% simple sugars which contributes most to the sweet taste of SPB (White, 1975). In addition, it contributes to weight gain, digestibility, immunity building, and medicinal properties (Ramenghi, Amerio, &Sabatino, 2001). During focus group discussions, a number of mothers proposed the use of sugar during SPB formulation instead of honey. This is possibly because it is convenient to prepare porridge from CSB+ that contained sugar than that of SPB with honey .At the moment, a few households in Karamoja can afford sugar making honey a better option. Sugar could be used by families that can afford it.

Aroma is known to influence the taste of the product. Low aroma ratings could reduce the acceptability of the food by young children. However, preferences in infants and young children are learned, not innate and developed slowly (Bovell-Benjamin, Allen, & Guinard, 1999).Young children may detect ‘unpleasant’ smells, but may not judge them as ‘unpleasant’ until they are about 5 years of age (Mennella & Beauchamp, 1997). During the two-week feeding trial, no side effect relating to consumption of the food supplements was reported. Diarrhoea, fever and acute respiratory infections (ARIs) were reported by a substantial number of mothers. It is however difficult to associate specific illnesses and side effects on consumption of a particular food. The highest prevalence of illnesses was reported for ARIs but this was not in any way related to the food supplements as supported by the baseline study. It is recommended that the number of allergic and intolerance cases towards a certain food, should not exceed 10% (Bovell-Benjamin et al., 1999). In this study, all cases reported were below the 10% threshold required to declare a product to have adverse effects even though it may not be associated with consumption of CSB+ and SPB.

Overall, focus group discussions with mothers and caregivers strongly indicated a liking for the two supplementary products. According to the focus group discussions and sensory scores, most mothers and caregivers were willing to continue feeding children on the two products. (Cardello, Schutz, Snow, & Lesher, 2000; Moskowitz, 1991) demonstrated that food consumption behaviour is an index that assesses attitudes of people towards a food product. A person may like the product but may not be willing to consume it on a regular basis or in large amounts (Moskowitz, 1991).The amount of food consumed over a given period of time can be used to assess consumer behaviours towards a food product (Cardello et al., 2000).

5.4 A comparison of the efficacy of SPB and CSB+ in the treatment of moderate acute malnutrition

The literature search so far conducted indicated no similar study comparing the efficacy and acceptability of a locally developed food supplement using local foods to treat moderate acute malnutrition using local foods with that of the standard WHO recommended treatment CSB+ and this also in agreement the standing committee on nutrition which suggested the need to CSB efficacy and development of local food supplements from locally available food stuffs (WHO, 2008). In this study, there was no significant difference in the cure rate on MAM between the children who received SPB and those who received CSB+ signifying that the two food supplements are equally effective in treating MAM in children. The cure rates in both groups were also within the acceptable levels of > 75% (Sphere Standards, 2004). Attaining the acceptable rate is a challenge in many settings even in studies, using CSB+ to treat MAM (Matilsky, Maleta, Castleman, & Manary, 2009).This study demonstrated that achieving cure rates >75% is possible with appropriate food supplement design. The relatively high cure rates achieved with SPB may be explained by the fact that the product was comparable to CSB+ in energy content. Energy density is vital for recovery of moderately malnourished children (King & Garza, 2007). Energy is needed for catch-up growth and maintenance. During malnutrition both lean and fat tissue are lost and need to be replaced (Golden, 2009). A food supplement with a high energy density directly relates to increased recovery rates. The findings of this study demonstrate that it is possible to achieve the recommended recovery rates as per the Sphere Standards 2004 with appropriate formulation using local food materials.

Addition of health and nutrition education component as per the management of moderate acute malnutrition as demonstrated by Ashworth (2009) played a great role in the attainment of this recovery rate. Giving extra rations for caretakers to cater for the presumed sharing of the food product within households may also have contributed to the impact achieved in rehabilitating the children with MAM.

Honey used in SPB has been reported to contain a number of medicinal effects, although this claim needs further investigation. Honey strengthens the immunity, results in better weight gain as well as better blood formation when fed to young children (Bogdanov et al., 2008). Therefore, the honey used in SPB could have led to faster recovery from illnesses and therefore recovery of the children from MAM.

Children on CSB+ recovered faster than those on SPB. The nutrient profiles of SPB and CSB+ were not comparable for a number of nutrients. CSB+ had significantly higher levels of protein, carbohydrates, Vitamin A, zinc and potassium whereas SPB had significantly higher levels of fat (Amegovu et al., 2013). The nutrient profile of CSB+ was therefore superior to that of SPB. Without fortification, the recommended requirement of zinc is difficult to meet from a plant-based diet (Dop & Benbouzid, 1999; King & Garza, 2007). Zinc is vital for growth, development and plays a major role in immunity function. Zinc is a growth type II nutrient (Golden, 2009). Zinc is related to maintenance requirements, and has direct effects on the primary hormonal system (IGF-I/GH) that controls growth in the postnatal phase (Rivero-Urgell & Santamaria-Orleans, 2001). The zinc content of a diet has a direct relation to the rate of weight gain (Golden, 2009).

The inadequacies in the micronutrient levels of SPB could be taken care of through micronutrient supplementation of the children. The longer recovery time for children on SPB compared to CSB+ could be partly attributed to the lower zinc level in SPB than recommended for children with MAM (Amegovu et al., 2013; WHO et al., 2000). Additionally, without fortification, recommended requirements of Vitamin A are difficult to meet from a plant-based diet (Dop & Benbouzid, 1999; J. C. King & Garza, 2007). CSB+ is fortified with micronutrients while SPB was formulated locally without any fortification. Vitamin A is also vital for growth and development. The higher level of anti-nutrients in SPB (Amegovu et al., 2013)probably interfered with the absorption/bioavailability of some nutrients.

5.4.1The Predictors of recovery time

Growth rates are directly related to age, with young children growing at faster rates (Mercedes De Onis & WHO, 2006). Breast milk provides almost three quarters of recommended energy from fats (United Nations University & WHO, 2004). Younger children took a shorter time to reach the target weight compared to older ones, especially those over 4 years of age. Controlling other factors, a unit change in the age of the child measured in months resulted in a slowing of the time taken to reach target weight by a factor of 0.015. Being on CSB+ accelerated the time it took children to attain target weight by a factor 12.572 compared to their counterparts on SPB. Some of the younger children were still breast feeding, thus the combination of breast milk and food supplements may have partly contributed to the accelerated growth in the younger children. Sex of the child and nutritional status at baseline did not predict recovery rate and time.

5.5 Cost of SPB and CSB+

There was no difference in the cost of SPB and CSB+ based on the cost of the food raw materials. However, the cost of CSB+ is 2 to 3 times more expensive than SPB when transportation and other overhead costs are considered. Sorghum and peanut are staple foods in most parts of Uganda particularly Karamoja sub-region. Ghee and honey were the most expensive raw materials in SPB formula but these are common commodities which are locally produced in Uganda. It is important to note that the prices of commodities used in SPB formulation are much lower than the cost of implementing the distribution of CSB+. The local availability of raw materials makes SPB a cheaper home based food supplement. In this study we compared the costing of the products without putting into consideration the cost of implementation (cost effectiveness) like in other studies.

5.6 Hypotheses testing

The study hypothesis that there is no difference in nutrient and anti-nutrient levels was rejected because there were significant differences in the levels of some of the nutrients and also the anti-nutrient levels.

The study hypothesis that there is no difference in acceptability of CSB+ and SPB to treat moderate malnutrition in children and caregivers was accepted.

The study hypothesis that there is no difference in the levels of the efficacy using the CSB+ and SPB to treat moderate acute malnutrition is children 6-59 months old in Karamoja, Uganda was accepted.

The study hypothesis that there is no difference in the cost of the food supplements CSB+ and SPB was rejected.

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Introduction

The purpose of the study was to investigate and compare the: nutrient and anti-nutrient profile of CSB+ and SPB, acceptability of CSB+ and SPB by the study participants, cost of the CSB+ and SPB locally formulated food supplement, and the efficacy of CSB+ and SPB in treating moderate acute malnutrition.

Levels of nutrients in CSB+ and SPB differed despite the fact that the majority of the nutrients were present in amounts adequate for treatment of moderate acute malnutrition in children aged 6–59 months. In terms of macronutrients, CSB+ had significantly higher amounts of protein and carbohydrates whereas SPB had significantly higher amounts of fat and crude fibre. Proximate components and micro nutrients were available in adequate amounts in both products. There was no significant difference in terms of energy content in SPB and CSB+. Vitamin A level was higher in CSB+ than SPB. Proportions of essential fatty acids were low in both products. Levels of anti- nutrients; condensed tannins, phytates, and trypsin inhibitors were in higher levels in SPB but in amounts lower than the acceptable limits.

From the acceptability study, both food supplements were acceptable in the community. Sensory attributes (colour, taste, mouth feel, aroma and consistency) of both food supplements had a score greater than 4 on a 5 - point hedonic scale. The only significant difference in the sensory attributes was observed in the taste of the products;

mothers/caregivers preferred the taste of CSB+ compared to that of SPB. Caregivers reported that children liked both CSB+ and SPB. Mothers/caregivers from the two study groups concurred that both food supplements were beneficial to their children and were willing to continue using them.

Over all, SPB was not significantly different to CSB+ in treating moderate acute malnutrition in children aged 6-59 months. Cure rates were comparable in the study groups (91.4%) in the SPB and (87.1%) CSB+ (chi-square test, p=0.193). Duration of recovery was significantly shorter for CSB+ group; median 43 days than the SPB group; 57 days (Kaplan-Meier survival test). The predictors of recovery time were age, younger children recovered faster, and type of food supplement of given, those children on CSB+ recovered faster.

6.2 Conclusions

Despite the fact that the nutrient and anti-nutrient profile of the developed SPB are not directly comparable to that of CSB+, the product contains adequate amount of nutrients to treat MAM. The anti-nutrient content of SPB is within acceptable levels despite being significantly higher than levels in CSB+. SPB is therefore a potential food supplement for the treatment of MAM in the study community and in other similar regions where sorghum, peanut, honey and ghee are readily available and commonly eaten.

Both the food supplements; CSB+ and SPB were acceptable to the study participants based on the sensory evaluation and therefore both could be used for the treatment of MAM.

The SPB was as efficacious as CSB+ in the treatment of MAM albeit at a slower rate, although the rate was within the acceptable period.

Given the lower cost of production of SPB and the local availability of the food materials used in this food supplement, SPB has the potential to become a cost-effective, sustainable locally-available home-based food supplement for treatment of MAM in the study community and other similar circumstances. Nonetheless, sustainability in the use of SPB may be challenged by seasonality in the availability of the food materials used in its production especially given that agriculture in most of sub-Saharan Africa in rain-fed. Continuous availability of the food materials would therefore be a major challenge.

6.3 Recommendations for Policy/Practice

The government through the Ministry of Health should encourage the use of supplementary foods made from locally available foods for the treatment of MAM instead of always relying on imported food products. For this to be effective, the Ministry of Agriculture should encourage production of such food products to ensure availability. There is also need to train households the formulation and preparation of such local food supplements.

6.4 Recommendations for Further Research

Future studies should focus on:

- Processing Technologies such as fermentation to reduce the anti-nutrient levels
- Testing of SPB's shelf life to establish its stability during storage
- Fortification to improve on micro-nutrient content of SPB
- Community perceptions of the product as treatment for MAM
- Sustainability
- Cost-effectiveness of locally formulated food supplement

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APPENDICES

Appendix A: Ethical approval from National Council for Science and Technology

Uganda National Council for Science and Technology

(Established by Act of Parliament of the Republic of Uganda)

UNCST

Our Ref: HS 1188 **5 July 2012**

Mr. Andrew Kiri Amegovu
P.O Box 830
Entebbe

Dear Mr. Amegovu,

RE: RESEARCH PROJECT, "EFFICACY OF SORGHUM PEANUT BLEND AND CORN SOY BLEND TO TREAT MODERATE ACUTE MALNUTRITION IN CHILDREN AGED 6-59 MONTHS IN KARAMOJA, UGANDA"

This is to inform you that the Uganda National Council for Science and Technology (UNCST) approved the above research proposal on **31 May 2012.** The approval will expire on **31 May 2013.** If it is necessary to continue with the research beyond the expiry date, a request for continuation should be made in writing to the Executive Secretary, UNCST.

Any problems of a serious nature related to the execution of your research project should be brought to the attention of the UNCST, and any changes to the research protocol should not be implemented without UNCST's approval except when necessary to eliminate apparent immediate hazards to the research participant(s).

This letter also serves as proof of UNCST approval and as a reminder for you to submit to UNCST timely progress reports and a final report on completion of the research project.

Yours sincerely,

Jane Nabbuto
for: Executive Secretary
UGANDA NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

LOCATION/CORRESPONDENCE

Plot 6 Kimera Road, Ntinda
P. O. Box 6884
KAMPALA, UGANDA

COMMUNICATION

TEL: (256) 414 705500, (256) 312 314800
FAX: (256) 414-234579
EMAIL: info@uncst.go.ug
WEBSITE: http://www.uncst.go.ug

Appendix B: Approval of research proposal

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: kubps@yahoo.com
dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Internal Memo

FROM: Dean, Graduate School — **DATE:** 9th March, 2012

TO: **Andrew Kiri Amegovu** — **REF:** H87EA/21211/2010
C/o Department of Foods, Nutrition and Dietetics

REF: APPROVAL OF RESEARCH PROPOSAL

This is to inform you that the Graduate School Board at its meeting of 1st March, 2012 approved your research proposal for Ph.D degree entitled, **"Efficacy of Sorghum Peanut Blend and Corn Soy Blend in the Treatment of Moderate Acute Malnutrition in Children Aged 6-59 Months in Karamoja, Uganda".**

JOSEPHINE K. NJAGI
FOR: DEAN, GRADUATE SCHOOL

c.c. Chairman, Department of Foods, Nutrition and Dietetics

Supervisors:

1. Dr. Sophie Ochola
   C/o Department of Foods, Nutrition and Dietetics
   Kenyatta University.
2. Dr. Patrick Ogwok
   Department of Food Processing Technology
   Kyambogo University, Uganda
   C/o Department of Foods, Nutrition and Dietetics
   Kenyatta University

JNK/rwm

Appendix B: Approval from Kenyatta University Graduate School

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: kubps@yahoo.com
dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: H87EA/21211/2010 **Date: 10th March, 2012**

The Permanent Secretary,
Ministry of Higher Education, Science & Technology,
P.O. Box 30040,
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR ANDREW KIRI AMEGOVU REG.NO H87EA/21211/2010

I write to introduce Andrew Kiri Amegovu who is a Postgraduate Student of this University. He is registered for a Ph.D degree programme in the Department of Foods, Nutrition and Dietetics in the School of Applied Human Sciences.

Mr. Amegovu intends to conduct research for a Thesis Proposal entitled, **"Efficacy of Sorghum Peanut Blend and Corn Soy Blend in the Treatment of Moderate Acute Malnutrition in Children Aged 6-59 Months in Karamoja, Uganda".**

Any assistance given will be highly appreciated.

Yours faithfully,

MRS. LUCY N. MBAABU
FOR: DEAN, GRADUATE SCHOOL

KENYATTA UNIVERSITY OFFICE OF DEAN GRADUATE SCHOOL P.O. Box 43844 - 00100, NAIROBI

LNM/rm

KENYATTA UNIVERSITY
OFFICE OF THE REGISTRAR (ACADEMIC)

P. O BOX 43844
NAIROBI, KENYA
TEL: 810901-19
EXT: 57183/4
Email: admissions@ku.ac.ke

Our Ref: H87EA/21211/2011 **DATE: 12th March 2012**

AMEGOVU KIRI ANDREW
C/o Dept. of Foods, Nutritions and Dietetics
KENYATTA UNIVERSITY

Dear Mr. Amegovu

RE: **SUBSTANTIVE REGISTRATION (PHD)**

Following the recommendation by Dean, Graduate School, you are hereby granted substantive Ph.D registration.

Please note that your registration number and all rules and regulations remain the same as per your admission letter.

Thank you.

DR.(MRS.) J.A.SIMBAUNI
FOR: REGISTRAR (ACADEMIC)

Cc: Dean, Graduate School
Chairman, Department of Foods, Nutrition & Dietetics

/jni

To be filled by Supervisor:
0.4 Household ID: |__|__|__|__|__|
(Check and complete during data entry)
(First digit for District; second and third digit for Cluster ID; fourth and fifth digit for household #)
Supervisor Name:

Appendix C: Questionnaire

Baseline Health and Nutrition Assessment form

0.1 Date |__|__|/|__|__|/2011
0.2 Interviewer Name: ________________________ Signature: _______________
0.3 District ID |__| 0.4 Sub country………………………..
0.5 Parish…………………… 0.6 Village……**……………**

SECTION 1 – HOUSEHOLD INFORMATION AND MORTALITY				
A household is defined as a group of people who routinely eat out of same pot and live on the same compound (or physical location). It is possible that they may live in different structures.				
1.1	What is the sex of the House Hold head? **CIRCLE**		Male=1	Female=2
1.2	What is the age of the House Hold head? (in years)		|__||__|	
1.3	Can the head of the House Hold read and write? (in any language) **CIRCLE**		Yes=1	No=0
1.4	How many people are currently living in this household, including members who have joined your house hold temporarily or permanently within the past 3 months (including newly born babies as well as members who may have either departed or died and children in boarding school)?		|__||__|	
1.5	Current age or age at the time of death if deceased 1. 0-5 years 2. 6-12 years 3. 13-18 years 4. 19-49 years 5. 50+ years (Write the code)	Sex Male=1 Female=2 (write code)	Current status as of today 1 Alive(living in this house hold) 2 Alive (living elsewhere) 3 Died 4 Missing/Unknown (Write the code)	If dead, what was the cause of death? 5 Fever/Malaria 6 Diarrhoea 7 Measles 8 Malnutrition 9 Accident 10 Lower respiratory tract infection 11 Other

SECTION 2– HOUSEHOLD HEALTH			
2.1	What is the **MAIN** source of drinking water for your household? ***CIRCLE***	1. Piped water 2. Water from open well/spring 3. Water from protected well/spring 4. Water from borehole	5. Surface water (river, dam, run off, etc.) 6. Rain water 7. Other
2.2	If borehole or protected well is your main source, how do you bring the water up/out?	1. Use electric / solar / wind power 2. Use hand pump or pulley	3. Use rope and bucket pull method
2.3	Who within your household usually collects water?	1. Children 2. Young girls 3. Young boys 4. Adult men	5. Adult women 6. The elderly 7. Everybody (whoever is available in the house)
2.4	Does your household treat its drinking water? ***CIRCLE***	1=Yes 0=No **(skip to Question 2.7)**	
2.5	How do you treat drinking water?	1. By chlorination (by adding water guard, aqua tab, etc) 2. By boiling	3. Other
2.6	How do you dispose of faeces? ***CIRCLE***	1. Private latrine 2. Community latrine 3. Bush (open air)	4. Neighbour's latrine 5. Others
2.7	Where do you dispose rubbish? ***CIRCLE***	1. Compost pit 2. In the garden	1. Bush 2. Others
2.8	Where do you and members of your household **MOSTLY** go for treatment when sick? ***CIRCLE***	1. Hospital 2. Health centre 3. Private Clinic 4. Village Health Team (VHT)	5. Traditional healer 6. Drug shop 7. Other
2.9	Who in the house sleeps under a mosquito net? ***CIRCLE***	1. Children 2. Adult men	3. Adult women 4. No one
2.10	What is the type of fuel MOSTLY used by your household for cooking/preparing food?	1. Charcoal 2. Firewood 3. Straw/shrubs/grass	4. Animal dung 5. No food is cooked in the house hold

SECTION 3: MOTHER/CAREGIVER		
3.1	Respondent relationship to children	1=mother 2= care taker
3.2	Age of mother/caregiver	|__|__| years
3.3	Educational level of mother/caregiver ***CIRCLE***	1. No formal education 2. Primary 3. Secondary 4. Tertiary
3.4	# of children by this mother (Parity)	|__|__|

CHILD HEALTH AND NUTRITION –MOTHER/CAREGIVER

Please ask all questions about Child 1 and write the responses given before moving to Child 2, 3, etc.

	Child 1	**Child 2**	**Child 3**
3.5 Sex of the child? ***CIRCLE***	1=Male 2=Female	1=Male 2=Female	1=Male 2=Female
3.6 Date of birth (Day/month/year)	|__|__|/|__|__|/|__|__|	|__|__|/|__|__|/|__|__|	|__|__|/|__|__|/|__|__|
3.7 Age of the child? (*in months*)	|__|__|	|__|__|	|__|__|

3. 8 Has (mention child's name) been taken for immunization, de-worming or supplementation?	**Measles**	DPT3	De-worming	Vitamin A (6 months)	**Measles**	DPT3	De-worming	Vitamin A (6 months)	**Measles**	DPT3	De-worming	Vitamin A (6 months)
Use the following codes **1**= Yes with card **2**= Yes without card **3**= No with card **4**= No without card												

	Child 1	Child 2	Child 3
3.9 How long after birth did you start breastfeeding? ***CIRCLE***	1. within first 1 hr 2. After 1 hr 3. Did not breast feed at all	1. within first 1 hr 2. After 1 hr 3. Did not breast feed at all	1. within first 1 hr 2. After 1 hr 3. Did not breast feed at all
3.10 How many months did you breastfeed your	|__|__| months	|__|__| months	|__|__| months

child?			
3.11 For children less than 2 years of age, at what age of your child did you introduce Liquid/ solid foods|(If child is older, skip to 3a.20)?	|__|__| months	|__|__| months	|__|__| months
3.13 What foods were introduced before the child reached 6 months of age? ***CIRCLEALL THAT APPLY***	1. Water 2. Milk/milk tea 3. Juice 4. Cereal Porridge 5. Tea without milk 6. Others **7.** Unknown	1. Water 2. Milk/milk tea 3. Juice 4. Cereal Porridge 5. Tea without milk 6. Others **7.** Unknown	1. Water 2. Milk/milk tea 3. Juice 4. Cereal Porridge 5. Tea without milk 6. Others **7.** Unknown
3. 14 What foods were given to the child yesterday? ***CIRCLE ALL THAT APPLY***	1. Cereal meal 2. Legumes 3. Fish 4. Milk / milk products 5. Meat + meat pdts 6. Tubers 7. Fruits + veg 8. Others	1. Cereal meal 2. Legumes 3. Fish 4. Milk / milk products 5. Meat + meat pdts 6. Tubers 7. Fruits + veg 8. Others	1. Cereal meal 2. Legumes 3. Fish 4. Milk/milk products 5. Meat + meat pdts 6. Tubers 7. Fruits + veg 8. Others
3.15 How many meals did the child eat yesterday?	|__|	|__|	|__|
3.16 How was the child served food?	1. Own plate 2. Plate shared with	1. Own plate 2. Plate shared with	1. Own plate 2. Plate shared with

CIRCLE ALL THAT APPLY	other children 3. Plate shared with adult 4. Own plate assisted by adult	other children 3. Plate shared with adult 4. Own plate assisted by adult	other children 3. Plate shared with adult 4. Own plate assisted by adult
3. 17 Mention the diseases your child has suffered in the last 2 weeks ***CIRCLE ALL THAT APPLY***	1. Fever/malaria 2. measles 3. diarrhoea 4. ARI/cough 5. skin diseases 6. Eye disease 7. other 8. No Illness	1. Fever/malaria 2. measles 3. diarrhoea 4. ARI/cough 5. skin diseases 6. Eye disease 7. other 8. No Illness	1. Fever/malaria 2. measles 3. diarrhoea 4. ARI/cough 5. skin diseases 6. Eye disease 7. other 8. No Illness
3.18 Does child sleep under a mosquito net? CIRCLE	1= Yes 0= No	1= Yes 0= No	1= Yes 0= No
3.19 Does the child have **o**edema?	1= YES 0 = NO ***(If yes, skip to Child # 2)***	1= YES 0 = NO ***(If yes, skip to Child # 3)***	1= YES 0 = NO ***(If yes, skip to Section 3b)***
3.20 Weight (Kg) of the child	|__|__|.|__|kg	|__|__|.|__|kg	|__|__|.|__|kg
3.21 Height (cm) of the child	|__|__|__|.|__|cm	|__|__|__|.|__|cm	|__|__|__|.|__|cm
3.22 MUAC (cm) of the child	|__|__|__|.|__|cm	|__|__|__|.|__|cm	|__|__|__|.|__|cm

SECTION 4 – HOUSEHOLD ASSET OWNERSHIP

4.1	Does anyone in your household **own** any of the following assets? If Yes, how many of each	1.	Bed	|__|__|
		2.	Table	|__|__|
		3	Chairs	|__|__|
		4.	Mattress	|__|__|

	asset does the household own? **WHILE ASKING, ALSO OBSERVE**	5.	Radio/Tape	|__|__|
		6.	Cell Phone	|__|__|
		7.	Bicycle	|__|__|
		8.	Hoe	|__|__|
		9.	Ox-plough	|__|__|

SECTION 5 – LIVESTOCK PRODUCTION

5.1	How many of the following livestock does your household currently own?	1.	Cattle	|__|__|__|
		2.	Sheep	|__|__|__|
		3	Goat	|__|__|__|
		4.	Pig	|__|__|__|
		5.	Rabbit	|__|__|__|
		6.	Poultry	|__|__|__|
		7.	Donkey	|__|__|__|

SECTION 6 – MAIN INCOME SOURCE

6.1 What are your **MAIN** income sources for your household over the past twelve months? For the income sources mentioned, what is the relative contribution of each activity to total income of the household during the year? (Using the 100 beans/beads you were given, assist the Head of	**Main Income Source:**	**% Contribution to Total**
	01 = Food Crop production (e.g. cereals, tubers)	
	02 = Growing Non-Food cash crops (e.g. coffee	
	03 = Livestock production (e.g. animal husbandry)	
	04 = Selling Animal products (e.g. herders with	
	05 = Trading in Food Crop or Non-Food Crops,	
	06 = Seller, commercial activity	
	07 = Petty trading	
	08 = Unskilled wage labour	
	09 = Agricultural labour	
	10 = Handicrafts	
	11 = Brewing	
	12 = Sale of Natural Resources (firewood, charcoal)	
	13 = Remittance / kinship	
	14 = Salaries, wages (employees)	
	15 = Government allowance	
	16 = Fishing, Hunting & Gathering	
	17= Gifts from neighbours, relatives	
	18= Begging	
	19 = Food aid	

household or respondent to do proportional piling to calculate the relative contribution of individual income sources mentioned by	20 = Others	
		100%

SECTION 7– EXPENDITURES		
In the Past 30 days how much money have you spent to acquire each of the following food for your family consumption?		
If not bought, write 0 Round up the figures (no decimals)		**Total expense in Uganda shillings during the past 30 days**
7.1	Cereals (sorghum, millet, maize, Rice, cassava,	|___|___|___|___|___|___|
7.2	Cooking oil	|___|___|___|___|___|___|
7.3	Meat/eggs/fish	|___|___|___|___|___|___|
7.4	Groundnuts/beans/pulses	|___|___|___|___|___|___|
7.5	Sugar	|___|___|___|___|___|___|
7.6	Milk/cheese	|___|___|___|___|___|___|
7.7	Fruit and vegetables (dry or fresh)	|___|___|___|___|___|___|
7.8	Cooked/processed food	|___|___|___|___|___|___|
7.9	Drinking water	|___|___|___|___|___|___|
7.10	Other foods (bread, coffee, tea, etc.)	|___|___|___|___|___|___|
What is the estimated share of the total expenditures by the household during PAST 30 DAYS (PAST MONTH) for the following items:		
Use proportional piling technique/divide pie (Write 0 if there is no expenditure)		**% of total expenditures for past 30 days**
7.11	Food expenditures	|___|___|___| %
7.12	Health expenditures	|___|___|___| %

7.13	Education expenditures	|___|___|___| %
7.14	All the rest of expenditures (milling, agricultural inputs, labour, ceremonies, transportation,	|___|___|___| %
	Total:	**100%**

SECTION 8– FOOD SOURCES AND CONSUMPTION

Read: I would now like to ask you a few questions about food consumption in your household

Could you please tell me how many days in the **past one week** (seven days) your household has eaten the following foods and what the main source was *(use codes on the right, write 0 for items not eaten over the last 7 days)*

ASK LINE BY LINE FOR EACH ITEM BOTH QUESTIONS

	Food Item	***a.*** *# Of days Eaten last 7 days*	***b.*** *Main Source (use codes from the next column)*
8.1	Maize	|__|	|__|
8.2	Rice	|__|	|__|
8.3	Sorghum	|__|	|__|
8.4	Millet	|__|	|__|
8.5	Wheat	|__|	|__|
8.6	Cassava	|__|	|__|
8.7	Potatoes	|__|	|__|
8.8	Yams	|__|	|__|
8.9	Bread, Mandazi, chapatietc	|__|	|__|
8.10	Beans and Peas	|__|	|__|
8.11	Vegetables	|__|	|__|
8.12	Ground nuts, Simsim	|__|	|__|
8.13	Fresh fruits	|__|	|__|
8.14	Meat (including chicken and pork)	|__|	|__|
8.15	Blood	|__|	|__|

Food Source codes

1 = Own production (crops, animals), direct or indirect-sale or exchange
2 = Hunting, fishing, gathering
3 = Exchange labour/items for food
4 = Borrowed
5 = Purchased
6 = Gift (food) from family/relatives
7 = Food aid (WFP, OPM, NGO's)
8=sale of household non-productive item
9=sale of household productive item

8.16	Oil, fat, butter, ghee	|__|	|__|	
8.17	Milk	|__|	|__|	
8.18	Eggs	|__|	|__|	
8.19	Beer residue	|__|	|__|	
8.20	Sugar	|__|	|__|	

SECTION 9– FOOD ASSISTANCE

9.1	Did any household member receive food aid between January to August 2011? 1=Yes 0=No (Skip to Section 10)								
	Which months did your child/children receive food for education? (Circle all the months								
		1=Jan	2=Feb	3=Mar	4=Apr	5=May	6=Jun	7=Jul	8=Aug
9.3	Which months did your child/children receive supplementary feeding? (Circle all the months								
		1=Jan	2=Feb	3=Mar	4=Apr	5=May	6=Jun	7=Jul	8=Aug
9.4	Which months did your child/children receive therapeutic feeding? (Circle all the months								
		1=Jan	2=Feb	3=Mar	4=Apr	5=May	6=Jun	7=Jul	8=Aug
9.5	Which months did you receive General Food Distribution?								
		1=Jan	2=Feb	3=Mar	4=Apr	5=May	6=Jun	7=Jul	8=Aug
9.6	Which months did you receive Food for Work?								
		1=Jan	2=Feb	3=Mar	4=Apr	5=May	6=Jun	7=Jul	8=Aug

SECTION 10– NON-FOOD ASSISTANCE

	Since January 2011, has your household received any of the following non-food items from Government or humanitarian agencies?	
10.1	Hoes	1= Yes 0 = No
10.2	Pangas	1= Yes 0 = No
10.3	Ploughs (animal drawn)	1= Yes 0 = No
10.4	Other agricultural hand-tools	1= Yes 0 = No
10.5	Seed or seed voucher	1= Yes 0 = No
10.6	Animal feed	1= Yes 0 = No
10.7	Veterinary services for animals	1= Yes 0 = No
10.8	Pots or other utensils for cooking	1= Yes 0 = No

10.9	Plates, cups, or other utensils for eating	1= Yes 0 = No
10.10	Buckets	1= Yes 0 = No
10.11	Jerry can	1= Yes 0 = No
10.12	Blankets	1= Yes 0 = No
10.13	Soap	1= Yes 0 = No
10.14	Plastic sheet	1= Yes 0 = No
10.15	Sleeping mat	1= Yes 0 = No
10.16	Mosquito net	1= Yes 0 = No
10.17	Credit for petty trade or other small business to generate income	1= Yes 0 = No
10.18	Cash for work or cash voucher	1= Yes 0 = No
10.19	Land opening service (land clearing for crop cultivation)	1= Yes 0 = No

Appendix D Focus Group Discussion Questionnaire

Topic: Efficacy of sorghum peanut blend with honey and ghee compared to standard CSB+ with sugar and oil to treat moderate acute malnutrition in children below five years of age in Karamoja, Uganda. You should include questions on perceptions of mothers in the usefulness and efficacy of the new product in treating malnutrition.

Questions

1. What types of other foods is given to your child?
2. What is the common type of foods eaten at your home by your child?
3. What happens to any food brought home and who eats the majority?
4. In which months in a year do you experience food shortage most?
5. Which child sex do you mostly give close attention in terms of food, medication etc?
6. On average, how often are children given food per day?
7. What is your perception on the food in regards to usefulness, cure, taste and appearance?
8. Is it something you can make by yourself?

Hedonic scale form

You are provided with a sample of a product. You are requested to carefully evaluate the sample in respect to the following parameters; color, aroma, taste, mouth feel, consistency and overall acceptability. The scale in the first table gives sample characteristics in form of scores. Please assign a characteristic score that suits the sample according to your own opinion and perception of your infant's degree of liking in the second table.

5-Point Hedonic Scale

Dislike a lot	Dislike a little	Neither dislike nor like (fair)	Like a little	Like a lot
1	2	3	4	5

Product Score Sheet

Parameter	**Sample score**
Colour	
Aroma	
Taste	
Mouth feel	
Consistency	
Over all acceptability	

Appendix E; Child weight- for- Height table

Weight for Length in percentage of the median (NCHS standards): Kg.

Length (cm)	100% Median	85% (target)	80% >=normal, <mod	75%	70% >=Mod, <Severe	60%
49	3.2	2.7	2.6	2.4	2.2	1.9
49.5	3.3	2.8	2.6	2.5	2.3	2.0
50	3.4	2.9	2.7	2.6	2.4	2.0
50.5	3.4	2.9	2.7	2.6	2.4	2.0
51	3.5	3.0	2.8	2.6	2.5	2.1
51.5	3.6	3.1	2.9	2.7	2.5	2.2
52	3.7	3.1	3.0	2.8	2.6	2.2
52.5	3.8	3.2	3.0	2.9	2.7	2.3
53	3.9	3.3	3.1	2.9	2.7	2.3
53.5	4	3.4	3.2	3.0	2.8	2.4
54	4.1	3.5	3.3	3.1	2.9	2.5
54.5	4.2	3.6	3.4	3.2	2.9	2.5
55	4.3	3.7	3.4	3.2	3.0	2.6
55.5	4.4	3.8	3.5	3.3	3.1	2.6
56	4.6	3.9	3.7	3.5	3.2	2.8
56.5	4.7	4.0	3.8	3.5	3.3	2.8
57	4.8	4.1	3.8	3.6	3.4	2.9
57.5	4.9	4.2	3.9	3.7	3.4	2.9
58	5.1	4.3	4.1	3.8	3.6	3.1
58.5	5.2	4.4	4.2	3.9	3.6	3.1
59	5.3	4.5	4.2	4.0	3.7	3.2
59.5	5.5	4.6	4.4	4.1	3.9	3.3
60	5.6	4.8	4.5	4.2	3.9	3.4
60.5	5.7	4.9	4.6	4.3	4.0	3.4
61	5.9	5.0	4.7	4.4	4.1	3.5
61.5	6	5.1	4.8	4.5	4.2	3.6
62	6.2	5.2	5.0	4.7	4.3	3.7
62.5	6.3	5.4	5.0	4.7	4.4	3.8
63	6.5	5.5	5.2	4.9	4.6	3.9
63.5	6.6	5.6	5.3	5.0	4.6	4.0
64	6.7	5.7	5.4	5.0	4.7	4.0
64.5	6.9	5.9	5.5	5.2	4.8	4.1
65	7	6.0	5.6	5.3	4.9	4.2
65.5	7.2	6.1	5.8	5.4	5.0	4.3
66	7.3	6.2	5.8	5.5	5.1	4.4
66.5	7.5	6.4	6.0	5.6	5.3	4.5
67	7.6	6.5	6.1	5.7	5.3	4.6
67.5	7.8	6.6	6.2	5.9	5.5	4.7
68	7.9	6.7	6.3	5.9	5.5	4.7

68.5	8	6.8	6.4	6.0	5.6	4.8
69	8.2	7.0	6.6	6.2	5.7	4.9
69.5	8.3	7.1	6.6	6.2	5.8	5.0
70	8.5	7.2	6.8	6.4	6.0	5.1
70.5	8.6	7.3	6.9	6.5	6.0	5.2
71	8.7	7.4	7.0	6.5	6.1	5.2
71.5	8.9	7.6	7.1	6.7	6.2	5.3
72	9	7.7	7.2	6.8	6.3	5.4
72.5	9.1	7.7	7.3	6.8	6.4	5.5
73	9.2	7.8	7.4	6.9	6.4	5.5
73.5	9.4	8.0	7.5	7.1	6.6	5.6
74	9.5	8.1	7.6	7.1	6.7	5.7
74.5	9.6	8.2	7.7	7.2	6.7	5.8
75	9.7	8.2	7.8	7.3	6.8	5.8
75.5	9.8	8.3	7.8	7.4	6.9	5.9
76	9.9	8.4	7.9	7.4	6.9	5.9
76.5	10	8.5	8.0	7.5	7.0	6.0
77	10.1	8.6	8.1	7.6	7.1	6.1
77.5	10.2	8.7	8.2	7.7	7.1	6.1
Length (cm)	100% Median	85% (target)	80% >=normal, <mod	75%	70% >=Mod, <Severe	60%
78	10.4	8.8	8.3	7.8	7.3	6.2
78.5	10.5	8.9	8.4	7.9	7.4	6.3
79	10.6	9.0	8.5	8.0	7.4	6.4
79.5	10.7	9.1	8.6	8.0	7.5	6.4
80	10.8	9.2	8.6	8.1	7.6	6.5
80.5	10.9	9.3	8.7	8.2	7.6	6.5
81	11	9.4	8.8	8.3	7.7	6.6
81.5	11.1	9.4	8.9	8.3	7.8	6.7
82	11.2	9.5	9.0	8.4	7.8	6.7
82.5	11.3	9.6	9.0	8.5	7.9	6.8
83	11.4	9.7	9.1	8.6	8.0	6.8
83.5	11.5	9.8	9.2	8.6	8.1	6.9
84	11.5	9.8	9.2	8.6	8.1	6.9
84.5	11.6	9.9	9.3	8.7	8.1	7.0
85	12	10.2	9.6	9.0	8.4	7.2
85.5	12.1	10.3	9.7	9.1	8.5	7.3
86	12.2	10.4	9.8	9.2	8.5	7.3
86.5	12.3	10.5	9.8	9.2	8.6	7.4
87	12.4	10.5	9.9	9.3	8.7	7.4
87.5	12.5	10.6	10.0	9.4	8.8	7.5
	12.6	10.7	10.1	9.5	8.8	7.6
88.5	12.8	10.9	10.2	9.6	9.0	7.7
89	12.9	11.0	10.3	9.7	9.0	7.7

89.5	13	11.1	10.4	9.8	9.1	7.8
90	13.1	11.1	10.5	9.8	9.2	7.9
90.5	13.2	11.2	10.6	9.9	9.2	7.9
91	13.3	11.3	10.6	10.0	9.3	8.0
91.5	13.4	11.4	10.7	10.1	9.4	8.0
92	13.6	11.6	10.9	10.2	9.5	8.2
92.5	13.7	11.6	11.0	10.3	9.6	8.2
93	13.8	11.7	11.0	10.4	9.7	8.3
93.5	13.9	11.8	11.1	10.4	9.7	8.3
94	14	11.9	11.2	10.5	9.8	8.4
94.5	14.2	12.1	11.4	10.7	9.9	8.5
95	14.3	12.2	11.4	10.7	10.0	8.6
95.5	14.4	12.2	11.5	10.8	10.1	8.6
96	14.5	12.3	11.6	10.9	10.2	8.7
96.5	14.7	12.5	11.8	11.0	10.3	8.8
97	14.8	12.6	11.8	11.1	10.4	8.9
97.5	14.9	12.7	11.9	11.2	10.4	8.9
98	15	12.8	12.0	11.3	10.5	9.0
98.5	15.2	12.9	12.2	11.4	10.6	9.1
99	15.3	13.0	12.2	11.5	10.7	9.2
99.5	15.4	13.1	12.3	11.6	10.8	9.2
100	15.6	13.3	12.5	11.7	10.9	9.4
100.5	15.7	13.3	12.6	11.8	11.0	9.4
101	15.8	13.4	12.6	11.9	11.1	9.5
101.5	16	13.6	12.8	12.0	11.2	9.6
102	16.1	13.7	12.9	12.1	11.3	9.7
102.5	16.2	13.8	13.0	12.2	11.3	9.7
103	16.4	13.9	13.1	12.3	11.5	9.8
103.5	16.5	14.0	13.2	12.4	11.6	9.9
104	16.7	14.2	13.4	12.5	11.7	10.0
104.5	16.8	14.3	13.4	12.6	11.8	10.1
105	16.9	14.4	13.5	12.7	11.8	10.1
105.5	17.1	14.5	13.7	12.8	12.0	10.3
106	17.2	14.6	13.8	12.9	12.0	10.3
106.5	17.4	14.8	13.9	13.1	12.2	10.4
107	17.5	14.9	14.0	13.1	12.3	10.5
107.5	17.7	15.0	14.2	13.3	12.4	10.6
108	17.8	15.1	14.2	13.4	12.5	10.7
108.5	18	15.3	14.4	13.5	12.6	10.8
109	18.1	15.4	14.5	13.6	12.7	10.9
109.5	18.3	15.6	14.6	13.7	12.8	11.0
110	18.4	15.6	14.7	13.8	12.9	11.0