NUTRIENT CONTENT OF THE POPULAR DISHES CONSUMED BY CHILDREN BELOW FIVE YEARS OF AGE IN BANANA GROWING COMMUNITIES: A CASE STUDY OF BUKOBA RURAL DISTRICT, TANZANIA

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ABSTRACT

The study was carried out to identify popular dishes that are given to children below five years of age in Bukoba Rural District. Cooking methods, ingredients used and percentage contribution of RDA to vitamin A and iron from the three popular dishes were assessed. The results showed that *katogo* (banana, beans and sardines), (stiff porridge, beans, and stewed sardines) and cassava with beans and sometimes sardines were the three popular dishes that were given to children below five years of age. The common cooking method used was boiling; others which were used rarely were steaming and frying the sardines with very little oil. The dishes were prepared as observed in the households during the survey. The nutrient content from the popular dishes were analysed and calculated using the HPLC and Microsoft Excel (2007) respectively. The proportion of the RDA for vitamin A and iron was calculated based on the RDA for vitamin A and iron which was 400 RAE and 10 mg respectively. The result on the proportion to the RDA showed that, for vitamin A, *katogo* dish with the average consumption size of 837.5 g had (43.68 RAE) and (77.81%) RDA of vitamin A, was the one with highest amounts ($p<0.05$) than the others. The component that had high and significant amount ($p<0.05$) of vitamin A was plain boiled banana (*nshakala*) with 78.57 RAE and 139.94% RDA of vitamin A with the average consumption size of 712.5 g. For iron the mixture of stiff porridge, beans and stewed sardines dish had 22.89 mg/100 g and 114.2% RDA. K*atogo had* 106.11% RDA of iron and showed no statistical significant difference ($p<0.05$) with that of a mixture of stiff porridge, beans and sardines. Steamed sardines with 28.31 mg/100 g and 53.08% of RDA of iron was the component with highest amount followed by stewed sardines with (25.38 mg/100 g) and (47.59%) contribution to the RDA.

DECLARATION

I, Namsifu Godson do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my own work done within the period of registration and that it has neither been submitted nor being concurrently submitted for degree award to any other institution.

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Prof. Joyce Kinabo Date

(Supervisor)

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LIST OF ABBREVIATIONS AND SYMBOLS

AAS	Atomic Absorption Spectrometry
AIDS	Aquired Immuno Deficiency Syndrome
ATP	Adenosine Triphosphate
BHA	Butylated Hydroxyanide
BHT	Butylated Hydroxytoluene
CDCP	Centre for Disease Control and Prevention
YFC	Yellow Fleshed Cassava
CIALCA	Consortium for Improving Agriculture-based Livelihoods in Central Africa
DALYs	Disability Adjusted Life Years
DNA	Deoxyribo Nucleic Acid
ESTD	External Standard
FAAS	Flame Atomic Absorption Spectrometer
FAO	Food and Agriculture Organization
FSSR	Food Safety and Standards Regulations
GDP	Gross Domestic Products
GHI	Global Health Index
HIV	Human Immunodeficiency Virus
HKIT	Helen Keller's International Tanzania
HPLC	High Pressure Liquid Chromatography
IAEA	International Atomic Energy Agency
ID	Iron Deficiency
IDD	Iodine Deficiency Disorder

IDA	Iron Deficiency Anemia
IFPRI	International Food Policy Research Institute
IOM	Institute of Medicine
ISTD	Internal Standard
MAFC	Ministry of Agriculture Food Security and Cooperatives
NBS	National Bureau of Statistics
PDA	Photodiode Array
PvAC	Provitamin A carotenoids
RAE	Retinol Activity Equivalent
RDA	Recommended Dietary Allowance
SACN	Scientific Advisory Committee on Nutrition
SAM	Severe Acute Malnutrition
TDHS	Tanzania Demographic and Health Survey
TEA	Triethylamine
VAD	Vitamin A Deficiency
WFC	White Fleshed Cassava
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Malnutrition is a serious physiological condition marked by a deficiency of energy, essential proteins, fats, vitamins, and minerals in a diet (Olack *et al.*, 2011). The condition is always more critical in communities growing mono type of crops like banana and other species. Over 10 million children aged less than five years (under-five children) die annually from preventable and treatable illnesses almost all of these deaths occur in poor countries (Webb and Bhatia, 2005; Olack *et al.*, 2011). Malnutrition contributes to more than one-third of all deaths of children below five years in Africa. Currently, 195 million of children below five years of age are affected by malnutrition 90% of them live in sub-Saharan Africa and South Asia (Uwazi, 2010; Babatunde *et al.*, 2011). At least 20 million children suffer from severe acute malnutrition (SAM), and another 175 million are undernourished. Malnutrition is the most recognizable and perhaps most outward consequence of poverty in the society (Olack *et al.*, 2011). The immediate causes of malnutrition being inadequate diet and diseases, thus assessing nutrient content of popular foods eaten by children below five years of age in banana growing community is vital for setting intervention strategies such as recipe modification and bio fortification.

In most developing countries problems are related to under nutrition rather than over nutrition. Types of malnutrition of public health importance include Iron Deficiency Anemia (IDA), Iodine Deficiency Disorders (IDD), and Vitamin A Deficiency (VAD). Basically, malnutrition is a result of simplified or reduced amounts of energy food to required quantities. These conditions mainly affect children below five years of age and pregnant women. It is estimated that up to 219 million children are deficient in vitamin A

(Mason *et al.*, 2005) and over 1 billion children are susceptible to iron deficiency. Children with these deficiencies are significantly more likely to experience morbidity and mortality. Vitamin A deficiency in newborn babies, infants, and children accounts for about 6% of the deaths of children below five years of age. Iron deficiency accounts for about 4% of the death of children below five years of age (Black *et al.*, 2008).

The National Bureau of Statistics (NBS and ICF Macro, 2011) during implementation of the Tanzania Demographic and Health Survey (2010 TDHS) reported that 35% of children below five years of age are iron deficient whereby 24% have iron deficiency anaemia (IDA) and 11% have Iron deficiency (ID) and 38% are Vitamin A deficiency (VAD). However, providing essential nutrients, diversifying local diets (popular foods) eaten by the majority of children in rural areas are rich in a variety of micronutrients like vitamin A, vitamin C, iron, zinc and calcium. These micronutrients enhance the immune system thus fighting diseases and infections like diarrhea, acute respiratory infections, malaria and tuberculosis that are the major causes of child mortality which leads into malnutrition in developing countries (SACN, 2010).

Deficiencies of vitamin A and zinc were estimated to be responsible for 0·6 million and 0·4 million deaths, respectively, and a combined 9% of global childhood DALYs. Iron and iodine deficiencies resulted in few child deaths, and combined were responsible for about 0·2% of global childhood DALYs. Iron deficiency as a risk factor for maternal mortality added 115 000 deaths and 0·4% of global total DALYs. In an analysis that accounted for co-exposure of these nutrition-related factors, they were together responsible for about 35% of child deaths and 11% of the total global disease burden. The high mortality and disease burden resulting from these nutrition-related factors make a compelling case for the urgent implementation of interventions to reduce their occurrence or ameliorate their consequences (Black *et al.*, 2008).

Adequate nutrition during the early years of life is of paramount importance for growth, development and long-term health through adulthood. It is during infancy and early childhood that irreversible faltering in linear growth and cognitive deficits occur. Poor nutrition during this critical period contributes to significant morbidity and mortality. Therefore, the quality of infant and young child feeding is fundamental for achieving optimal growth and development.

1.2 Problem Statement and Justification

1.2.1 Problem statement

Malnutrition in sub-Saharan Africa contributes to high rates of childhood morbidity and mortality. The nutritional value of the common foods eaten by children below five years of age is questionable. Little information on the recommended dietary allowances (RDAs) to children is available (WHO and CDCP, 2004). It has been estimated that approximately 168 million children of below five years of age are underweight, meaning that they do not get enough nutrients to meet their body's needs. Micronutrient deficiencies, such as iron, zinc, and vitamin A, are affecting the lives and health of billions of people in the developing world (WHO, 2002).

In Tanzania, malnutrition is a result of insufficient or imbalance consumption of dietary energy and nutrients and it manifests in under nutrition, macro and micronutrients malnutrition (Kinabo *et al.*, 2006; Leach and Kilama, 2009). This information becomes important when assessing the nutritional values to children below five years of age in the banana growing communities of Bukoba Rural District.

In Tanzania lack of nutrition security reflects different forms of malnutrition (UNICEF and WHO, 2009). The common ones include Iron deficiency anemia (IDA) and Vitamin A deficiency (VAD). These forms of malnutrition are manifested at the age of below five years, and this calls for the greater emphasis in monitoring child nutrition so as to avoid or reduce the adverse effects that may be caused (Leach and Kilama, 2009). According to Kinabo (2001), the actual number of malnourished children has increased world wide and 25.6% is found in Africa.

Iron deficiency is common in populations dependent on cereal-based diets because of the poor bioavailability of these minerals from those diets. In developing countries, 53 % of school children and 42 % of preschool children are anaemic (Mitchikpe *et al.*, 2010). Iron deficiency with or without anaemia has important consequences for human health and child development. Infants are at greater risk of dying during the perinatal period. Children's mental and physical development is delayed or impaired by iron deficiency. There have been many efforts to fight iron deficiency and anaemia over the past two decades but, despite these efforts, the conditions are still common (WHO and CDCP, 2004). According to Shariff *et al.* (2008), promoting healthy eating practices and regular physical activity in young children have been shown to benefit the health of children.

Vitamin A is one of very important nutrient in human body; its deficiency as observed by Marjorie and Ribaya-Mercado (2005) can result in anemia, reduced resistance to infection, impaired cellular differentiation and ultimately blindness and death. Because of the detrimental effects of vitamin A deficiency on human health, accurately assessing nutritional value of vitamin A in common foods eaten by the banana growers' community is necessary to make informed decisions regarding intervention programs.

Many studies (Kinabo, 2001; WHO, 2002; FAO, 2004) and International conferences such as The World Summit for Children in 1990, the International Conference on Nutrition in 1992 and the World Food Summit in 1997 adopted as a goal to eliminate VAD by the year 2000. The focus was on the impacts of Vitamin A deficiency (VAD) and distribution of vitamin A supplements in national immunization programs but little is known on assessing vitamin A content in order to address the root cause of deficiency. Promoting health intervention is good but it is crucial to know nutritional values of the respective types of food (Mannar *et al.*, 2009). Therefore, this called for the study on the determination of the amount of Iron and Vitamin A from the popular foods consumed by the children below five years of age in Bukoba rural district.

1.2.2 Justification of study

In banana growing communities there are numerous types of dishes that are prepared. However children are fed with monotonous type of dishes mostly starchy based staples (Ekesa *et al.*, 2011). The starchy foods are sometimes provided with or without animal products, vegetables and/ or fruits. Varieties of dishes with required nutritional values help children to grow well (IFPRI, 2012). It has been observed that areas with large volumes of food also tend to show high rates of malnutrition and child mortality (FAO, 2008, NBS and ICF Macro, 2011). It should be noted that, most popular dishes lose their nutritional value during food processing (Ekesa *et al.*, 2012).

This study therefore established how much iron and vitamin A nutrient are found in each popular dish and their components that are given to children below five years of age in Bukoba Rural District. Moreover, the study showed how much percentage of iron and vitamin A is being contributed to the RDA through dishes of the children below five years of age in Bukoba Rural District.

The findings of this study will help stakeholders to understand whether these children meet or do not meet the RDA, and what should be done so as to improve or maintain the status of these nutrients from the popular dishes from their own sources of food. Furthermore, the findings of this study will be used to establish the methods used to prepare childrens' dishes in this community and clearly identifying the bad and good methods (those which cause loss of nutrient and those which maintain the nutrient status).

1.3 Study Objectives

1.3.1 General objectives

The overall objective of the study was to assess the content of vitamin A and iron in three popular dishes consumed by children below five years of age in a banana growing community in Bukoba Rural District.

1.3.2 Specific objectives

The specific objectives of this study were:

1) To identify the three popular dishes given to children below five years of age
2) To describe the common cooking procedures used in preparation of foods for children below five years of age
3) To determine the content of vitamin A (pro-vitamin A) and iron in three popular dishes given to children below five years of age
4) To determine the percentage contribution of Recommended Dietary Allowance (RDAs) for vitamin A and iron from the three popular dishes

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Nutrition Status of Children below Five Years in Tanzania

Nutrition status depends on whether the country is food secured or insecure. Food and nutrition security continue to be one of the most fundamental challenges for human welfare and economic growth in Tanzania (Lusty and Smale, 2003). The country can be food secured but her people especially children below five years of age are malnourished (mostly undernourished) (FAO, 2004). The study by the Ministry of Agriculture, Food Security and Cooperatives (MAFC, 2010), cited by Helen Keller International -Tanzania (HKIT, 2012) documented that despite the country being food secure in the years between 2006 and 2012 as shown by the food self-sufficiency ratio (FSSR) of above 100%; there are still variations in food security between different regions and district in the country. International Food Policy Research Institute (IFPRI) developed a better measure for health in the Global Health Index (GHI) by calculating from a combination of equally weighted indicators such as:

- The proportion of the undernourished as a percentage of the population;
- The prevalence of underweight children under the age of five; and
- The mortality rate of children under the age of five (IFPRI, 2012).

In 2012 Tanzania had a GHI of 19.3 indicating serious hunger problems in many regions and districts despite the FSSR being above 100%. Food insecurity in Tanzania is caused by low food production and complicated by low purchasing power leading to the inability of many to buy food existing in the local markets and poor distribution. For example, the FSSR for the national level was 102% in 2009/10, a food surplus (FSSR>120) was seen in the regions of Kagera, Iringa, Kigoma, Mbeya, Mtwara, Rukwa and Ruvuma.

Nonetheless, Kagera Region especially Bukoba Rural being food secured children below five years of age are malnourished (HKIT, 2012).

2.2 Extent of Malnutrition in Tanzania

The extent of malnutrition according to the Tanzania Demographic and Health Survey (TDHS) of 2010, 5% of the children below five years of age were wasted, 42% stunted and 16% underweight (NBS and ICF Macro, 2011). The high rates of stunting in the country indicate chronic and intergenerational malnutrition. According to the findings by NBS and ICF Macro (2011), it is observed that between the year 1999 and 2010 there has been some improvements in the nutritional situation however; Iron deficiency and anemia remain unacceptably high in Tanzania this is due to the fact that number of interventions have been put in place to address anaemia in children. These include promotion of use of insecticide-treated mosquito nets (ITNs) by children below five years of age and deworming of children age 2 to 5 years every six months. However, compared with the values of the 2004-05 TDHS, the prevalence of anaemia has dropped by 18 percent in the past five years, from 72 percent to 59 percent.

Anemia is highly prevalent among under-fives with 72% of all children between 6-59 months being anemic (NBS and ICF Macro, 2011). Anemia can be caused by micronutrient deficiencies in iron, folate, vitamin B12 or vitamin A, and/or infections like malaria and hookworm infestation. Iron deficiency, some of which causes anemia, is seen in 35% of children fewer than 5 years of age (HKIT, 2012). Another very important next to water a major component of body tissues is protein. Essentially it works for body growth. Protein provides the essential amino acids as initial materials for tissue synthesis and constituent of tissue protein. Its deficiency has contributed to anemia to children below five years of age in Tanzania.

2.3 Common Diseases that Affect Children below Five Years and their Causes

According to research done by Ekesa (2008), it was stated that the diseases that affect children below five years are mainly; malaria, intestinal worms, kwashiorkor, anemia and diarrhea. The main causes include lack of sufficient food as well as lack of information on good feeding practices. FAO (2004) documented that there are many reasons why a child becomes undernourished. The causes vary from person to person but they can be divided into immediate i.e. poor diet and disease which may be due to insufficient breast milk; meals that are too small; poor variety of food; infrequent meals; low concentrations of energy and nutrients in meals.

Sick people may not eat much; absorb few nutrients; lose nutrients from the body or use up nutrients in the body more quickly (e.g. during fever). Underlying causes include family food shortages, inadequate care and feeding practices and poor living conditions and poor health services. Basic causes include widespread poverty and lack of employment opportunities; unequal distribution and control of resources; the low status and education of women; lack of health, education, and other social services.

2.3.1 Why children need vitamin A?

Vitamin A is often thought of as the 'anti-infection' vitamin as it plays an important role in maintaining the immune system. It is also essential for growth, which is why children have a relatively higher requirement for vitamin A than adults. Vitamin A is also associated with good vision in dim light. Retinol (normally found in animal foods) is essential for the rod cells in the eye which allows night vision. It is also believed that carotene (normally found in fruits and vegetables) as a provitamin has a much wider role as it protects the body from internal damage which could lead eventually to heart disease or the development of cancer (Crawley, 2006). However this vitamin promotes a healthy immune system and also giving healthy strong bones. Moreover,the vitamin is found in vegetables which are normally green, yellow orange and red in color such as carrots, spinach, tomatoes, mango and papaya. The animal sources include milk, eggs, chicken and cheese (Tyndall *et al.*, 2012). Institute of Medicine (IOM, 2001) gives the recommended dietary allowance for vitamin A to children below five years of age as 400 µg/day.

2.3.2 Why children need iron?

Iron is essential for the function of several body systems as it is a component of hemoglobin which is the protein molecule found in red blood cells that carries oxygen. Therefore a deficiency in iron can cause anemia. This deficiency means that the blood transports less oxygen compared to the body's need and as the result limits the person's ability to be physically active. Children with iron deficiency will be pale and tired and their general health, resistance to infection, appetite and vitality will be impaired.

However, prevention of iron deficiency is important because, apart from these immediate effects, it is suggested that iron deficiency in children has an immediate and longer term impact on intellectual performance and behavior (Crawley, 2006). Other function of iron include regulation of cell growth and differentiation, conversion of nutrients into energy and manufacture of new deoxyribonucleic acid (DNA) and is also needed to synthesize Adenosine Tri-phosphate (ATP) a form of energy. Iron sources include red meat, fish, poultry, shellfish, eggs, legumes, dried fruits and fortified cereals (Tyndall *et al.*, 2012). According to the IOM (2001) the recommended dietary allowance for iron to children below five years of age is 10 mg/day.

2.4 Deficiency of Micronutrients including Vitamin A and Iron

Micronutrients play an essential role in the metabolic processes of the human body, but are only required in small quantities, this was reported by the International Atomic Energy

Agency (IAEA) in the year 2010. Micronutrient deficiencies are a serious public health concern in most developing countries such as Tanzania (Ferrari and Branca, 2002). Iron deficiency results in low levels of hemoglobin. Vitamin A deficiency (VAD) is associated with visual impairment and skin problems depending upon the severity of the condition. In general micronutrients deficiencies interfere with normal physiological functioning of the body and can be associated with a wide range of health problems (WHO, 2009).

Micronutrients deficiencies affect low-income countries but are also a significant factor in health problems in industrialized societies with impacts among wide vulnerable groups in the population, including women, children and the elderly. Globally, micronutrient deficiencies are of great public health and socio-economic importance (Tulchinsky, 2010). They significantly contribute to major causes of morbidity and mortality in these countries. According to the World Health Organization (WHO), more than 2 billion people worldwide suffer from vitamin and mineral deficiencies with important health consequences (WHO, 2009).

Micronutrients deficiencies have increased international interest whereby there is the realization that they result into malnutrition which contributes substantially to the global burden of disease. In addition, micronutrient malnutrition is responsible for a wide range of non-specific physiological impairments, leading to reduced resistance to infections, metabolic disorders, and delayed or impaired physical and psychomotor development. Micronutrient deficiencies are not always clinically apparent or dependent on food supply and consumption patterns. They are associated with physiologic effects that can be life threatening or more commonly damaging to optimal health and functioning. Some micronutrients deficiencies are intrinsic in current dietary patterns and some result from life situations determined by place of residence, religious practices, and recreational activities. They can directly impact communicable disease severity and can greatly affect quality of life.

2.4.1 Iron deficiency and iron deficiency anemia

Recent statistics from the World Health Organization (Miller, 2013) indicates that two billion people, over 30% of the world's population, are anemic, much of this is due to IDA. Iron deficiency (ID) prevents the bone marrow from producing enough hemoglobin for the red cells, resulting in smaller red blood cells that have a reduced oxygen carrying capacity. Microcytic, hypochromic anemia is one of the most common and widespread nutritional disorders globally, affecting large numbers of women, infants (especially premature or low-birth-weight infants), and children and adolescents (especially females) in resource-limited areas (Kakunted, 2008).

2.4.2 Symptoms of vitamin A and iron deficiency

Symptoms of VAD include impaired vision, weakened immune system, hyperkeratosis (goose-bump like appearance on the skin) on the forearms and thighs initially, and eventually spreading all over the body and increased susceptibility to viral infections. Symptoms of IDA include lack of energy, feelings of weakness, feeling cold frequently, increase infections, irritability, decreased performance, sore or swollen tongue and the urge to eat dirt or other non-food substances (Tyndall *et al.*, 2012).

2.4.3 Effects of micronutrients deficiencies

2.4.3.1 Health effects of micronutrients deficiencies

The adverse effects of micronutrients deficiencies and excesses in human beings are well known and well documented, although some questions which are inevitable remain. The adverse effects include health outcomes affecting mental and neuromotor performance, physical working capacity, morbidity, mortality, and overall reproductive performance and risk of maternal death. Affecting the size of the health impact are nutrient-to-nutrient interactions of micronutrients. The effects have also undergone re-positioning with regard to their public health impact over a certain period of time. The major risk factors of the global burden of disease include iron deficiency and vitamin A deficiency (WHO, 2002).

Iron deficiency remains a public health challenge despite its long-recognized negative impact on the health and productivity of people. Its role in impairing the cognitive development in infants and young children has provoked a renewed interest in treating and preventing iron deficiency. In the developing countries, iron deficiency impairs the mental development of 40%–60% of children aged 6–24 months. Widespread iron deficiency negatively impacts on national productivity with losses of up to 2% of the gross domestic product (GDP) in worst affected countries. Vitamin A remains the commonest cause in some countries of preventable childhood blindness.

2.4.3.2 Social effects of micronutrients deficiencies

Social effects of micronutrients deficiencies are associated with distortion of normal and daily systems of living in any society (Lusty and Smale, 2003). Marginalised social groups or households experience the effects of micronutrients deficiencies than those which are well. The marginalised households always face food insecurity. Mortality resulting from deficiencies leads to destructed family structure and increased dependence to capable people. Future effects of blindness to children will be reduced labour force which leads to low productivity.

There is insufficient information on the costs of micronutrient deficiencies to people as individuals and communities. Socially, effects of micronutrients are not only observed collectively but also in individuals within households (Lusty and Smale, 2003). However, it has been observed that it is difficult to separate social effects and economic costs of micronutrient deficiencies because they are directly related. For instance, in Sierra Leone, where it was concluded that in the absence of adequate policy and program action to reduce anemia rates in women, the monetary value of agricultural productivity losses associated with anemia in the female labor force over the next 5 years would exceed USD 94.5 million; the present value of the future productivity losses associated with the intellectual impairment resulting from intrauterine iodine deficiency, and under five deaths due to vitamin A deficiency (Huffman *et al.*, 1998; Latham *et al.*, 2003).

There are also major costs of micronutrient deficiencies associated with humanitarian crises. Women are typically overrepresented in terms of negative impacts of today's complex emergencies roughly 70% of refugees and people displaced inside their own countries by armed conflict are women and children. Wherever crises have resulted in compromised access to food, the threat of acute micronutrient deficiencies rises; if a population is already deficient in vitamins and minerals when an emergency unfolds, the impact is worse than if preexisting conditions had been satisfactory (Ameringen *et al.*, 2009; Klemm *et al.*, 2009; WHO, 2009).

2.4.4 Effects of preliminary food processing

Vitamins, carotenoids, flavonoids and fiber are more concentrated in the peel than in the pulp. Thus, the simple trimming or peeling of fruits and vegetables can discard appreciable amounts and significantly reduce the levels of these substances in the portions utilized. Vitamins and bioactive compounds are naturally protected in plant tissues. Cutting, chopping, shredding and pulping of fruits and vegetables destroy this protection, increase exposure to oxygen and release enzymes that catalyze their degradation. Enzymatic degradation may be a more serious problem than thermal decomposition in many foods. Thus, thermal processing should be carried out immediately after peeling and cutting operations (Rodriguez-Amaya and Kimura, 2008).

2.4.5 Effect of food processing on micronutrients

Food processing can have either positive or negative effects on micronutrients but depending on the technology used. In many resource-poor settings, the limiting factor to adequate nutrition is dietary quality. Bioavailability is one of the dietary quality aspects with respect to adequacy of micronutrient intakes. Bioavailability of micronutrients in plant-based diets can be enhanced by several modern and traditional food-processing methods. A study by Mulokozi *et al.* (2000) on improved solar drying of vitamin A-rich foods by women's groups in the Singida District of Tanzania showed the effects of processing on micronutrients.

The study compared the amount of beta carotene in vegetables blanched only but not dried with that of the same blanched varieties dried using the traditional open-air direct sun method and using the improved enclosed solar dryer. It was found that samples dried in the enclosed solar dryer retained more of their beta carotene content (between 56% and 90%) than those dried using the traditional open-air direct sun drying method (between 49% and 65%).

From the study, it was revealed that the highest proportion of beta carotene was retained in the samples of *ngwiba*, cowpea leaves, and *mgagani*. Although the beta carotene content of vegetables dried using the traditional method (direct sun drying) are rather high, they fall just outside the ranges for similar vegetables in other parts of the world (West and Poortvliet, 1993). Traditional methods that are always used include thermal processing, mechanical processing, soaking, fermentation and germination/malting. These strategies aim to increase the physicochemical accessibility of micronutrients, decrease the content of antinutrients, such as phytate, or increase the content of compounds that improve bioavailability. A combination of strategies is probably required to ensure a positive and significant effect on micronutrient adequacy. There are also industrial (modern) methods of food processing which can affect micronutrients.

2.5 Strategies for Combating Micronutrients Deficiencies

Designing strategies for the prevention and control of diseases such as HIV/AIDS, malaria and tuberculosis, and diet-related chronic diseases has implications on micronutrient deficiencies. However, WHO (2009) defines food fortification as the deliberate practice of increasing the content of an essential micronutrient, i.e. vitamins and minerals in a food, in order to improve the nutritional quality of the food supply and provide a public health benefit with minimal health risk. Apart from food fortification, another intervention includes dietary diversification to children and elderly. Policies and programs to address micronutrient deficiencies depend on public health leadership and understanding of the vital role this issue plays in the policies of the public health (Horton *et al.*, 2008; Dary and Mora, 2012).

Moreover, micronutrient deficiencies, particularly vitamin A deficiency and iron deficiency disorders pose a serious threat to the health of vulnerable segments of population. Dietary inadequacy is the primary cause of vitamin A deficiency and iron deficiency anemia. Other three major intervention strategies are available for the control of micronutrient deficiencies, these are supplementation of the specific micronutrients; horticulture intervention to increase production and nutrition education to ensure regular consumption of micronutrient rich foods (Bloem *et al.*, 2002).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of Study Area

The study was conducted in Rural Bukoba District which is one of the eight districts of Kagera Region. The reason for choosing this District is that it is the best banana grower but the leading when it comes to malnutrition to the children below five years of age, thus the site was purposively selected. The District covers an area of 7 780 square kilometers. It is bordered to the North by Misenyi District, to the East by Lake Victoria and Bukoba Municipality, to the West by Karagwe District, to the South by Muleba District. The main staple foods in this District are banana, maize and beans.

3.2 Study Design

A cross-sectional research design was used. Data were collected at one point in time from the sample selected to present a larger population (Bailey, 1997). In this study women of reproductive age with children below five years of age were interviewed on the common dishes given to children, how they prepared children's meals, proportions and ingredients of the dish cooked. The information obtained was used to prepare dishes from samples collected from the field for laboratory analyses. This study was done in two visits, in the first visit the women and/or care givers were interviewed on the common dishes that are given to children below five years of age, ingredients and proportions used whereas in the second visit the mothers and care givers were asked to prepare the common dishes that were given to children below five years of age mentioned in the first visit. The aim of this visit was to establish recipe used, cooking methods and procedures used (Fig. 1and 2) below.

Figure 1: Mother preparing *Katogo* (Mixture of banana and beans)

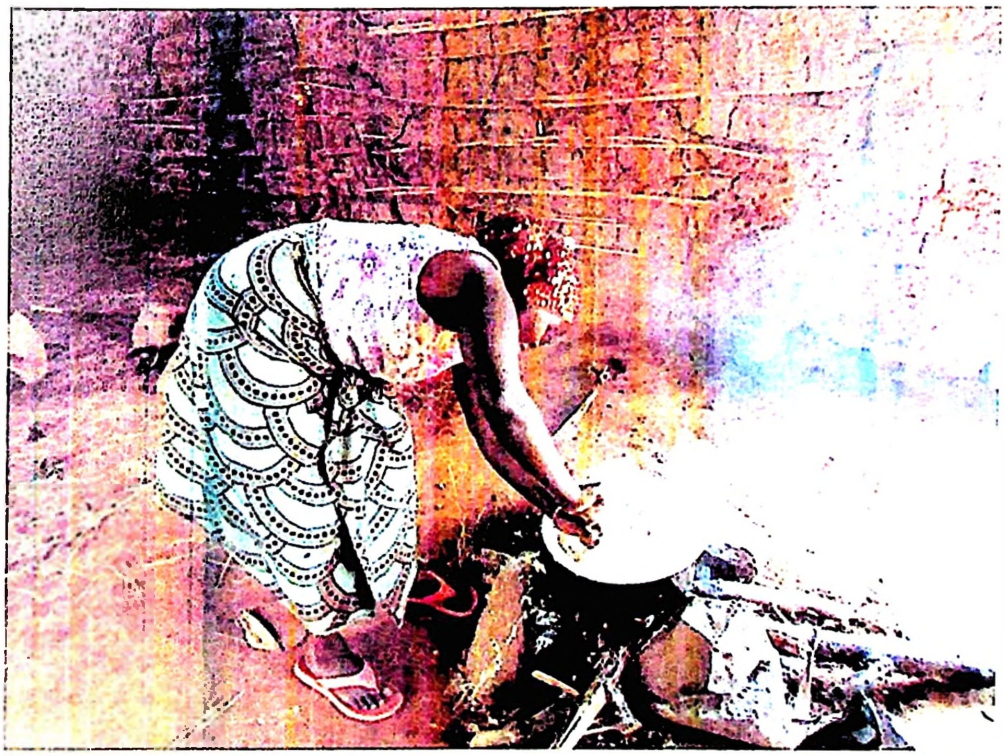

Figure 2: Mother cooking *obugali* (stiff porridge)

3.3 Study Population

The total population of Izimbya Ward is 16 916 people. The ward was purposive selected as it was the leading ward in food production yet led to high prevalence rate of malnutrition to children below five years of age. Study population was sampled from the ward total population in the two villages which are Izimbya and Rugaze, the ward had only two villages in which they were included in the study and the target was mothers /caregivers with children below five years of age. A questionnaire was administered to give information on common dishes given to children, ingredients used, cooking methods, time and procedures used.

3.4 Sampling Procedure and Sample Size Determination

3.4.1 Sampling procedure

Both purposive and random sampling procedures were applied during the study (Kothari, 2004). The households were used as sampling units and village registers were used as sampling frame. Firstly, purposive sampling was used to select households with children below five years of age. Secondly, the selected households from the two villages were randomly sampled regardless of their socioeconomic status.

3.4.2 Sample size calculation

The sample size formula according to Kothari (2004) was used for determination of sample size of children below five years of age. A total of 206 respondents were selected for this study. The household sample size for diagnostic survey was determined using the following formula:

$$N = \frac{t^2 pq}{e^2}$$

Where N = required sample size, t = confidence level at 95% (standard value of 1.96) p = estimated proportion of children below five years of age with regards to total population of the region/area, e = margin of error at 5% (standard value of 0.05).

In Izimbya ward, the total population was 16 916 and the proportion of children below five years of age to the general population was 16% (2 706). Since we needed households with at least a child of below five years of age, the number of children below five years of age to be sampled was therefore equal to the number of households visited:

$$N = \frac{1.96^2 (0.16 \times 0.84)}{0.05^2}$$

N=206 children below five years of age (206 HHs with at least one child of below five years of age)

The households were purposely selected and the youngest child among the children below five years of age (not less than seven months) in the household was taken.

3.5 Data Collection

Both primary quantitative data and qualitative information from the focus group discussion were collected. Before the actual data collection, the questionnaire was pre tested to the few households which were randomly selected. A questionnaire was constructed in such a way that the information such as type of foods given to children below five years of age, ingredients and proportion used and the cooking process (detailed recipes), including duration of cooking, the point at which each ingredient is added were collected. Information collected from the focus group discussion was on popular foods given to children below five years of age, number of meals per day, varieties of foods that are found within the area.

3.5.1 Method of data collection

Interviews using a questionnaire were conducted to mothers and/or caregivers to identify the three popular dishes given to children below five years of age and the common cooking procedures used in preparation of foods for these children as well as duration used for cooking. The researcher/enumerator asked questions to the mothers/caregivers and filled in the questionnaires. The interview was face to face since the researcher (enumerator) visited the households. Prior the beginning of data collection, enumerators were gathered and trained on how to conduct the interview, the training was done for three days. During the data collection they had a researcher supervising them so as to make sure that the information collected is adequate and correct.

3.6 Analysis of Diagnostic Survey Data

The information collected from the households were analysed by using Predictive Analysis Software (PASW) version 16 for windows in order to determine the most common meals given to children in this community, whereby five meals were obtained in which the three popular meals were determined and the most common three ingredients used to make each meal/dish were established basing on the frequencies and percentage.

3.6.1 Determination of the recipe and preparation methods of the common dishes by mothers/ care givers

The second visit to the households involved random selection of twenty households from the four sub villages in the two villages and each was then represented by five households. Each household was asked to prepare one child meal from the five meals that were established from the survey data and all of the steps, procedures, ingredients, proportion and time at which each ingredient was added were carefully observed and recorded for future food sample preparation for the laboratory analyses. The foods were provided by the households and those who were not able to obtain from their stock, they were provided by the study because it was off season.

3.7 Sample Preparation for Laboratory Analysis

Fresh food stuff such as banana (*nshakala* type), sweet potatoes, cassava, beans, maize flour, and sardines were bought from the study village and taken to Vienna for Laboratory analysis at the Food Science and Biotechnology Department - Boku University. Food-stuff such as tomatoes, onions and salt were bought in Vienna. The dishes were then prepared according to the established recipe and stored at -18°C until analysis of the nutrient content. A portion of each sample was freeze-dried prior to analysis. Additionally, small amounts (15-45 g) of the samples were weighed in Petri dishes, frozen at - 24°C for 6 hours and then freeze-dried for about 36 hours. Dry matter was determined and samples were homogenized ready for analysis.

3.7.1 Pro-vitamin A analysis

Most of the dishes were from plant origin and contained very small amounts of animal foods; in that case analysis of vitamin A was not undertaken. Therefore, the analysis of provitamin A carotenoids (pVAC) was carried out. Carotenoids are very sensitive to light and oxygen. Exposure to light leads to trans-cis isomerization and destruction of pVAC. Therefore, carotenoid extraction and analysis was carried out under subdued light and flasks were wrapped with aluminum foil to prevent the sample from direct light (Bognar, 1986; Rodriguez-Amaya and Kimura, 2008).

3.7.1.1 Instruments used for analysis

The instruments used included: High Pressure Liquid Chromatography (HPLC) – [Thermo Fisher Scientific Accela^{TM} (Autosampler, 600 Pump, PDA detector (80 Hz), C18 column (ACE 5, 250x4 mm)] was used for analysis of carotenoid types and amount (carotenoid characterization); Rotavapor for carotenoid extraction and Centrifuge used to spin liquid samples in order to separate substances of greater and lesser density from whole sample for further analysis of each specific part.

3.7.1.2 Reagents and Chemicals Used

The reagents used for analysis included, Petroleum ether, acetone, hexane, ethanol, $NaHCO_3$, NaCl, KCl, $CaCl_2.H_2O$, K_2HPO_4. HPLC mobile phases: acetonitrile (Roth), methanol, ethyl acetate were also used.

3.7.2 Analysis of carotenoid content

3.7.2.1 Extraction

Analysis was carried out in triplicate, one gram of each freeze-dried sample (0.5 gram of sample containing just banana) 1 ml of trans-β-apo-8-carotenal as internal standard and 15 ml of petroleum ether (0.1% BHT) were added. After shaking the sample was centrifuged for 5 minutes at 1100 rpm. The supernatant was filtered through a funnel stuffed with glass wool and collected in a flask then 10 ml of petroleum ether were again added to the precipitate, followed by 5 ml petroleum ether for the following extraction steps until the supernatant was clear. A rotavapor was used to vaporize the petroleum ether. To eliminate lipids the remaining extract was dissolved in 1 ml acetone and frozen at -24°C for 3-4 hours. 1 ml of frozen acetone was then added and the liquid sample was filtered through a funnel stuffed with glass wool to separate the fat (Rodriguez-Amaya and Kimura, 2008). The filtered sample was filled in a vial and stored at -24°C waiting for the analysis.

3.7.2.2 High pressure liquid chromatography analysis

The mobile phase consisted of acetonitrile (0.05% triethylamine (TEA), 0.1% BHT) as eluent A and methanol: ethyl acetate (1:1, v/v, containing 0.05% TEA, 0.1% BHT) as eluent B. Flow rate was set at 1000 µl/min and the injection volume at 25 µl. TEA was added to ensure a slightly improved peak resolution (Davey *et al.*, 2006).

In the quantification of the carotenoids a calibration curve was established from 5 standard solutions with different concentrations containing trans-β-apo-8'-carotene as internal standard (ISTD) and β-carotene as external standard (ESTD). For the preparation of the internal standard 5 mg of trans-β-apo-8'-carotenal were weighed into a 100 ml flask and filled up to the mark with acetone (0.1 % BHT). 5 ml of this solution was collected, transferred to a 50 ml flask and diluted with acetone (0.1 % BHT). For the preparation of the external standard 2.5 mg of β-carotene were weighed into a 50 ml flask and filled up to the mark with acetone (0.1 % BHT). 4 ml of this solution were collected, transferred to a 25 ml flask and diluted with acetone (0.1 % BHT) to the mark.

Identification of carotenoids was based on the characteristics in absorption spectrum and retention time (compared to the added standards) of different carotenoids (Davey *et al.*, 2006). Area under the curve was used to calculate the carotenoid contents. Calculations were carried out using Microsoft Office Excel 2007.

3.7.3 Iron analysis

For the determination of iron content of the samples, a microwave digestion was carried out followed by a flame atomic absorption spectroscopy (AAS). To analyze the iron concentration in the AAS the sample solution was transformed into aerosols and transported to the flame which vaporized and atomized the sample. This step led to a reduced intensity of the light (by absorption of a defined quantity of energy) coming from a hollow-cathode lamp. The detector then measured the amount of incoming light wavelength absorbed. The difference between the radiation without sample and the one with sample (absorbance) was used to calculate the iron concentration. Freeze-dried samples of all dishes were analysed in this way.

3.7.3.1 Instrument used

Microwave system FAAS (flame atomic absorption spectrometer) was used for analyzing iron.

3.7.3.2 Reagents and chemicals used

The reagents used during the analysis of iron in food samples were Iron standard (1000 mg/L), 3% Nitric acid (HNO_3), 69% Nitric acid (HNO_3), Hydrogen peroxide (H_2O_2), Volatile distilled water and 5% Calcium chloride ($CaCl_2$).

3.7.3.3 Iron content analysis

About 0.5 g (exact amount was noted) of each sample was weighed in a Teflon vessel. 5 ml of 69% HNO_3 and 1 ml of 30% H_2O_2 was added. The vessels were closed, surrounded by high pressure safety coats, (red or fluorescent dyes to aid in visual leak detection), put into rotor segments and placed inside the microwave. The heating control was done by assigning a temperature sensor into vessel identified as number one. The following process was applied, 34 min heating (10 min/1000 W/160°C, 4 min/1000 W/190°C, 20 min/700 W/190°C) followed by 30 minutes cooling.

After one hour the Teflon vessels were removed from the microwave and opened to let the nitrogen oxide volatilize. The digested liquid samples were transferred to 50 ml round bottomed flasks. The vessels and breeches were rinsed with volatile distilled water three times. The water was then used to fill the flasks to the mark, shaken well and filtered through a filter paper.

3.7.3.4 Measurement

For the calibration curve the iron standard was diluted to 4 different concentrations: 0. 04 mg/L; 0.1 mg/L; 0.5 mg/L; 1.0 mg/L. A blank value, of 3% HNO_3 was also used for the measurement. 250 µl of a 5% $CaCl_2$ buffer was added to 10 ml of each sample, standard and the blank value. The tubes were closed and mixed on a vortexer.

The sequence of the analysis was as follows: blank value, followed by the standards and the samples. Basing on the calibration curve and the specific absorption of the different samples the AAS calculated the iron concentration of each sample, respectively.

3.8 Statistical Analysis

The data generated from each sample were subjected to statistical analysis using two way analysis of variance (ANOVA) tests and the differences in means were compared using the Duncan's new Multiple Range test ($p \leq 0.05$) (Duncan, 1955). This was done to test for differences of nutrient contents among the test varieties and the test treatments.

CHAPTER FOUR

4.0 RESULTS

4.1 Common Dishes Given to Children

Different types of dishes that were given to children below five years of age in Bukoba Rural District included *katogo* (Banana and beans) (52.7%), stiff porridge with beans (21.5%), cassava mixed with beans (17.5%), sweet potatoes mixed with beans (14.6%) and porridge made from whole maize flour (11.8%). The first three dishes were taken as the most popular dishes offered to children (Fig. 3) below.

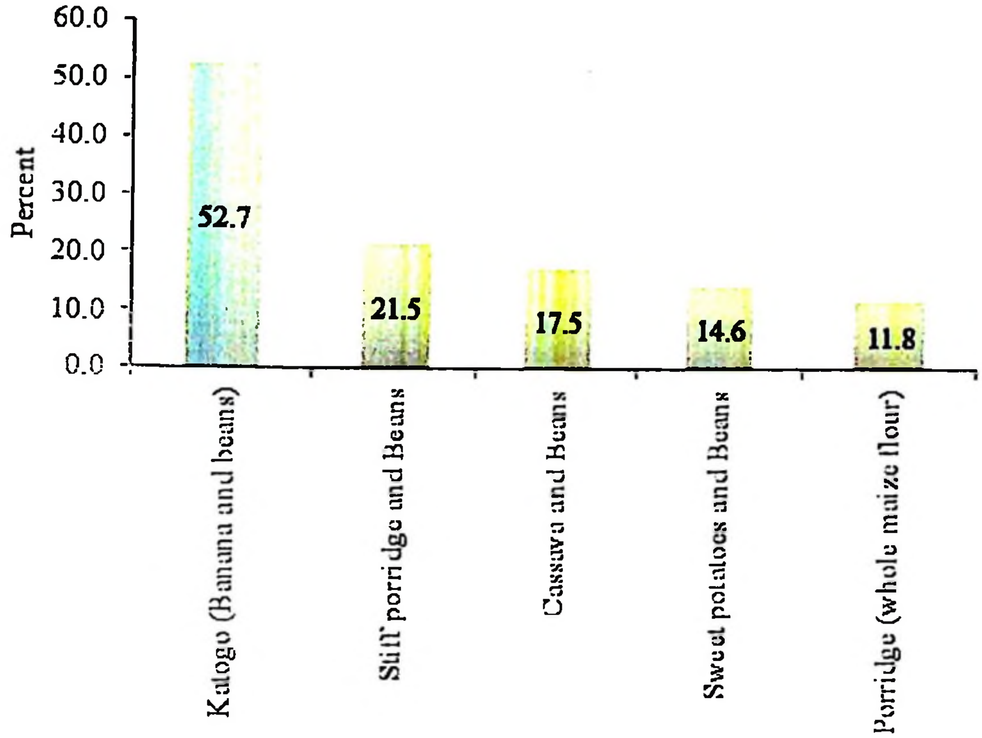

Figure 3: Common dishes given to children below five years of age

4.2 Ingredients Used to Prepare the Three Popular Dishes Given to Children below Five Years

The main three types of ingredients that were used to prepare each of the three popular dishes given to children below five years in Bukoba Rural District included beans (56.2 %, 52.1 % and 51.9 %), banana (52.7 %), maize flour (25.1 %), sardines (17.7 %, 14.2 % and 12.8 %) and cassava (17.5 %).

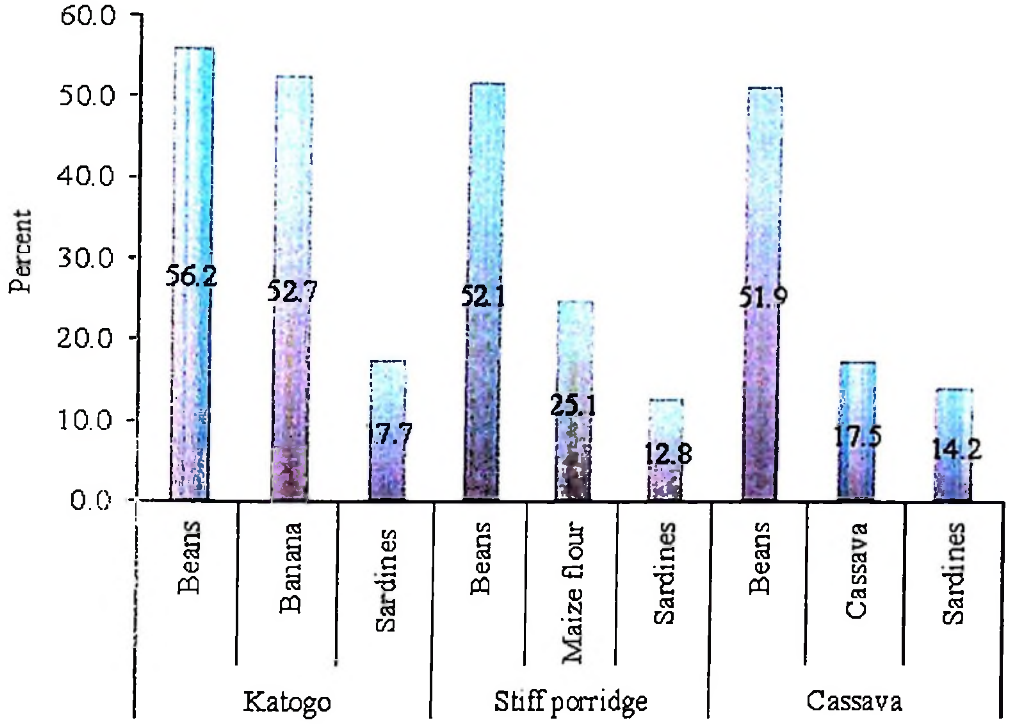

Figure 4: Three popular dishes and main ingredients given to children below five years of age

4.3 Three Popular Dishes Given to Children below Five Years of Age

4.3.1 Recipe for banana and beans dish (*katogo*)

The main ingredients and proportions used to prepare *katogo* included banana (475 g to 950 g), beans and sardines (125 g to 250 g). Other ingredients are tomatoes, onions, salt and cooking oil. Tomatoes and cooking oil were used depending on the household income and availability.

Table 1: Recipe for banana and beans dish (*katogo*)

Ingredients used	Proportions of ingredients	Cooking methods and procedure
Main Ingredients		*Katogo*
-Banana	-5 to 10 fingers of banana	- Beans were sorted and washed and put into sauce pan, about 1000 mls of water were added and put on
-Beans	(475 g -950 g)	fire to boil. Banana were peeled and cut into two pieces and then put into sauce pan without water and kept
-Sardines	-125 g-250 g of beans	apart. Beans were cooked for about 56 minutes (partially cooked) together with its soup; 500 mls of water
-Water	-125 g -250 g of sardines	was added into unwashed banana and put on fire for the mixture to be cooked.
	Water for beans boiling 1000 mls	While beans and banana are boiling, sorting of sardines was done and washed once with cold water to remove other dirt mixed with sardines, these were cooked in two ways;
	-Water for the mixture of beans and banana 500 mls	-First, *Luompo* (steamed sardines) after washing and removing the dirt onions were cut and mixed with washed sardines together with salt.
	-Water for sardine's sauce 250 mls	Mixture of onion and sardines were put on banana leaf and tied closely by using banana ropes and then were put on top of the boiling banana and steamed for 36 minutes, this type of (food) sardine is called *Luompo*. When the mixture of beans and banana is about to be cooked, dilution of salt with cold water was done and diluted salt was added to the food to boil until well-cooked (7 minutes) before taking out of the fire.
Other Ingredients Used	1-2 big tomatoes	-The second way in which sardines are prepared is as follows; (This is cooked separately)
-Tomatoes	1 medium size	Tomatoes and onions were washed, peeled and chopped into large pieces. Oil heated into sauce for 5
-Onions	¼ table spoon	minutes and five seconds, the chopped onion were added into the heating oil and fried for 6 minutes
-Salt	2 table spoons	followed by addition of sardines (fried for 3 minutes), tomatoes (fried for 4 minutes and 5 seconds), salt
-Cooking oil		(fried for 7 minutes), water was lastly added into it and left to boil (10 minutes) so as to make sauce.

4.3.2 Recipe for stiff porridge (*obugali*)

Main ingredients used to prepare stiff porridge are maize flour (500 g), this was accompanied with beans and sardines (of 125 g-250 g). Other ingredients used were tomatoes, onions, cooking oil and salt (Table 2).

Table 2: Recipe for stiff porridge (*obugali*)

Ingredients used	Proportions of ingredients	Cooking methods and procedure
Main Ingredients used		**Stiff porridge**
- whole maize flour		- Firstly the traditional stove was lit, the sauce pan was then filled with water and put on the lighten traditional stove where it was left until it is completely boiled (15minutes and 5 seconds)
-Beans	500 g of whole maize flour	-After that a small amount (62.5 ml), of boiling water was drawn from the sauce pan, whole maize flour was then added and mixed to form stiff porridge, usually more flour was added to form a much thicken stiff porridge but the water that was previously drawn was then added so as to make it a bit soft (10 minutes).
-Sardines	125 g -250 g of beans	**Beans**
-Water	125 g-250 g of sardines -Water for stiff porridge 500 ml -Water for beans 1000 ml -Water for sardines-250 ml	Beans were sorted, washed and then put into a sauce pan with cold water and boiled for 60 minutes , since these were the beans (lushala) for ugali they needed to be more soft and thus they were to be boiled for a long time. After that the soup was drawn out and the beans were mashed, when totally mashed the soup was then put back into the beans then salt was added to boil for about 7 minutes and onions for 6 minutes followed by palm oil or sunflower oil which was boiled for 8 minutes.
		Sardines
Other Ingredients Used	(1-2) big tomatoes	-Fire was started using firewood, tomatoes and onions were then washed, peeled and chopped into large pieces. After that cooking oil was heated in the sauce pan for 5minutes and 5 seconds, onions ,sardines, tomatoes and salt were cooked for 6 minutes, 3 minutes, 4 minutes and 5seconds and 7 minutes respectively. Water was lastly added into the mixture and left to boil for about 10 minutes before serving the food.
-Tomato	1 Medium size	
-Onions	2 Table spoon	
-Palm oil or sun flower oil	¼ table spoon	
-Salt		

4.3.3 Recipe for cassava mixed with beans (*Ebigando ne mpelege*)

Table 3 presents ingredients and proportions used to prepare cassava and beans for children below five years of age; these included cassava (240 g-360 g), beans (62.5 g -125 g) and ¼ tablespoon of salt.

Table 3: Recipe for cassava mixed with beans

Ingredients used	Proportions of ingredients	Cooking methods and procedure
2 to 3 small Cassava	240 g- 360 g	-The fire was started using firewood, the beans were then sorted and washed and put into sauce pan then on the stove and boiled for about 50 minutes.
Beans Salt Water	62.5 g – 125 g ¼ table spoon -Water for beans 750 ml -Water for the mixture-500 ml	-Cassava was peeled and cut into small pieces and then put into another sauce pan without water, when the peeling and cutting were done water was added into the sauce pan and the pieces of cassava were washed. -When the beans were partially cooked together with its soup and water were added into the sauce pan containing cassava and then put on fire to boil together. -When about to be served (after about37 minutes of boiling) salt was diluted in small amount of water and added to the food then the food was left to boil for about 8 minutes before serving.

4.4 Carotenoid Contents of the Foods given to Children below Five Years of Age

Only six types of food formulations were found to have carotenoids among the 11 food samples that were analysed for this specific nutrient (Table 4). These were boiled banana, banana and beans (red/pink beans -*kashukari*), stewed sardines, the mixture of stiff porridge, bean (yellow beans-*lushala*) and sardines, boiled cassava and the mixture of cassava and beans (yellow beans-*lushala*).

Table 4: Pro-Vitamin A Content in Different Food Formulations in Fresh weight (µg/100 g)

Food formulation	Forms of carotenoid		
	α-Carotene	All trans β - Carotene	cis β - Carotene
Boiled Banana	575.0 ± 428.6^{a}	574.3 ± 346^{a}	162 ± 99.9^{a}
Banana + beans	303.7 ± 157.2^{b}	326.3 ± 98^{b}	92.0 ± 29.9^{b}
Stewed Sardines	-	263.0 ± 34^{b}	63.13 ± 1^{c}
Stiff porridge + Beans + Sardines	-	140.1 ±89^{c}	36.43 ± 25.7^{d}
Boiled cassava	-	43.1 ± 186^{cd}	11.90 ±50.2^{e}
Cassava +beans	-	26.1 ± 2.03^{d}	7.27 ± 54.9^{e}

Values are expressed as means of triplicate determinations; Values with different superscripts down the column are significantly different from each other at p< 0.05.

The α-Carotene found in the mixture of banana and beans and boiled banana ranged from (303. 7 µg /100 g to 575 µg /100 g) respectively, all trans β – Carotene was found in all the six food formulations and the range was (26.1 µg /100 g to 574.3 µg /100 g) from the mixture of cassava and beans to the boiled banana, however there was no significant difference (p<0.05) between that from the mixture of banana and beans (326.3 µg/100 g) and stewed sardines (263.0 µg/100 g). cis β – Carotene was also found in the entire six food formulations and ranged from (7.27 µg /100 g to 162 µg /100 g) from the mixture of cassava and beans to the boiled banana and showed significant difference (p<0.05) for the first four food formulations as shown in Table 4.

4.5 Percentage Contribution to the Recommended Dietary Allowance for Vitamin A

4.5.1 Vitamin A calculation

Vitamin A was calculated as retinol activity equivalent (RAE) units, using the conversion factor of 12 µg/g for trans beta carotene (t-BC), 24 µg/g for cis beta carotene (c-BC) and alpha carotene (t-AC). The formula used in this calculation was RAE = (all trans beta carotene/12 + cis beta carotene/24 +all trans alpha carotene/24) expressed in μg/100 g (Tanumihardjo, 2012).

Table 5 shows the estimated amount of RAE and their percentage contribution to the recommended RDA of vitamin A of the three popular dishes which are given to children below five years of age. Plain boiled banana showed high amount of 78.6 RAE and also high RDA of vitamin A of 139.9% to this age group. Banana mixed with beans contained 43.7 RAE and 77.8% RDA. Stewed sardines contained 24.6 RAE and 11.5% to RDA of vitamin A, boiled cassava with its derived dish (mixture of cassava and beans) contained 4.1RAE and 2.5RAE respectively.

Table 5: Content of pVACs and %RDA contribution in freshly prepared dishes consumed by children below five years in Bukoba Rural

Dishes	All trans β carotene	α carotene	13 cis β carotene	Total pVAC	RAE in μg/100g	RDA child 712.5g/day (consumption size)	RDA child 187.5g/day (consumption size)	RDA child 300g/day (consumption size)
Boiled banana	574.30	575.00	162.0	1311..30	78.57	139.94%	-	-
Banana mixed with beans	326.30	303.70	92.00	722.00	43.68	77.81%	-	-
Stewed sardines	263.00	-	63.13	326.13	24.55	-	11.51%	
Stiff porridge mixed with, beans and, sardines	140.10	-	36.43	176.53	13.19	-	6.18%	
Boiled cassava	43.10	-	11.90	55.00	4.09	-	-	3.06%
Cassava mixed with beans	26.10	-	7.27	33.37	2.48	-	-	1.86%

4.6 Iron Contents of the Foods given to Children below Five Years of Age

The results in Table 6 show that, the amount of iron from steamed sardines was higher (2.8 mg/100 g) than in all the dishes and their components. Among the three popular dishes the amount of iron ranged from 0.9 mg/100 g for cassava with beans to 2.3 mg/100 g from the mixture of stiff porridge, beans and sardines. Among the components that were used to make dishes the amount of iron ranged from 0.2 mg/100 g boiled banana to 2.8 mg/100 g steamed sardines. However, there was no significance difference ($p < 0.05$) between stewed sardines and red beans, and boiled banana and boiled cassava. The observation also showed that there was significant difference ($p < 0.05$) between steamed sardines and stewed sardines, and between steamed sardines and the rest of components and dishes.

Table 6: Iron content of different food formulations in fresh weight (mg/100g)

Food formulation	Iron content
Steamed sardines	2.83 ± 1.338^{a}
Stewed sardines	2.54 ± 1.048^{ab}
Red beans	2.29 ± 0.796^{ab}
Mixture of stiff porridge, beans and sardines	2.28 ± 0.791^{ab}
Yellow beans	1.85 ± 0.355^{cd}
Banana mixed with beans	1.18 ± 0.314^{cd}
Cassava mixed with beans	0.89 ± 0.607^{de}
Stiff porridge	0.63 ± 0.868^{de}
Boiled cassava	0.24 ± 1.255^{e}
Boiled banana	0.21 ± 1.281^{e}

Values are expressed as means of triplicate determinations; Values with different superscripts down the column are significantly different from each other at $p < 0.05$.

4.6.1 Percentage contribution to Recommended Dietary Allowance (RDA) of iron

According to Brown *et al.* (2011 and (IOM, 2001), the RDA of iron for children below five years of age is 10 mg/day. Therefore all the calculations on the percentage contribution were based on this amount of RDA. The percentage contribution was calculated by comparing the 100 g that was used in the analysis and the actual amount of the specific dish and the component consumed by the children from this community. Table 7 shows how much percentage of iron was contributed to the RDA from each type of food that contained iron.

Table 7: Content of iron and %RDA contribution in freshly prepared dishes consumed by children below five years in Bukoba Rural (mg/100g)

Dishes	Amount of Fe mg/100g	%RDA in mg/100g	%RDA child 187.5g/day (consumption size)	%RDA child 300g/day (consumption size)	%RDA child 393.75g / day (consumption size)	%RDA Child 712.5g/day (consumption size)	% RDA child 500g/day (consumption size)	%RDA child 900g/day (consumption size)
Steamed sardines	2.83	28.31	53.08	-	-	-	-	-
Stewed sardines	2.54	25.38	47.59	-	-	-	-	-
Red beans	2.29	22.89	42.92	-	-	-	-	-
Stiff porridge, beans and stewed sardines	2.28	22.84	-	-	-	-	114.20	-
Yellow beans (Lushala)	1.85	18.48	34.65	-	-	-	-	-
Banana with beans	1.18	11.79	-	-	-	-	-	106.10
Cassava with beans	0.89	8.87	-	-	34.93	-	-	
Stiff porridge	0.63	6.26		-	-	-	31.3	-
Boiled cassava	0.24	2.39	-	7.17	-	-	-	-
Boiled banana	0.21	2.13	-	-	-	15.18	-	-

The findings showed that, the percentage contribution ranged from (7.2%) from boiled cassava to (114.2%) from the mixture of stiff porridge beans and sardines which was the highest amount contribution to the RDA.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Common Dishes Given to Children below Five Years of Age

Katogo (mixture of beans and banana) and sometimes accompanied by sardines was the most popular dish that was given to children below five years of age in Bukoba Rural District community. This is because it was the staple crop among other crops grown by this community. About 95% of the population in banana growing areas used banana as a staple food. Among the four types of banana that were found in Bukoba Rural District, cooking banana had been used regularly than other types, which are used in form of a fruit or for brewing and for roasting. These results implied that among the four varieties of banana that are grown in Bukoba Rural District, cooking bananas dominated.

Cooking banana being dominated they form the main sources of nutrients for children and adults. Njuguna *et al.* (2012) also made similar observations that among the four types of banana that were found in the area cooking banana dominated. This type of food was said to be rich in carotenoids (from banana), protein and iron. Protein and iron are said to be from beans though in this study protein was not analyzed, other nutrients that could be found included water soluble vitamins and minerals such as thiamin, folate, manganese and phosphorus.

Carotenoids prevents the child from night blindness, protein helps to maintain and strengthen the child's tissue, regulate cell division, and also replenishes aged or damaged cells. Lack of enough protein can lead to underweight (low weight for age), stunting (low height for age) or wasting (low weight for height). Lack of iron from the food or diet of the child can cause anaemia which prevents the child from reaching neural developmental milestones; phosphorus is important for the healthy bones and thus prevents a child from rickets (Bhutia, 2014).

This contribution to children below five years should be improved by using good cooking methods that preserve and maintain nutrients during cooking such as boiling, steaming, quick stir frying as well as considering the time that the food is being cooked, such as soaking the beans so as to reduce cooking time because long heating at high temperature destroys nutrients such as beta carotene.

Stiff porridge which was eaten together with beans was the second most important food that was given to children below five years of age in this community. This was because maize was the second food staple that was grown in this community after banana, followed by cassava which was the third food crop grown in this community. Maize and beans were grown in the same farm; as a result this made both crops to be part of the second staple that are found in Bukoba Rural District community. The implication of this practice on nutrition is the diversification of food so as to attain balanced diet. There are also some benefits of having these growing on the same piece of land such as improving soil fertility and increase crop yield, also the products and refuse from one crop plant helps in growth of the other crop and vice versa, it also ensures against crop failure in abnormal weather condition (Stone *et al.*, 2011).

Cassava which was mixed with beans had been given to children below five years of age in this community. It was used during the time when there is no rain and banana, maize and beans are scarce. This is because it was a crop that could withstand drought; sometime sweet potatoes were used instead of cassava. This type of production provided households with food availability throughout the year and ensured some form of nutrient availability for children. Ekesa, (2008) and Stone *et al.* (2010) also observed that the dishes consumed in banana growing area are banana, roots (sweet potatoes), tubers (cassava) and cereals (maize).

Porridge which is known to be a popular food given to children below five years of age in other communities in Tanzania was observed to be rarely provided to the children in Bukoba Rural District. The information from the focus group discussion shows that children are given porridge at their very early life stages as complement (one month to one and a half months), with the argument that the child cries a lot due to insufficient breast milk. This is usually prepared as a thin porridge that is made from whole maize flour and water. This could also be the reason as to why porridge is just given to few children compared to *katogo* and other foods; the reason is that, the child could easily be satisfied. This type of child feeding tends to increase the incidence of stunting or underweight to children of this age (Ekesa *et al.*, 2008). It is also a possible risk factor of micronutrient malnutrition because the foods given are bulky and are only rich in carbohydrates (energy giving foods). Because of the bulkiness of the foods, the amount of energy that a child is able to consume would not be sufficient to meet the child's growth requirements (Ekesa *et al.*, 2011). In this regard it is crucial to modify the dishes in terms of ingredients to ensure adequate content of various nutrients. Moreover the only nutrients that were analysed in this study were only iron and carotenoids; further research should then be done so as to come up with other types of nutrients contents that can be found in these dishes.

In this study it was observed that, fruits and vegetables were not offered to children. Fruits and vegetables were considered as less important and often excluded from the diet of children as well as adults, as shown in the findings of this study and if given it was in small amount which could be a possible risk factor for the high level of micronutrient malnutrition among children below five years of age in banana growing areas (Kikafunda *et al.*, 2003).

It was also observed that foods from animal sources are not given to children below five years of age apart from sardines (part of staple) that are often mixed with banana and as relish for stiff porridge. Otherwise foods from animal origin are mainly given during special occasions such as during marriage ceremonies or festivals. This is because in the common dishes mentioned that are given to these children, there was no or very few dishes (less than 5%) of animal source. Also children were denied eggs and meat because parents believed that these will make them steal meat and eggs, which is considered as bad practice and should not happen in their families. If this is done it means it will reduce the amount of income when eggs are sold and reduce the number of chicks if the eggs are left to hatch. Lack of these foods in the children's diet may be a leading cause of deficiency of micronutrients such as vitamin A (pre formed) iron and calcium, which could lead to blindness, anaemia, impaired cognitive development and poor physical development (Ekesa *et al.*, 2011).

5.2 Three Popular Dishes Given to Children below Five Years of Age, Ingredients Used and Cooking Methods

5.2.1 *Katogo* (mixture of banana and beans)

Katogo was the most popular dish that was given to children below five years of age in Bukoba rural and was made from beans, banana and sardines: sometimes sardines were also used as relish or not be there at all, depending on whether the family had money to buy them or not (household economic status). Moreover, some few households (11%) used tomatoes in making sardine relish while others used salt and onions only. This type of dish was mainly boiled. First beans were boiled, and bananas were peeled and cut into two pieces and left into an open sauce pan until the beans are partially cooked, and then the beans are added into the sauce pan containing banana so as to boil them together. This method of boiling banana has also been reported by Ekesa (2008) that 70% of the households in banana growing communities consumed banana by peeling and boiling them in water until they soften.

5.2.2 Stiff porridge (*Obugali*)

Stiff porridge was the second dish given to children below five years of age and was made from whole maize flour accompanied by beans and sardines as relishes. In case of very small children, the three were mixed together and mashed. Maize was the only cereal that was used to prepare stiff porridge in this community. However in order to avoid monotous type of meals other cereals such as sorghum could also be used to make stiff porridge. This could not only change the diet and the taste to the child but also were highly rich in iron (4.1 mg/100 g) compared to whole maize grain which had 3.5 mg/100 g (Lukmanji *et al.*, 2008).

The method of preparation for both stiff porridge and the relish is boiling. This type of cooking method has no effect on the iron content of the food, but rather it reduces vitamin A content of the food Hosseini *et al.* (2014) though this nutrient (pre formed) was only found in sardines (from tomatoes) and in most cases are stewed or steamed in the banana leaf (*Luompo*).

5.2.3 Cassava and beans (*Ebigando ne mpelege*)

The third popular dish that was given to children below five years of age was cassava which was mixed with beans and sometimes accompanied with sardines which were cooked separately. The cassava varieties used were the sweet ones (*mkaanyigimwa*). A few households (7%) used tomatoes and cooking oil in preparing sardines while others used only salt and/or onions. This type of dish was mainly boiled, whereby beans were boiled first until partially cooked and the pieces of peeled and diced cassava were added and cooked. Sometimes cassava was cut into small pieces and the children ate the dish, without being mashed.

The findings showed that cassava was only cooked in this one way, whereas other studies have shown that cassava root could also be given to children as porridge or stiff porridge so as to change the form which helped children to like the food as it is one of the staple foods found in the area. Similar observations were also reported by Nungo *et al.* (2012). Beans that were mixed with cassava were boiled without soaking in water, a way which hindered bioavailability of the nutrient such as iron due to presence of ant-nutritional compounds known as polyphenolic compounds. Similar case was also reported by Tako *et al.* (2014). It was also shown that the soaked or non-soaked of the beans had no effect on the amount of nutrients that are found in the beans especially iron. With the exception for cooking time which might destroy other nutrients such as protein, because the beans were dry and therefore took long time to be cooked and at high temperature (Pereira *et al.*, 2014).

Studies show that persons consuming poorly processed cassava in large quantities are susceptible to neuropathology, when cassava-based diets are not supplemented with good sources of protein and iodine, Goiter and rickets are also prevalent (Teles, 2002; Dhas *et al.*, 2011). This is because cassava tubers are rich in carbohydrate and major source of energy and deficient in protein, fat and some minerals and vitamins. Unless this diet is supplemented by protein from animals it can hinder growth and development of children (Teles, 2002; Dhas *et al.*, 2011). The study showed that beans (legumes) are the only source of protein and might not be enough sources or meet the child's requirements; as a result children may face the consequences discussed above as well as protein energy malnutrition (PEM).

However, boiling method of cooking in a normal sauce pan is said to have no effect on iron content of the food as it will be found the same as it was in the raw food, though this method has shown significantly to decrease in sodium, potassium, phosphorus and zinc. Vitamin A is also said to be reduced when the food is boiled (Hosseini *et al.*, 2014) though it is not clear as to how much is reduced by boiling and the extent of the heating. Beans are used as an associate and accompaniment to the three popular dishes that are given to children below five years of age in this community. The reason to this could be that, it is the most consumed staple and it forms part of the daily menu of most of the population in Tanzania, providing the important nutrients such as protein, iron, and zinc when well handled (Pereira *et al.*, 2014).

5.3 Carotenoid Contents of the Three Popular Dishes and their Components

5.3.1 *Katogo* (Mixture of banana and beans)

All the three forms of carotenoids were found in both foods *katogo* and in the plain boiled banana. The amount of α-carotene from plain banana in this study was higher than that reported in the study by Ekesa *et al.* (2013) from *Vulambya* and *Nshikazi* cultivars, whereas the cultivar used in this is study is *Nshakala*. Alpha carotene from *Nshakala* exceeds that of *Vulambya* and *Nshikazi* by 101.8 and 168.6 folds respectively. There could be several reasons which caused these differences, one of them being the type of the cultivar that has been used to prepare the dish, just as it is seen from *Vulambya* and *Nshikazi* while that which is reported in this study is *Nshakala*.

Moreover it was observed that, the amount of α-carotene found in the mixture of banana and beans was lower than that in plain boiled banana whereby the same bananas were used to make *katogo*. The reason for this variation could be due to preparation methods. In this process the factor of cooking time when it comes to banana is not considered because beans were cooked first for 56 minutes and thereafter, peeled and cut bananas were added and the two were cooked together for 43 minutes before the food was served. Exposure to light could have contributed to low carotene content because the bananas were peeled, cut into two pieces and left in an open sauce pan while waiting for the beans to be partially cooked. Carotenoids are said to be destroyed when the specific food is exposed to light and heat treatment, such as boiling which can result into substantial losses. As a result this makes consistency difficult since different foods are prepared by different methods (Fungo, 2009).

Therefore this emphasizes the need for community education in the handling this kind of food so as to reduce the loss of carotenoids which is the main source of vitamin A in this region. This is because of poor or no consumption of animal origin sources and dark green leafy vegetables. The amount of α-carotene that was lost from this type of dish was 271.3 µg/100 g which was almost half of that from plain boiled bananas as beans were found to have no carotenoids. This reflects that the main source of α-carotene from this type of food is banana and therefore they should be well handled in the process of cooking so as to avoid loss and also reduce or prevent vitamin A deficiency in the region and the nation at large.

The amount of all trans β – Carotene that was found in *katogo* was 326.3 µg/100 g and that from plain boiled banana was 574.3 µg/100 g. This type of carotenoid is usually found abundant in food than the rest of the carotenoids, just as it has been in the plain boiled banana that all trans β – Carotene exceeded the α-carotene by 22.6 μg/100 g.These findings are supported by those made by Tanumihardjo, (2012). However in *katogo* there was no significant differences ($p<0.05$) between α-carotene (575 μg/100 g) and all trans β – Carotene (574.3 μg/100 g), the reason for this could also be the type of banana (cultivar) used in the study, since beans used in this study contained no carotenoids. A similar difference was also observed by Ekesa *et al.* (2012) in the report on the bio-accessibility of pro-vitamin A carotenoids in banana and derived dishes in Africa, and it was due to types of cultivars used *Vulambya* and *Musilongo.* The two results imply that the amount of α-carotene and all trans beta carotene from the cultivars used are more or less the same.

The type of cultivar used in this study is *Nshakala* and the amount of all trans β – carotene in *katogo* is lower than that found in the plain boiled banana by 1.76 folds. This difference can be related to the procedures used, specifically the exposure of peeled bananas to light while waiting for the beans to be partially cooked. Direct light destroys carotenoids (Englberger *et al.*, 2003; Mulokozi *et al.*, 2006). This therefore calls for sensitization on proper food handling techniques and processing to the respective community so as to avoid loss of carotenoids which is the main source of vitamin A (provitamin) since there is very little from animal origin (sardines). The mothers and caregivers have to be educated that light destroys carotenoids and therefore banana should not be peeled and left in the direct light while beans are cooked, instead should be peeled when beans are ready to be mixed with banana so as to avoid waiting in the direct light.

The cultivar (*Nshakala*) that was used in this study was creamy in colour before boiling and after boiled it turned into yellow, the colour which could make anyone predict that there was a lot of carotenoids found in it especially all trans β – Carotene which is said to be abundant in food that are sources of provitamin A carotenoids and as a result it turned out to be true. However in the study which involved Papua New Guinea bananas cultivars which are creamy in colour contained 155 μg/100 g amounts of beta carotene Englberger *et al.* (2003), which were lower than that observed (574.3 μg/100 g) in this study which used bananas of the same colour. Therefore these results indicated that cultivars which were creamy in colour could also differ in the amount of carotenoid found in them, thus further studies should be done on these varieties so as to come up with the best cultivar that can be relied upon as a better source of carotenoid in banana growing and consuming communities and were banana is the most popular food that is given to children. In the food formulations that involved banana, lutein was also detected but in trace amounts. Generally it is also reported that the nutritional composition of banana and other fruits at harvest can vary widely due to cultivar, maturity, climate, soil type and fertility (Fungo and Pillay, 2011).

Stewed sardines which were sometimes used as relish with *katogo* were also found with high all trans β – Carotene of 263 μg/100 g and this type of carotenoid could be from tomatoes Gama *et al.* (2006) and small amount of cooking oil used (cotton seed oil) Bresnahan *et al.* (2014), since there was no any vitamin A analysis that was carried out due to the fact that most of the dishes were of plant origin. However the predominant carotenoid in tomato was lycopene (Gama *et al.*, 2006). This was also detected in this study but in trace amount and is said to be the precursor of beta- carotenes in tomato. This type of carotenoid has been reported to have no vitamin A activity but rather as an antioxidant Englberger *et al.* (2003) that protect the body against oxidative stress.

Cis beta carotene was found in both *katogo* and plain boiled banana with the amount of 92 μg/100 g and 162 μg/100 g respectively. This form of carotenoid is the result of cooking especially under high heat Ekesa *et al.* (2013) which in this study was not measured. This form of carotenoid could be due to enzymatic or non-enzymatic oxidation and isomerisation of trans-carotenes to cis-isomers (*ibid*). On the other hand it has been observed that the amount found in plain boiled banana was higher than that of *katogo* (mixture of banana and beans), the reason being that the heat used to boil banana was higher than the heat used for cooking *katogo*. Moreover this form of carotenoid was known to have lower vitamin A activity and was presented in insignificant levels compared to the trans carotene observed in this study (Maroya *et al.*, 2012).

5.3.2 Stiff porridge (*Obugali*)

Stiff porridge was taken with beans and sometimes sardines. Stiff porridge in this study was made up of whole maize flour and water. The maize used was white whole maize which are said to have no carotenoids. These findings are supported by (Lukumanj *et al.*, 2008). Among the two relishes that were used, stewed sardines was found to have carotenoids which were all trans beta (263 µg/100 g) and cis beta (63.13 µg/100 g) whereas that which was found in the mixture of beans, sardines and stiff porridge were 140.1 µg/100 g and 36.43 µg/100 g respectively.

All trans beta carotene and cis beta carotene that was found in sardines is said to have been extracted from tomatoes and cooking oil that were used to prepare them. This is because no vitamin A analysis was carried out because the dishes and their components were mainly from plant origin. It was also observed that the amount of all trans beta carotene that was found in the mixture of homogenised beans, sardines and stiff porridge after cooking was lower than that of stewed sardines by 1.88 folds. The reason for this fall could be due to handling and homogenization of the three in which light might have interfered the process and caused instability of the carotenoids.

The cis beta was the result of enzymatic or non-enzymatic oxidation and isomerisation of trans-carotenes to cis-isomers, from both heat used in cooking sardines and light when the three were mixed and homogenized together.

5.3.3 Mixture of cassava and beans (*Ebigando ne mpelege*)

The only forms of carotenoids that were found in this dish were all trans beta carotene and cis beta carotene. These forms of carotenoids were all from cassava as there was no carotenoid that was found in the yellow beans (*Lushala*). Plain boiled cassava had all trans beta of 43.1 µg/100 g and cis beta of 11.9 µg/100 g while the mixture of cassava and beans had 26.1 µg/100 g and 7.27 µg/100 g respectively. One would imagine as to how the yellow beans were found with no carotenoids, in this case it is not the fact of the colour, but where and to what type of food is that colour found since carotenoids are widely distributed in natural pigments responsible for the yellow, orange, and red colors of fruits, roots, flowers, fish, invertebrates, and birds.

It was therefore observed that, the amount of all trans beta carotene that was found in plain boiled cassava exceeded that which is found in the mixture of cassava and beans by 1.7 folds. This fall from plain boiled cassava when the two are mixed is due to dilution factor of some sort which depends on the amount, type, and physical form of the carotenoid. Another reason would be procedures used in preparation of this food. That being the case this amount is lost when cassava is peeled and cut into small pieces and left into an open sauce pan in the light while waiting for the beans to be partially cooked, before the two are mixed together. In these cooking procedures and handling, light has also been observed as the reason to the loss of this amount of carotenoid as it has been in *katogo*.

It has been reported that, all trans β-carotene is the most potent and widespread form of provitamin A and is the predominant carotenoid in cassava (Maroya *et al.*, 2012). The report is similar to the findings of this study since the only type of carotenoids found was all trans *β*-carotene and its isomers. Moreover, it is said that the amount of carotenoids found in cassava increases with age of the plant, these finding are useful to community education that they can harvest the root in its mature period so that they can get the amount of carotenoid that could be obtained in cassava (Ortiz *et al.*, 2011).

5.4 Retinol Activity Equivalent (RAE) and the Percentage Contribution of the Three Popular Dishes and their Components to the Recommended Dietary Allowance (RDA) for Vitamin A to Children below Five Years

5.4.1 Mixture of banana and beans (*Katogo*)

The result revealed that plain boiled banana had 78.57 RAE which was equivalent to 139.94% contribution of RDA of vitamin A for the children below five years of age which is 400 RAE, while the mixture of banana and beans had 43.63 RAE which is equivalent to 77.81% of the RDA for vitamin A contribution. It was therefore observed that RAE from plain boiled is greater than 70RAE, while that in the mixture of banana and beans was less than 70RAE by 23.37RAE. Based on these results plain boiled banana of *Nshakala* cultivars are said to be good sources of vitamin A to children below five years of age in Bukoba rural district. Engelberger *et al.* (2006) cited by Ekesa *et al.* (2012 and 2013) reported that, food with RAE of around 70 or higher is considered to be good source of vitamin A. *Nshakala* cultivar which was the type of banana used in this study is said to be good source of Vitamin A when cooked plain and can readily reduce the prevalence of vitamin A deficiency specifically to children of this age and the community at large.

Moreover in the mixture of banana and beans though had less 26.32RAE to reach 70RAE which was of 77.8% of the RDA for vitamin A with one third (33.33%) of the RDA, it is therefore considered to be a good contribution to the RDA of vitamin A to children below five years of age. These findings are also supported by Abia *et al.* (2007) who observed that the contribution of at least one third to the RDA is adequate to maintain the nutrition status of the child regarding the specific nutrient.

As it was mentioned earlier that the fall of this percentage contribution to the RDA is the handling of banana during preparation as they were exposed to light in an open sauce pan while waiting for the beans to be partially cooked. This can therefore be prevented by sensitizing the community not to peel bananas until the beans are partially cooked or to keep them in closed sauce pan inside the house until when needed to be mixed together so as to retain the amount of vitamin A that may be present in banana.

Another way in which can help maintain the vitamin A that could be obtained in this type of banana is to look for an alternative associated food such as dark green leafy vegetables which are easily cooked and can be mixed to the boiled banana. Dark green vegetables are also good sources of carotenoid that could be converted to vitamin A (Ekesa *et al.*, 2012). In this case the community needs to be sensitized on establishing home gardens so as to be able to plant, harvest and use these vegetables which are good sources of nutrients such as vitamin A (provitamin), iron, and folate. However, beans and banana may be cooked separately and mixed together when the food is served so as to avoid loss of carotenoids to be converted to vitamin A in the cooking and waiting processes.

5.4.2 Stiff Porridge (*Obugali*)

The mixture of stiff porridge, beans (*lushala*) and stewed sardines had 13.2 RAE which contributed 6.2% of the RDA for vitamin A, whereas stewed sardines alone had 24.6 RAE which contributed 11.5% of the RDA for vitamin A. Neither stiff porridge nor beans (*Lushala*) was found with carotenoids which could be converted to RAE. The fall of 24.6 RAE from stewed sardines to 13.2RAE when mixed with the stiff porridge and beans was due to carotenoids lost in the process of mixing the three together due to presence of direct light.

Since the two foods provide less than one third (33%) of the contribution, they are said to be poor sources of vitamin A to children below five years of age in Bukoba Rural District. Another reason which might have led to this food being a poor source of vitamin A is that the only source of carotenoids in this dish was from tomatoes whose predominant carotenoid is lycopene, and beta carotene was found in small amounts.

5.4.3 Mixture of cassava and beans (*Ebigando ne mpelege*)

Plain boiled cassava had 4.1 RAE which could meet 3.1% of RDA for vitamin A, and the mixture of cassava and beans had 2.5 RAE and 1.9% of RDA for vitamin A. The fall of RAE as well as the RDA proportion from plain boiled cassava when the two are mixed is due to procedures of handling of food during preparation .Generally the cooking method which was mainly boiling in the pot and covered was said to be good method as it didnot cause loses of β carotene, unlikely when cooking is done by using a pressure cooker (Elizalde-González and Hernández-Ogarcía, 2007). Consequently, in this case this form would be lost through other handling processes especially in the peeling and waiting for the other components of the recipe to be cooked before mixing them together.

The amount of RAE obtained from both plain boiled cassava and the mixture of cassava and beans were not able to reach one third of percentage RDA; as a result this type of dish is said to be a poor source of vitamin A to children below five years of age in Bukoba rural. Another reason for this dish to be a poor source of vitamin A is because the type of cassava used was white fleshed cassava. Similar observation was reported by Maroya *et al.* (2012) that the typical white-fleshed cassava (WFC) genotypes largely used in Nigeria contain only small amounts of all trans β-carotene.

Another reason which could cause this low amount of vitamin A from this dish could be the time taken before they were cooked and extracted for the carotenoids. This is due to the fact that they were transported from Tanzania to Vienna and it took about three days before the cooking and the analysis took place. This was also reported by Barret and Bevis (2013) that, perishable foods naturally lose minerals and vitamins over time, therefore the speed with which fresh foods are delivered and the means by which they are preserved, processed or cooked do matter a lot when it comes to their nutrient content. Though it was not clearly stated as to how much is lost and at what period will the loss be significant.

Cassava and its derived dishes had very little carotenoids which led to poor percentage contribution (3.06%) and (1.86%) of RDA for the vitamin A respectively and being the third staple food given to children below five years of age in banana growing communities, it is therefore suggested that the community should come up with another cassava derived food, by changing the component beans to green leafy vegetables or add the green leafy vegetables as relish to the dish since these are said to be good sources of vitamin A. Abia *et al.* (2007) observed that, *fufu* (cassava stiff porridge) and *eru* (green leafy vegetables) were cooked separately but served together and eru contributed up to one third of the RDA of carotenoids.

In addition intervention such as bio fortification breeding to produce yellow fleshed cassava (YFC) which contains up to about 100 times of carotenoids as much from what is obtained in white fleshed cassava (WFC) is recommended. It has also been shown that this genotype retains up to about 55.7% of *β*-carotene after boiling, which is significant amount to the RDA Maroya *et al.* (2012). It is therefore very imperative to breed and promote these types of cassava varieties so as to combat vitamin A deficiency in this community in particular and the nation at large, since this type of food is available almost throughout the year. One study has shown that caretakers and children perceived a significant difference in taste between white and pro-vitamin A rich cassava (YFC). Both preferred pro-vitamin A rich cassava over white cassava because of its soft texture, sweet taste and attractive color (Talsma *et al.*, 2013).

5.5 Iron Content of the Three Popular Dishes and Their Components

5.5.1 Mixture of Banana and Beans (*Katogo*)

The mixture of banana and beans had 1.2 mg/100 g amount of iron, plain boiled banana had 0.2 mg/100 g amount of iron and plain boiled beans (*Kashukari*) had 2.3 mg/100 g amount of iron. It was therefore observed that the amount of iron found in *katogo* was less than that found in beans. In normal interpretation, one would expect the amount of iron in this type of dish to be greater than what was observed but it was found that due to the fact that, iron in banana is affected by the dilution factor when the two were mixed together to form one dish.

Another reason could be the time taken to cook beans as bananas were mixed and then cooked together, since the beans used were dry beans which were said to be cooked for a long time and as a result led to loss of iron nutrient. This was because heat treatment could change the content of sulfhydryl groups produced from cysteine and thereby affect iron content (Baech *et al.*, 2003).

In order to avoid this loss of nutrients, the community should be educated on soaking dry beans prior to cooking as this will not only get rid of polyphenol compounds but also reduce the cooking time and bring a good texture of the food. However on the other hand phenolic compounds are considered useful as prevent people from diseases such as cancer due to their antioxidant activity. Among the eleven studies that were done on the discarding or not discarding the water used in soaking the beans it was only one study that suggested that the water should not be discarded and the rest suggested that the water should be discarded so as to allow utilization of nutrients in the body (Fernandes *et al.*, 2010).

Banana being the most popular component in making the dishes was found to have very low amounts of iron (0.2 mg/100 g). These findings corroborate the findings by Fungo *et al.* (2010) which showed that in East African high lands, cooking banana have very low amounts of iron (0.6 mg/100 g) and (0.1 mg/100 g) for *Nakhaki* and *Kikundi* cultivars respectively whereas the one used in this study is *Nshakala*. This shows that the amount of iron from banana varies from one cultivar to another. Steamed sardines (*Luompo*) which is sometimes used as a relish to *katogo* was found to contain 2.8 mg/100 g of iron. This is because it is from food of animal origin which is a good source of iron, and the cooking method used is said to be conserving nutrients (Zhejiang *et al.*, 2011).

5.5.2 Stiff porridge (*Obugali*) and the Mixture of cassava and beans (*Ebigando ne mpelege*)

It was found that stiff porridge had 0.6 mg/100 g of iron, while the relish which was sardines and beans (*Lushala*) had 2.5 mg/100 g and 1.9 mg/100 g iron respectively. When the three were mixed and homogenized the iron content was 2.3 mg/100 g which was greater than that obtained from stiff porridge but lower than that observed in sardines. On the other hand the mixture of cassava and beans had 0.9 mg/100 g of iron while that of beans (*Lushala*) had 1.8 mg/100 g and plain boiled cassava had 0.2 mg/100 g of iron. Normally one would expect that the amount of iron in the main dish would be greater than the components, but that was not the case. The reason to this could be due to measurements of samples during the analysis and the digestion process in iron determination; it might be that when the three were mixed together the digestion was not complete.

Another reason could be the time taken to cook beans as bananas were mixed and then cooked together, since the beans used were dry beans which are said to be cooked for a long time and as a result led to loss of iron nutrient. This was also reported by (Pereira *et al.*, 2014). So far the iron content show variation from one crop to another as reported by Fanzo *et al.* (2013) that variation of iron levels is different between crops.

5.6 Percentage Contribution of the Three Popular Dishes and their Components to the Recommended Dietary Allowance (RDA) of Iron for Children below Five Years

5.6.1 Mixture of Banana and Beans (*Katogo*)

It was found that mixture of banana and beans could meet 106.11% of the RDA of iron for children below five years of age. red beans (*kashukari*) which is mixed with banana to make this dish could meet 42.92% of the RDA of iron, plain boiled banana which is also the component used to make this dish could meet the iron RDA by 15.18%. Among the three dishes, banana and beans seemed to have significantly met the RDA of iron for children below five years of age in this community. Yellow beans and plain boiled banana showed to be poor sources of iron that would meet the RDA for children below five years of age. This is due to the fact that the required amount to meet iron RDA ranges from 97%

to 98% as children of this age requires a lot of iron for their growth and development. When there is no enough iron in the body fewer red blood cells are produced. This reduces the capacity of the blood to transport oxygen. As a result symptoms from fatigue and inability to concentrate, as well as impaired physical and cognitive development of the children can occur (IMO, 2001; WHO, 2002). Therefore the red beans used to make this dish were said to be good sources of iron and were therefore needed to be mixed with this type of banana so as to obtain both vitamin A and iron as required by children below five year of age in this community.

Banana as the most popular food was found to be poorly meeting the RDA of iron to children below five years of age (15.2%). It is therefore regarded as a poor source of iron when eaten alone and hence can increase the prevalence of iron deficiency in the area. In order to get rid of this problem it is suggested that new variety of orange banana which was found with (6.1 mg/100 g of iron) should be introduced in the area, as it was found that this variety would reduce the rate of iron deficiency anaemia of more than 50% in the region (Fungo, 2009).

Steamed sardines (*Luompo*) being of animal origin and sometimes used as relish to *katogo* was found to have 53. 1% of RDA for iron, and according to Abia *et al.* (2007) it is said to be a good source of iron. Furthermore the mixing of banana and beans and sometimes sardines as a relish was said to be a good source of iron. Therefore banana and beans (*katogo*) dish was said to be a good source of iron to children below five years of age in this community.

5.6.2 Stiff porridge (*Obugali*)

The mixture of stiff porridge, beans (*Lushala*) and stewed sardines when prepared showed to have met the RDA of iron to children below five years of age by 114.2%. However the amount of RDA from the three individual foods (stiff porridge, beans and stewed sardines) was lower than when the three were mixed together (31.3%, 34.7% and 47.9% respectively). The results implied that this type of dish was a good source of iron since its contribution is greater than 98% (IMO, 2001) and 33.3% (Abia *et al.*, 2007) therefore recommended for the children below five years of age. The relishes were said to be good sources of iron and thus made a complete dish to provide sufficient amount of iron to children below five years of age since they were all about one third of the RDA.

Such high amount of contribution of iron RDA is encouraged especially in banana growing communities whose sources of iron are from plant based foods. In additional to that plants are found with non heme iron which is not readily available in the body compared to animal origin foods such as meat, fish and poultry.

5.6.3 Mixture of cassava and beans (*Ebigando ne mpelege*)

Results showed that, mixture of cassava and beans could have 34.9% RDA of iron for the children below five years of age, and that beans (*Lushala*) and plain boiled cassava had 34.7% and 7.2% RDA of iron respectively. However the amount of RDA of iron from the mixture was more or less the same as that from the beans which had more amount of iron than the plain boiled cassava. The reason could be due to loss of this nutrient in the process of cooking for a long time. However, since it was not less than 33.3% as referenced by Abia *et al.* (2007) it was therefore considered as a justifiable source of iron.

In addition, the reason to such kind of RDA of iron was due to iron loss while cooking beans which took long time due to dryness (Pereira *et al.*, 2014). In order to avoid nutrient losses (iron), fresh beans should be used when available (Ekesa *et al.*, 2012).

However, since in most cases the cooked banana and boiled cassava were mixed with beans then the child would be able to receive the required amount of iron, though sometimes it could be difficult for the child eating the same food every day as a result he or she could be deficient of iron. Therefore the community is urged to modify the dishes. Instead of using beans everyday they can use dark green leafy vegetables such as amaranth, cassava leaves, pumpkin leaves which can easily be obtained at home from home gardens during dry season. Such practices were also reported by Abia *et al.* (2007) whereby boiled roots of cassava were mashed and eaten with dark green leafy vegetables known as *eru*. In which the amount of iron from the dish was found to be 1402 mg/409 g which was very high and exceeded the RDA where the child obtained 1349 mg/393.75 g. Therefore dark green vegetables are good sources of iron. To achieve this community awareness campaign should be emphasized.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study was set out to investigate popular foods consumed by children below five years of age in banana growing communities in Bukoba Rural District. The popular foods given to children included boiled banana, banana and beans (Red beans/pink) (*Kashukari*), stiff porridge, beans (*Lushala*) and stewed and steamed sardines. The most common method that was used to prepare the food was boiling, others were steaming and frying.

The dishes which were found with high and sufficient amount of iron were stiff porridge and beans and stewed sardines, steamed sardines (*Luompo*), banana and beans, stewed sardines, red/pink beans (kashukari) and yellow beans (*Lushala*). These types of food that were given to children below five years of age in these communities had the potential to meet RDA for this age group.

However, they were not enough to combat both VAD and IDA since the levels of vitamin A deficiency (46.7%) and iron deficiency (49.3%) in children below five years in Kagera Region and Bukoba Rural District in particular were still high.

These findings will help people in banana growing communities to understand types of dishes that are appropriate for children below five years of age bearing in mind that children of this age have higher requirements of vitamin A and iron for their growth, optimal health and development.

6.2 Recommendations

In view of the findings of this study it is recommended as follows:

1) Bananas and cassava should not be peeled until it is ensured that beans are partially cooked so as to avoid exposure to light which destroys carotenoids.
2) Beans should be soaked in water overnight and pour the water before cooking so as to get rid of ant nutritional compounds such as polyphenolic compounds that hinder bioavailability of nutrients in the body.
3) Parents and care givers in the community should be enabled to keep chicken or ducks and dairy goats at home which will help them provide foods from animal origin to their children so as to get enough iron.
4) Research of this kind should be carried out at different time or season of the year so as to capture the other types of dishes/food that are given to the children below five years of age in this community this is because season determines the type of food given to children below five years of age.
5) Parents and caregiver should be educated on how they can preserve the foods which were of high nutrient content (eg. dark green leafy vegetables) to be used during the time when they were not available (off season)
6) These findings will enable other researchers to conduct further studies on new varieties of food such as cassava which were found to have very little contribution of both vitamin A and iron and design recipes which have good amount of nutrients for children below five years of age

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APPENDICES

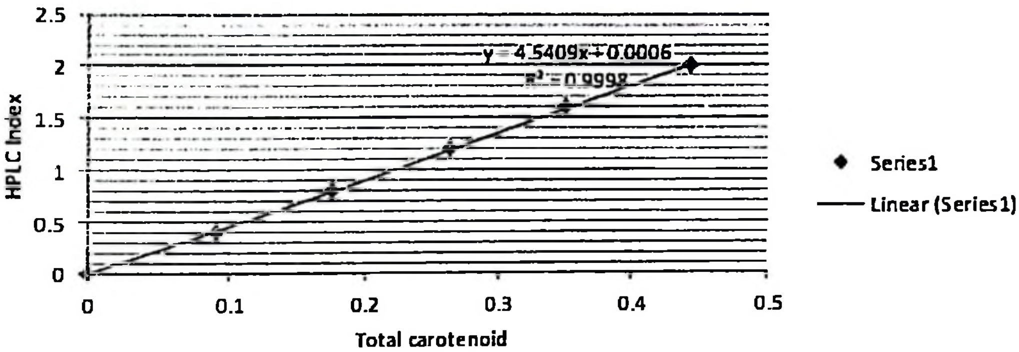
Appendix 1: Nutrient content of the popular dishes consumed by children below five years of age in banana growing communities

ID ____

HOUSEHOLD NUMBER________________________________

	Common name of meal	Three main Ingredients used and proportions	Cooking procedure including time of cooking
44.1.			
44.2.			
44.3.			

Appendix 2: Best of fit curve for carotenoids



Appendix 3: Four varietal Analysis of Variance (ANOVA) for carotenoids content

Source of variation	Df	Trans beta carotene		Cis beta carotene		TransAlpha carotene	
		F-v	F-p	F-v	F-p	F-v	F-p
Replication	2	1063	0.001	42.3	0.001	610.01	0.001
Variety	5	128071	0.001	10236.4	0.001	176497.6	0.001
Residual	10	3550	0.001	158.4	0.001	548.1	0.001
Total	17						

F-v: F-value; F-p: F-probability; Df-Degrees of freedom

Appendix 4: Four varietal Analysis of Variance (ANOVA) of iron content

Source of variation	Df	Iron content	
		F-v	F-p
Replication	2	0.2789	0.001
Variety	9	2.9003	0.001
Residual	18	0.1682	0.001
Total	29		

F-v: F-value; F-p: F-probability; Df-Degrees of freedom