ORANGE FLESHED SWEET POTATO CONSUMPTION FOR IMPROVED NUTRITION IN GAIRO

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ABSTRACT

In developing countries like Tanzania, vitamin A deficiency remains a public health concern, due to monotonous, cereal-based diets that lack diversity. Evidence from study on Orange Fleshed Sweet Potatoes (OFSP) consumption for improved nutrition in Gairo shows that the diets of a large percentage of households are deficient in vitamin A. Overall objective of the study was to increase contribution of sweetpotato particularly OFSP as a component of dietary intake on improved nutrition in Gairo district. It was observed that there were differences in household-level 24 hours dietary recall that was taken for two non-consecutive days (i.e., during weekday and weekend) whereas in Meshugi was (n=42 households), Ngiloli (n=44 households) and Ihenje (n= 45 households). Of the commonly grown cultivars, Kabode and Mataya had the highest content of β-carotene (878.31 and 426.39 µg/g) respectively and lowest were Naspot 1 and Polista (9.99 and 5.40 µg/g). The study revealed that 59.5% of the respondents' households cultivated non-OFSP while 10.7% solely grew OFSP and 29.8% cultivated both. Only 16% of the visited respondents had knowledge on how to store sweetpotato. Most of complementary foods given to children aged 6-24 months did not meet their RDA. Household Dietary Diversity Score (HDDS) across villages during weekdays and weekends differed statistically during weekdays ($p<0.001$) and during weekends ($p<0.01$). There was higher variation of per capita vitamin A intake during weekdays compared to weekends. OFSP and vitamin A food rich sources were consumed inadequately. Results of sensory evaluation showed that, the highest overall acceptability of the formulated food types was recorded on $MAKAG_2$ (7.53) and the lowest (6.69) MAG_2. The study concluded that there was inadequate consumption of OFSP among visited households and limited dietary diversity among the consumed foods. It is recommended that OFSP should be promoted to increase consumption and advocate food diversification.

DECLARATION

I, Sakina Magadi Mustafa, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

____________________________ ____________________

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The declaration is hereby confirmed by;

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Prof Henry S. Laswai Date

(1st Supervisor)

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Dr Gration. M. Rwegasira Date

(2nd Supervisor)

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DEDICATION

This dissertation is dedicated to my lovely parents; my father, the late Mr. Mustafa Ally Magadi and my mother, the late Mrs. Margareth Mbwana Magadi as every step of my success depended on them. "*Innah lillah waina lillah rajioun*" Ameen.

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ABBREVIATIONS AND SYMBOLS

AIDS	Acquired Immune Deficiency Syndrome
AOAC	Association of Official Analytical Chemists
CF	Crude Fibre
CIP	International Potato Center
cm	Centimeter
CP	Crude Protein
DDS	Dietary Diversity Score
DM	Dry Matter
FAO	Food and Agriculture Organization
Fe	Iron
FTNCS	Food Technology, Nutrition and Consumer Sciences
g	Gram
GDP	Gross Domestic Product
GMSPL	Green Midrib Sweet Potato Leaves
h	Hour
HCl	Hydrochloric acid
HDDS	Household Dietary Diversity Score
HIV	Human Immunodeficiency Virus
HKI	Helen Keller International
IFPRI	International Food Policy Research Institute
IMFNB	Institute of Medicine, Food and Nutrition Board
IQR	Inter Quartile Range
MC	Moisture Content
mcg	microgram

mg	milligram
MNP	Micro Nutrient Powder
NaCl	Sodium Chloride
NBS	National Bureau of Statistics
^{o} C	degree Celsius
OFSP	Orange Fleshed Sweet Potato
p.p.m	parts per million
PMSPL	Purple Midrib Sweet Potato Leaves
RDA	Recommended Daily Allowances
SUA	Sokoine University of Agriculture
SUGECO	Sokoine University Graduate Entrepreneurs Cooperative
TDHS	Tanzania Demographic and Health Survey
TFCT	Tanzania Food Composition Table
TFNC	Tanzania Food and Nutrition Centre
UNICEF	The United Nations Children’s Fund
URT	United Republic of Tanzania
US$	United States Dollar
USAID	United States Agency for International Development
VAD	Vitamin A Deficiency
VAS	Vitamin A Supplementation
WHO	World Health Organization
Zn	Zinc
β- Carotene	Beta Carotene

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Sweet potato (*Ipomoea batatus* L. Lam) is a dicotyledonous plant of the family Convolvulaceae (Tortoe *et al*., 2010) but, behaves as an annual when cultivated. It is cultivated in the tropical, subtropical zones and warm temperate regions (Saranya *et al*., 2006). The crop is a source of dietary fibre, complex carbohydrates, proteins, vitamins A, C and B, iron, calcium as well as making of industrial starch (Korada *et al*., 2010). Leaves are consumed as vegetable in some communities (Masumba *et al*., 2007) and also for animal feed (Etela *et al*., 2008).

Sweet potato is already an important staple food for many Africans. It is adaptable and easy to grow. It is drought tolerant, has low nutrient demands and provides reasonable yields during seasons where other crops would fail. Another advantage is that it can be harvested piecemeal to provide daily fresh food.

Over a decade ago, new varieties of Orange Fleshed Sweet Potatoes (OFSP) were introduced in Tanzania and since then their popularity continues to grow due to its high levels of nutrients especially (β-carotene), high yield and ability to generate high income. OFSP is now grown more in developing countries than any other root crop. Its promotion is good for food security and it is a high nutritious substance, toward alleviating vitamin A deficiency (VAD) by many governments (CIP, 2009) and is an important staple food and cash tuber crop in Tanzania (Kapinga *et al*., 2007).

In recent years, the amount of sweet potato consumed in urban areas has increased. This is partly due to the increase in urban population and consumer positive changes towards the consumption of the crop, especially during the Holy month of Ramadan as well as low prices compared to other commodities. The crop is marketed and consumed in both urban and rural areas (Kapinga *et al.*, 2000; Ndunguru, 2001).

Despite substantial advances over the past century in both agricultural production and nutrition research, approximately 1 billion people are globally chronically hungry, 2 billion regularly experience periods of food insecurity and just over one-third of the population is affected by single or multiple micronutrients deficiencies (IFPRI, 2011). Traditionally, indigenous vegetables are the most economically efficient sources of micronutrients (Mwanri *et al.*, 2011). Consumption of OFSP vegetables micronutrients will improve intake and overall diet and health status.

1.2 Problem Statement and Justification

In Tanzania, micronutrient malnutrition is a public health problem, which is caused by poor dietary intake or severe and repeated infections, particularly in underprivileged populations. Sweet potato is among the top most cultivated crops for food and cash in Tanzania, particularly Gairo district. Some of the newly introduced sweet potato varieties in the area are orange fleshed, which would help curb the high rate of malnutrition if the crop is incorporated as vital component of the daily dietary intake.

Micronutrient malnutrition and hunger are major problems affecting developing countries, especially in Sub-Saharan Africa (FAO, 2012).Tanzania has among the world's highest rates of under nutrition, with around 2.4 million children malnourished and 34.7% of children suffering from stunting (NBS, 2015).

Deficiencies in micronutrients, which are required in small amounts, but crucial to children's health and development, are widespread. About one-third of children in Tanzania are deficient in iron and vitamin A (TFNC, 2012 and NBS, 2011).

Growing and consuming crops with rich levels of beta-carotene are more promising solutions. OFSP varieties have high beta-carotene content, offering an inexpensive complementary vitamin A source. If OFSP was incorporated into diets in Sub-Saharan Africa, the prevalence of vitamin A deficiency could be significantly reduced (Meenakshi *et al.*, 2010).

Although Sweet potato is among the most grown crops in Gairo, the challenge is how to get this crop from farms to the lunch or dinner plates of family members. This is particularly for mothers, pregnant women and young children who require pre-cursors to Vitamin A from OFSP in such a way that the dietary intake would fit into the recommended amount per day according to their status and shift consumption from white to orange varieties. In Tanzania, Sweet potato tubers are primarily used for human food, and are mainly consumed freshly cooked. Information on how tubers and vegetables are to be consumed is clearly vital when determining important quality on nutrition criteria (Kapinga *et al.*, 2003).

Existence of plans to make special consideration on making Sweet potato specifically OFSP a necessary part of dietary intake is not known. The current study intended to explore the contribution of OFSP consumption trend for improved nutrition to the community of Gairo as part of dietary daily intake. The study findings may be based upon in integrating OFSP as an essential component of daily meals at every household to mitigate malnutrition problems in Gairo and similar areas.

In Gairo district, the dry season is characterized by acute shortage of green leafy vegetables and edible wild vegetables that supply micronutrients. This means supply of micronutrients, particularly vitamin A is compromised. OFSP have a big opportunity of making for this shortage as the tubers will still be available. This is an added advantage since the traditional sweet potato varieties are generally poor in supplying this vitamin because vitamin A animal rich sources are expensive and therefore not easily afforded by many.

Locally available food crops together with OFSP can be used to formulate nutritious foods, which can contribute towards alleviating vitamin A deficiency. OFSP is enormously rich in beta carotene (Mitra, 2012) and is also a loaded source of carbohydrate, fibre and good sources of vitamins C, E, K and several B vitamins (Burri, 2011).

Vitamin A deficiency is one among national's nutrition problems in Tanzania, whereby some mitigation measures have been implemented to overcome the problem. These include food fortification, vitamin A supplementation, bio-fortification and food diversification.

In 2014, Vitamin A Deficiency (VAD) prevalence was estimated at 42 percent among children under five years in Africa (The Washington Times, 2014), which represents approximately 78 million affected children. It is also particularly severe among pregnant and/or lactating women. The deficiency increases children's vulnerability to common illnesses and impairs growth, development, vision, and immune systems. In severe cases, it results in blindness and death. National prevalence of VAD is 33% of which Morogoro has 36.3% (TDHS, 2010). There is need to do educate people to consume OFSP in their daily food intake.

1.3 Objectives

1.3.1 Overall objective

To increase contribution of sweet potato particularly OFSP as a component of daily dietary intake for improved nutrition in Gairo District.

1.3.2 Specific objectives

The specific objectives of the study were as indicated hereunder:-

i. To determine the household dietary diversity with special focus on sweet potatoes in Gairo.

ii. To quantify the proportion of OFSP in the dietary intake of selected households in Gairo

iii. To quantify the vitamin A intake in the selected households in Gairo.

iv. To develop an acceptable OFSP-based blend formula for reducing vitamin A under-nutrition in Gairo.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Sweet Potato Production in Tanzania

In Tanzania, sweetpotato is the third most important root and tuber crop after cassava and Irish potato. In terms of volume produced, sweet potato is the most important in the Lake Zone (330 600 tons/year). Production in other zones is Southern Highlands Zone (271 000 tons/year), Eastern Zone (107 400 tons/year) and Southern Zone (37 400 tons/year) (URT, 2011). Sweet potato production is mainly for home consumption. The preparation for consumption in most families in Tanzania involves boiling, roasting and deep-frying of the roots and the leaves are eaten as a green vegetable with ugali, rice or other food items. The vegetables are sometimes dried and packed for consumption during the dry season. One small to medium boiled root (125 g or half to 1 cup) of OFSP can supply the RDA amount of vitamin A for young children and non- breastfeeding women (Low *et al.*, 2007).

There is low awareness of the nutritional benefits of OFSP and the importance of its orange colour in stimulating Vit A demand and this leads to low daily recommended intake of OFSP. The World Health Organization reported that vitamin A deficiency (VAD) affects about 190 million preschool- aged children and 19 million pregnant women, mostly in Africa and South-East Asia (WHO, 2011). Children in developing countries are at risk of consuming vitamin A deficiency diets (Sommer, 2011).

In Tanzania, micronutrient deficiencies including Vitamin A costs the country over US$ 518 million, around 2.65% of the country's GDP (World Bank, 2012). Beyond the economic losses, micronutrient deficiencies significantly contribute to infant and maternal mortality, with over 27 000 infant and 1 600 maternal deaths, or 28 600 total deaths annually (World Bank, 2012).

2.2 Orange Fleshed Sweet Potatoes

Orange - fleshed sweet potato' (OFSP) refers to several varieties of sweet potato (*Ipomoea batatas*) that are rich in β-carotene, a vitamin A precursor. This β-carotene content gives the tubers their orange colour. OFSP tubers are good sources of bio-available vitamin A. OFSP has potential in reducing vitamin A deficiency in Tanzania, particularly in young children. It is estimated to be the most affordable source of this micronutrient and can be incorporated into a number of popular foods. The crop can be grown across a range of climatic conditions and requires little land. Helen Keller International (HKI) estimates that the crop has potential to benefit 50 million children under six in the country (HKI, 2012).

2.3 Prevalence of Malnutrition

Globally, malnutrition contributes about 60% of the 11 million deaths that occur each year among children below four years old (Sunguya *et al.*, 2006). Malnutrition refers to disorders resulting from an inadequate (under- nutrition) or excessive diet (over- nutrition) or from failure to absorb or assimilate dietary elements (UNICEF, 2008). It is one of the most serious health problems affecting infants, children and women of reproductive age. Vitamin A is an essential micronutrient for the immune system that plays an important role in maintaining the epithelial tissue in the body. Severe vitamin A deficiency (VAD) can cause eye damage. VAD can also increase the severity of infections, such as measles and diarrhea diseases in children, and slow recovery from illness (TDHS, 2010).

2.4 Nutritional Significance of Sweet Potato

Sweet potato leaves are consumed in Tanzania, but they are principally considered as animal feed. The leaves also contain a significant amount of β- carotene but bioavailability is certain to be much lower than for OFSP roots (Low *et al.*, 2007). Non-orange fleshed sweet potato is poor in micronutrients but OFSP has potential for reducing vitamin A deficiencies, particularly in young children. It is considered to be the most affordable source of this micronutrient and can be incorporated into a number of popular foods. According to a project promoting OFSP, the crop could benefit up to 50 million children under six in Tanzania (HKI, 2012). OFSP is rich in β- carotene, a micronutrient that becomes vitamin A in the body. Further, the β-carotene in OFSP is more bioavailable than alternative vegetable sources. It is also rich in starch, calcium, potassium, vitamins C and anti-oxidants such as β-carotene, all of which are very essential for optimal health. OFSP varieties are believed to represent the least expensive, year-round source of dietary vitamin A and other nutrients to poor families. This variety has a comparative advantage over other common staple foods, especially cereals and legumes, which provide zero to minor traces of β- carotene.

OFSP as a staple food has an advantage over most vegetables in that it can supply significant amounts of vitamin A and energy simultaneously, thus helping to address both VAD and under nutrition. OFSP is an example of a biofortified crop in which the micronutrient status of staple foods is enhanced through plant breeding to the point where impact on micronutrient status can be achieved (Bouis, 2002). Since the poorest households typically obtain over 60% of their energy needs from food staples, this strategy is particularly suited to poor rural households that cannot access purchased fortified food products but could grow this OFSP.

Children below 5 years, 7-10 years and adults need to eat about 30, 40 and 80g of the vitamin A rich sweet potato, respectively, to meet the daily requirements (Sweet Potato Knowledge Portal, 2016).

2.4.1 Sweetpotato consumption and utilization

OFSP can be consumed and utilized in different forms; such as fresh tubers and dried chips. Fresh tubers and dried chips are used in industries in making starch, wine, alcohol and animal feeds (Barnes and Sanders, 2012).

Farmers grow OFSP for their families' consumption and to earn some extra income. For human consumption, OFSP in Ibuti village and some in Ihenje are boiled, roasted, fried and some dried to make flour from which chapatti, maandazi (doughnuts), cake and porridge are made. Knowledge on OFSP preservation and storage is less known. Only a few people know how to prepare dried OFSP (*makewe*) and make flour. Consumption rises during peak harvesting season which is from March to August. However, during the current year people of Gairo faced rainfall deficiency whereby until I completed data collection they had not started planting which could led to failure or late planting with subsequent low harvest due to rain shortage. The limited availability of food led to capitalizing on consuming vines which they used as vegetables.

OFSP, either in fresh or processed form, can be branded as a health improving product. When marketed to urban consumers, there are additional income benefits to rural producers that could induce a potentially complementary impact on nutrition through increased spending on other health enhancing services and products.

In every household, at least after one or two days, leaves from OFSP are used as vegetables in their dishes. The leaves of OFSP have nutritive value comparable to common dark green leafy vegetables (Bovel-Benjamin, 2007). Consumption of sweet potato leaves, which are rich in dietary fibre, vitamins and antioxidants in the form of carotenoids would be useful in neutralizing free radicals in the body and hence reduce the harmful effects of oxidative stress (Teow *et al*., 2007).

2.4.2 Nutritional qualities of OFSP and its importance in the human body

2.4.2.1 Vitamins

OFSP storage roots offer excellent nutrition and health benefits due to the presence of abundant vitamins (vitamin A precursor β-carotene, vitamin B_1 and C, and one of the few non-fat sources of vitamin E), antioxidant micronutrients, beneficial complex carbohydrates, minerals and dietary fibers (Bovel-Benjamin, 2007). OFSP is an excellent source of pro-vitamin precursor β- carotene A. In many developing countries, sweet potato is a secondary staple food and may play a role in controlling vitamin A deficiency.

Apart from their high content of β-carotene, OFSP are good sources of carbohydrate, energy, protein and fiber (HKI, 2012). Consequences of their high moisture content, sustained metabolism and microbial attack, leading to damage during harvest and storage shorten their shelf life (Temu *et al.*, 2014). Carbohydrate is a good source of energy , while fibre is important in the diet for enhancing bowel movement, preventing overweight and constipation and reducing risk of colon cancer (Ayinde *et al*., 2012; Anderson *et al*., 2009).

2.4.2.5 Minerals

Minerals are naturally occurring chemical elements the body uses to help performing certain chemical reactions (Ikewuchi and Ikewuchi, 2009). They are essential for the normal functioning of muscles, heart, nerve and the maintenance of body fluid composition as well as for building strong bones (Chaney, 2006). Orange fleshed sweet potatoes are rich sources of minerals. Both tubers and leaves are good sources of fibre, zinc, potassium, sodium, manganese, iron and vitamin C (Antia *et al.,* 2006).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in Gairo district in Morogoro region. Field studies were undertaken from November to March 2017, followed up by laboratory tests and recipe formulations in the Food Technology, nutrition and consumer sciences laboratory at SUA. Three villages were selected for the field study namely Ihenje, Meshugi and Ngiloli. Ibuti was used as a pre-testing village. Gairo district is one of the seven districts of the Morogoro region of Tanzania, East Africa. It is located in the northwest corner of Morogoro region (Fig. 1).

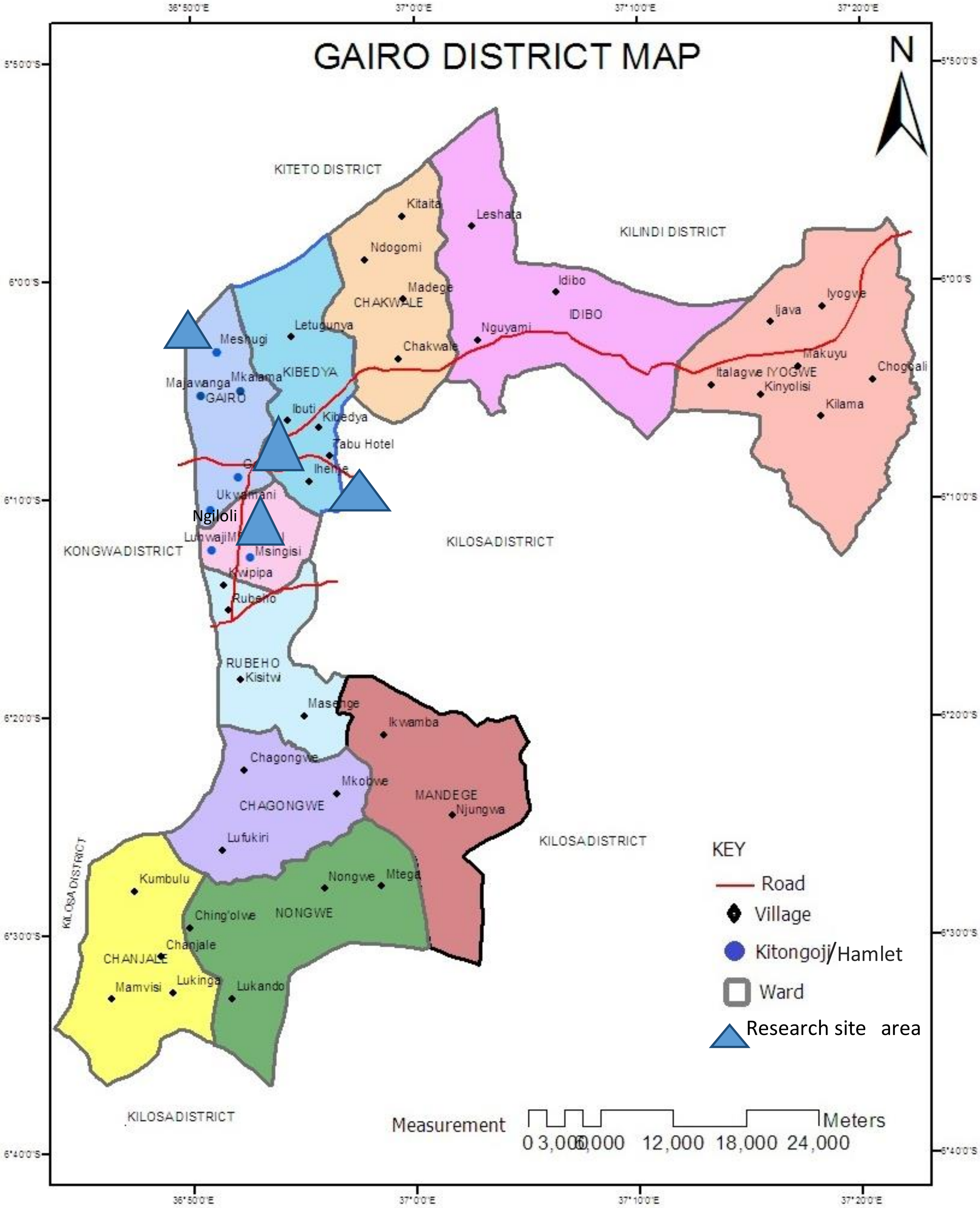

Figure 1: Map of Gairo (Adopted from Gairo District Council 2017)

It lies between latitude 6^0 and 16^0 south and longitudes 36^0 and 55° east. The area produce, utilize, process sweet potato in large amount compared to other districts in the region. The main crops grown in Gairo district include maize, sweet potatoes, sunflower, groundnuts, beans, lentils, cassava, tomatoes, onions, pumpkins and several other vegetables. Since 2013 OFSP introduced by the Commercialization of Sweet Potato Seed Project and cultivated increasingly. Varieties of edible wild vegetables are also grown in Gairo. Farmers in the area are grouped in three categories namely small, medium and large (commercial) scale farmers.

Gairo has access to the market as it dissected through by the main road to Dodoma and Morogoro town with well established transshipment point, as well as a collection point for the agricultural products in the district. The district was chosen purposely due to its potential and diversity of orange fleshed sweet potato production, utilization and genetic variation of varieties. Also it is a study site for the project titled, "Commercialization of Sweet Potato Seed", which is the funded of this study.

3.1.1 Population

The district has a total population of 193 011 persons (NBS, 2013). It receives rainfall of between 400 and 500 mm per year between December and April, with a short dry spell from mid-January to mid-February. The dry season is between May and November. The major land use system in the study area is subsistence crop farming and keeping indigenous ruminant multi-livestock breeds comprised of cattle, goats and sheep. The dominant ethnic groups in the district are Kaguru, Lugulu, Nguu and Kamba; who shares more or less similar language but retain their original tribal identities, traditions, beliefs and rites.

3.2 Study Design

A cross sectional study design (Bailey, 1994) was employed in three villages to collect both qualitative and quantitative data at a single point in time in Gairo district. The use of both quantitative and qualitative methods was necessitated by the fact that the study required varied information to achieve the desired results.

3.2.1 Study population

The study population included a representative sample of households living in Gairo currently growing both OFSP and Non orange fleshed sweet potatoes.

3.2.1.1 Inclusion criteria

All members living in those particular households were included focusing on those who were currently involved cultivating the OFSP and Non- orange fleshed sweet potatoes.

3.2.1.2 Exclusion criteria

All household members who were mentally retarded and those who were not permanently residing in those particular households were excluded.

3.2.2 Sampling technique

Purposive sampling was used to identify the region, district wards and villages to be covered in my study. Random sampling was used to select study households.

3.2.3 Sample size

The sample size was computed using the equation and procedure shown.

$n=Z^2Pq/d^2$

where; by n = desired sample size

Z = standard deviation at required confidence interval usually 1.96 at 95% C.I

d = degree of accuracy desired, 5% = 0.05

P = the proportion of the villages which cultivated OFSP to which had been supplied with vines by project, which were 4 out 50 which giving us 0.08

q= 1-p

$$n=\frac{1.96^2 \times 0.08 \times 0.92}{0.05^2}$$

=113

The proportionality of how many households were surveyed was 113/3= 37.6 approximately to 38 households per village were surveyed.

The computed sample size of 113 was based on the villages supplied with OFSP vines. Households were selected based on the advice of local leaders and extension workers. Only households known to grow and consume OFSP and traditional sweet potatoes were interviewed.

The questionnaire and 24-hour dietary recall sheet were pre-tested in 10 households in Ibuti village. The aim was to see if the questions were understandable, that they were in a logical order and that provided the expected feedback from respondents. The questionnaire was then revised and adjusted based on the responses during the pretesting. Some questions were reformulated to make them more understandable.

3.2.4 Data collection

Data collection involved primary data, which were collected from the field and laboratory. Fieldwork involved a survey, which used a 24 hour dietary recall, consumption on OFSP, knowledge on behavioural dietary intake of OFSP, household dietary diversity score and interviews using structured questionnaires.

Laboratory analyses included the determination of β- carotene composition of raw or fresh and dried roots and vegetables, mineral analysis and OFSP vegetable samples collected from Gairo district during the survey and composition of blended food formulae which were prepared in the Food Analysis laboratory at Sokoine University of Agriculture. Food formulations were made from blended samples of sweetpotato tubers and vegetables with high content of β- carotene with incorporation of Micronutrient Powder (MNP).

3.2.5 Preparation for data collection

3.2.5.1 Information to the government officers

The study was introduced to Gairo District Executive Director, Gairo District Medical Officer, and Gairo District Extension Officer by a letter and formal meeting. This was followed by meetings with Ward Executive Officers of Ibuti, Ihenje, Meshugi and Ngiloli wards. The Extension Officer introduced us to village leaders prior to data collection in their villages. Village leaders informed their residents about our presence and arranged appointments for our visits and accompanied us to different households during the days of interviews.

3.2.5.2 Field survey

A survey in three villages was carried out by interviewing sweetpotato growers using a structured questionnaire, which was divided into sections (Appendix 3). The questionnaires designed to capture information on OFSP household behavior used a 24 hour dietary recall, consumption on OFSP, knowledge on behaviour dietary intake of OFSP and household dietary diversity score.

3.2.6 Sample collection

A total of four commonly grown varieties of OFSP (Mataya and Kabode) and non-OFSP (Polista and Naspot 1) and their leafy vegetables were randomly sampled and used in this study. Samples of sweet potato tubers and their leafy vegetables, and maize were collected for laboratory analysis carried out in the Department of Food Technology, Nutrition and Consumer Sciences laboratory at SUA. The raw materials studied (*Ipomoea batatas*) tubers and leaves together with maize (*Zea mays*) were chosen because they were widely grown and consumed in Gairo and were among the cheapest sources of carbohydrate and minerals. These materials were purchased from the selected households of sweetpotato growers in Gairo. The fresh samples were stored at room temperature (24˚C) before processing. Processed samples were stored in the freezer at –20˚C for 24 hours until analysis was conducted.

3.2.7 Laboratory work

Proximate compositions of the four different cultivars of raw, dried roots, fresh vegetable varieties and maize grains from Gairo district were determined. The analyses also included and proximate analyses also included proximate analysis of the porridge samples. The parameters determined were moisture, dry matter, crude protein, crude fat and ash and carbohydrate content that was determined by difference. Minerals, β- carotene and viscosity were also analyzed. The analyses were carried out in duplicates.

3.2.8 Sample preparation

Raw roots (Fig. 2) were peeled using a kitchen knife, cut into cubes of about 2.5 cm, washed by using distilled water and then ground using motor and pestle. The samples were then subjected to chemical analysis immediately after preparation, especially for total β-carotene analysis. This minimized the chances of enzymatic oxidation.

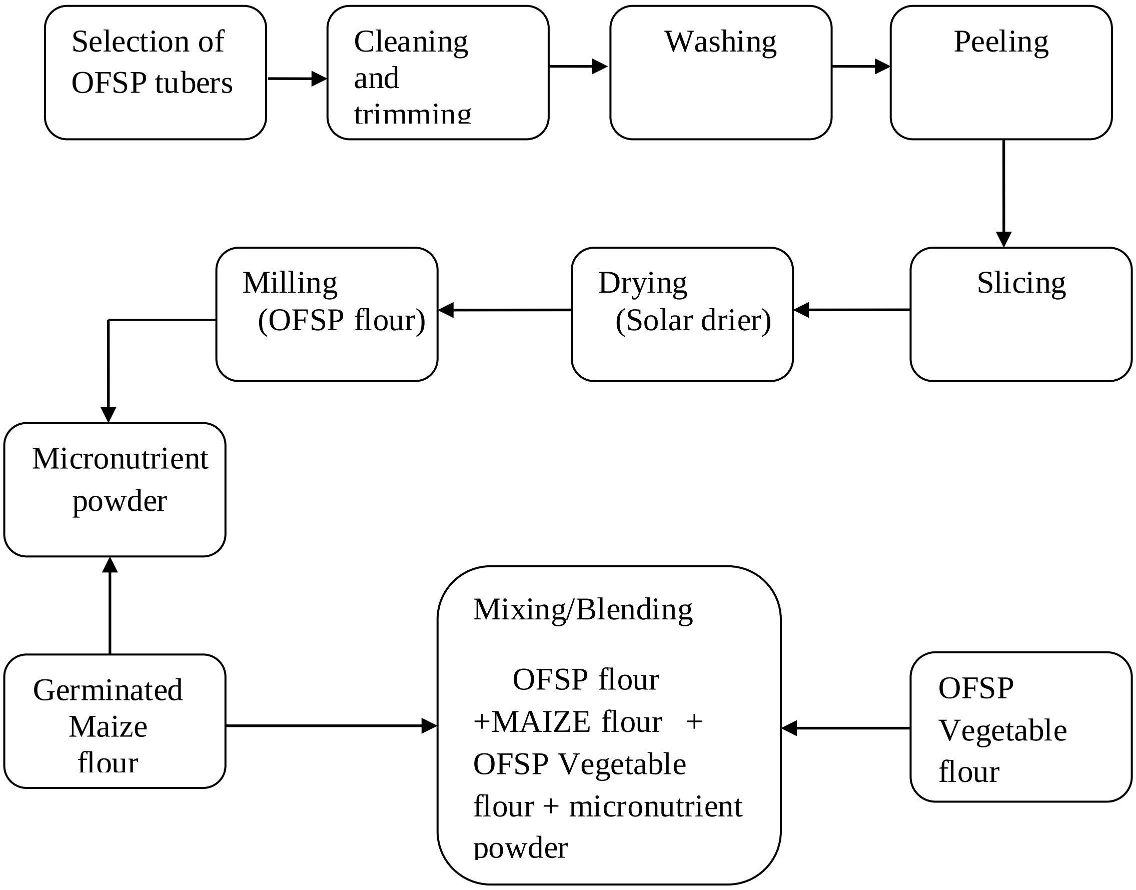

Figure 2: Procedure for preparation of blended OFSP formulae

The remaining OFSP samples were peeled, sliced using kitchen knife to slices of about 0.5 cm thickness, then solar dried (60-70ºC) for two days. Dried samples were packed in polythene bags and kept at room temperature (20˚C) for storage until proximate analysis was done. The remaining samples were taken for milling to get flour, which was used for incorporating feeding formula. Maize grains were germinated, dried, milled and packed in polythene bag and kept at room temperature (20˚C) until analysis.

Some of the vegetables of OFSPs were chopped and ground using mortar and pestle. Grinded samples were packed in polythene bags and kept at room temperature (20˚C) for 24 hours storage until analysis.

3.2.8.1 Germination of maize

The maize grains were manually cleaned to remove husks, stone, cob, damaged and discoloured seeds. This was achieved through winnowing, sieving and hand picking. The seeds were washed in 5% (w/v) sodium chloride solution to suppress mould growth and soaked in distilled water. Then, the cleaned maize grains were soaked for approximately 12 hours in an equal volume of water at room temperature and then wrapped in a moist muslin cloth and left for 48 hours at room temperature to germinate. Distilled water was sprinkled at every 24 hours to support germination. The sprouted grains were then dried in a dehydrator at 65º C for approximately 5 hours. The soaking increased water content in the seeds and brought them out of seed dormancy. After 48 hours germinated maize seeds were separated from the ungerminated maize seeds. These germinated seeds were then dried, milled and stored in air tight container for analysis.

Sweetpotato tuber, sweetpotato vegetable and germinated maize flours and micronutrient powder were mixed to get different food formulae compositions as per sample and then mixed flours were packed in strong polythene bags for analysis. Culturally, white maize (*Zea mays*), which is devoid of β-carotene (Nuss and Tanumihardjo, 2010) is the major cereal that is used in preparing foods for infants (Nuss *et al.*, 2012).

3.2.8.2 Sweetpotato vegetable flour processing

Sweetpotato leafy vegetables were collected from farmers of the selected households in Gairo and transferred for laboratory analysis carried out in the Department of Food Technology, Nutrition and Consumer Sciences laboratory at the Sokoine University of Agriculture. The leaves were washed under running water to remove the adhering mud particles followed by cleaning with double glass-distilled water and drained completely. The fresh samples were stored at room temperature (24˚C) before processing.

One set of sweetpotato greens was used as such for analysis. Another set of these OFSP leafy vegetables was steam blanched for 5 min after chemical treatment with a solution of 0.2% of sodium chloride (NaCl). They were drained after blanching and spread on steel trays for drying in an oven at 67°C for 8 –10 h. After drying the sweetpotato green leafy vegetables were ground to a fine powder in a grinder mixer, stored in an airtight container in a refrigerator. After all procedures (Fig. 2) flours were mixed to get blends ready for laboratory analyses.

3.2.9 Laboratory analysis

Proximate analyses of both fresh and processed samples were determined as follows:

3.2.9.1 Determination of moisture content

The moisture content of fresh and processed OFSP tuber and vegetable samples was determined in duplicate samples following the AOAC method 925.10 (AOAC, 1995). The OFSP samples were then dried at 105ºC overnight and then weighed. The average moisture content was calculated using the following formula:

$$\text{Percent moisture in g/100g} = \frac{(W_2 - W_1) - (W_3 - W_1)}{(W_2 - W_1)} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where; W_1 = weight of crucible (g)

W_2 = Weight of wet sample and crucible (g)

W_3 = Weight of dry sample in a crucible (g)

i.e, MC = 100 - % Dry matter

3.2.9.2 Dry matter

Dry matter was calculated based on moisture content according to Egan *et al.* (1981), that is;

Percent dry matter = 100 - % moisture

3.2.9.3 Crude protein determination

Crude protein of sweet potato samples was determined using the semi micro (Kjeltec) Kjeldahl method as described in the method 920.87 (AOAC, 1995). About 0.3 g of OFSP samples were weighed in duplicate and hot digested with concentrated sulphuric acid with bromocresol green and methyl red indicators. The obtained clear digested sample was steam distilled using Kjeltec distillation unit Kjeltec 8 200 Auto Distillation Serial No. 91719280 Part No. 10 014 901, 2012, Sweden) and the distillates titrated against standard 0.1N hydrochloric acid (HCl).

Total Nitrogen (N*)* and crude protein in the sweet potato samples were worked out as follows:

$$\text{Percent nitrogen} = \frac{14.01 \times N \times A}{W} \times 100 \quad \text{.........(2)}$$

where;

A = the titre of acid used in milliliters

W= original weight of the digested sample (g)

N= Normality of HCl used

Percent crude protein (g/100g) = Percent Nitrogen x Factor (6.25)

3.2.9.4 Crude fat (ether extract) determination

Crude fat content of sweetpotato samples was determined by the Soxtec HT Ether extraction method as described in method 920.85 (AOAC, 1995). Sweetpotato samples were ground in a mortar and pestle in order to increase the surface area for the extraction. About 3 g of the sample were subjected to the Soxtec extraction. Dried and pre- heated (W_2) in the oven for 30 minutes was taken and 25ml of the solvent were added and used for ether extract for 15 minutes in boiling position and for 45 minutes in rinsing position. The solvent was evaporated and the cups were dried at 100ºC for 30 minutes. The extracted oil samples were cooled in desiccators for 30 minutes and weighted. The percent crude fat was calculated as follows:

$$\text{Percent fat/oil (g/100g)} = \frac{(W_3 - W_2)}{W_1} \text{ X } 100 \quad \ldots\ldots(3)$$

where;

W_1= Weight of empty extraction cup (g)

W_2= Weight of sample (g)

W_3= Weight of extraction cup and extracted fat (g)

3.2.9.5 Ash content determination

The ash content of the tested samples was determined by using method 940.26 (AOAC, 1995). About 5 g of the test sample were weighed in a pre-weighed crucible. The samples were then ignited in carbolite muffle furnace (530 2RR, England) at 525º C for three hours.

The ash content was calculated from the relationship:

$$\text{Percent ash} = \frac{(W_3 - W_1)}{W_2} \text{ X } 100 \quad \ldots\ldots(4)$$

where;

W_1 = Weight of crucible (g)

W_2 = Weight of sample (g)

W_3 = Weight of sample in a crucible (g)

3.2.9.6 Carbohydrate

The total carbohydrate content was determined by difference, according to (AOAC, 1995) that is, 100% - other proximate compositions, using the formula:

Total carbohydrate = 100 – (% CP +% EE + % CF + % AC+ % MC)……………........(5)

where;

CP = Crude protein

EE = Ether extract

CF = Crude Fibre

MC = Moisture Content

AC = Ash content

3.2.9.7 Mineral analysis

The mineral content of processed samples was carried out by method 968.08 (AOAC, 1995). Mineral contents (Fe and Zn) for the six sample formulation (Table 3) were determined by using Atomic Absorption Spectrophotometer (AA 30-12). Absorbences of various cations were read at 248.3 and 213.9 nm for iron and zinc, respectively. The mineral content (mg/100g) was calculated as follows:

$$\text{Mineral content (mg/100g)} = \frac{\text{R X 50ml D.F}}{\text{S X 1000}} \text{ X 100} \quad \ldots\ldots(6)$$

where; R = Reading in ppm

S = Sample weight (g)

D.F = Dilution factor

50 = Volume of sample made (ml)

1000 = Conversion factor to mg/100g

3.2.9.8 β-carotene content determination

OFSP β- carotene determination was done according to Delia and Mieko (2004), where 2.0 g homogenized sample taken into Polytron bottle was extracted four times using 50 ml proportions of cold acetone. The 4 portions of extracts were transferred into the separating funnel containing petroleum ether (40-60^{o}C Bp), followed by a thorough washing with about 300 ml of distilled water until the extracts were acetone free. During the washing process, the distilled water was added by wall of the glass separating funnel to avoid formation of emulations (water stones) in the carotenoid extracts. The washed samples were then passed through anhydrous sodium sulphate to make it free from any trace of water. The dried carotene extract was then collected into a clean and dry volumetric flask. The extract was then read under UV-Visible Spectrophotometer (X-ma 3 000 Spectrophotometer) at 450 nm to obtain its optical density (OD).

Beta carotene standard solution with the concentration of 118 µg/ml was prepared by taking 0.0118 g of β-carotene standard powder obtained from Sigma-Adrich (CAS# 7225-40-7) into 100 ml volumetric flask. 10 ml petroleum ether added and swirled to dissolve and finely petroleum ether added until the volume made to 100 ml mark of the volumetric flask. Serial dilution of 0, 1, 2, 4, 8 and 16µg/ml were prepared by taking 0, 0.2, 0.4, 0.8, 1.7 and 3.4 of the stock standard solution (118 µg/ml) into 25 ml volumetric flask. Petroleum ether was added to complete volumes (25 ml).

3.2.9.9 Preparation of food formulation formula

Various feeding formulae incorporating OFSP tubers flour and vegetables flour together with germinated maize flour and MNP were formulated to get most acceptable sample which will be used to feed children aged 6-24 months which meets WHO nutrients requirements for the given age (Table 1).

Table 1: Formulation of OFSP flour blends

Sample	OFSP Vegetable flour (g)	OFSP Tuber flour (g)	MNP (g)	Germinated maize Flour (g)
$MAKAG_1$	5	30	1	64
$MAKAG_2$	10	20	1	69
MAG_1	0	30	1	69
MAG_2	0	20	1	79
KAG_1	10	0	1	89
KAG_2	5	0	1	94

Note $MAKAG_1$-composite of 5g OFSP vegetable flour,30g OFSP tuber flour,1g MNP and 64g of germinated maize flour,$MAKAG_2$- composite of 10g OFSP vegetable flour,20g OFSP tuber flour,1g MNP and 69g of germinated maize flour,MAG_1- Composite of 30g OFSP tuber flour,1g MNP and 69g of germinated maize flour,MAG_2-Composite of 20g of OFSP tuber flour,1g MNP and 79g of germinated maize flour,KAG_1-Composite of 10g of OFSP vegetable flour,1g MNP and 89g of germinated maize flour and KAG_2 –Composite of 5g of OFSP vegetable flour,1g MNP and 94g of germinated maize flour.

The recipes were developed to provide Gairo farmers and mothers with local and easy to use foods especially OFSP roots, vegetables and germinated maize with the use of micronutrient powder to meet RDA of the aged children.

A sample of the OFSP found to have high amount of β- carotene after analysis together with other processed samples were mixed together to get different blends (Table 1) shown. Formulation ratios for the six blends were as follows 30:5:1:64, 20:10:1:69, 30:1:69, 20:1:79, 10:1:89 and 5:1:94 coded $MAKAG_1$, $MAKAG_2$, MAG_1, MAG_2, KAG_1 and KAG_2, respectively.

The nutrient requirements for children 6 -24 months is as shown in Table 2.

Table 2: RDA nutrient requirements for children aged 6 -24 months (per day)

Nutrients	Amount
Energy (kcal)	900
Protein (13g)	13
Vitamin A (µg)	300
Iron (mg)	7
Zinc (mg)	3

Source: (WHO, 2005)

3.3 Micronutrient Powder (MNP)

Micronutrient powders or *virutubishi* as commonly known in Tanzania, are single-dose packets of vitamins and minerals in powder form that can be sprinkled onto any ready to eat semi-solid food consumed at home, school or any other point of use. The powders are used to increase the micronutrient content of a child's diet without changing their usual dietary habits. A diet with insufficient micronutrients can lead to a number of negative consequences for health, including compromised physical growth, mental development and immune function. Micronutrient powders (MNPs) can offer a safe, cost-effective and practical solution to improve the nutritional quality of complementary foods, by providing the necessary vitamins and minerals the body needs. This helps to support early life nutrition and future health.

To tackle the problem of under-nutrition in infants aged 6-24 months home -fortification of complementary foods with multiple micronutrient powder (MNP) was recommended by the (WHO, 2011). At the age of six months, the iron stores that the infant had at birth can no longer be recycled to support the escalating demands of growth (Dewey and Chaparro, 2007). Breast -milk has low iron content and thus beyond six months can no longer fulfill the role of complete nutrition (Dewey and Chaparro, 2007).

Due to the nutritional demands of meeting high growth rates with low gastric capacity, complementary foods should be nutrient dense, with increasing amounts of energy and fat as breast -milk intake declines and the infant's energy requirements increase. "Multiple Micronutrients" refers to any combination of (at least) iron, zinc and vitamin A (Regil *et al.*, 2011).

3.3.1 Energy content

To calculate the energy available in a food, the number of grams of carbohydrates, protein and fats were multiplied by 4, 4, and 9kcals, respectively. Then, the results were added. Therefore, the energy content in the OFSP tubers and vegetable flour together with germinated maize flour blend instant porridges were determined using the formula:

Energy calculations (kcals) = (4 x protein +9 x fat +4 x carbohydrate) kcals…………..… (8)

3.3.2 Sensory evaluation

3.3.2.1 Preparation of porridge

Blended food formulation of each sample was mixed with 250 ml of milk and 750 ml of water to make 1 000 ml of porridge for each sample blended. Cooking time was 10 minutes. The porridge was stirred well to avoid lumps.

3.3.2.2 Sensory evaluation of porridge

Sensory evaluation was carried out in the Food analysis laboratory at Sokoine University of Agriculture in order to select the most acceptable formula from each of the six formulations .Hedonic scale ranging from 1 to 9 was used on the degree of their liking (where 1 = dislike extremely and 9 = like extremely and 5 = neither like nor dislike) as described by Lawless and Heyman (2010).

The sensory attributes included colour, taste, aroma, mouth feel and overall acceptability. Panelists were oriented on blended formula of the porridge samples and were required to make inferences and recording the scores for each sample. The samples were coded with 3-digit random numbers using statistical random tables and served to the panelists in a randomized order. Samples in plastic cups were presented to the panelists in a cool environment. Necessary precautions were taken to reduce crossover effects by selecting greater number of interested panelists rather than motivating panelists and using small number and repeating preparations. Distilled water was provided for rinsing the palate between samples. The panelists were instructed to indicate their degree of liking or disliking of different porridge samples using the provided scale for scoring. Panelists were asked to taste each sample of the porridge at a time, and express their degree of preference in relation to given attributes.

3.3.2.3 Viscosity measurements

Viscosity measurement of porridge was performed according to Carvalho *et al.* (2013). A Stable HAAKE Viscometer 2 plus, Thermo Scientific ™ 399-0200 2011 13745 137 Dieselstr. 4 76227 Karlsruhe, Germany was used to analyze the viscosity of the blends porridge samples. Samples were measured in a beaker in which they were cooled to feeding temperature (43ºC). All measurements were performed in duplicate on separately prepared samples.

3.3.3 24 Hour dietary recall

Dietary intake data were based on the 24-h dietary recall method and were obtained from 131 households in three villages in Gairo district. A study was conducted to assess how foods and beverages were consumed to envisage vitamin A intake of the selected households. A mother or a person responsible for meal preparation was requested to provide detailed information on all the type of foods and beverages consumed by household members in the previous 24 hours prior to the survey date including food items consumed outside the home. Food items were grouped into 15 food groups as follows: cereals ,vitamin A rich vegetables and tubers; white tubers and roots; dark green leafy vegetables; other vegetables; fruits; other fruits; meat, fish, eggs; legumes, nuts and seeds; milk and milk products; oils and fats; spices and condiments; salt and sugar (FAO, 2011). A household was considered to have consumed a particular food group if consumed at least one food item belonging to that particular food group independent of its frequency in the previous 24 hours preceding the survey date. Dietary data were collected in homes in two different days of the week. One day was within week days and another during weekends. The aim of this was to obtain detailed information about all foods and beverages consumed on a given day.

The 24-hour recall data using volumetric estimates of quantities consumed was obtained. Containers marked in millilitres were used to quantify food such as rice and flour. The person who had prepared the food was asked to demonstrate how much she used of each ingredient, using her own container or other method (e.g., handfuls). Then the enumerator transferred that amount into a container to estimate volume. In the case of vegetables such as tomatoes, enumerators carried small-, medium-, and large-sized models and asked the respondent to specify the size and quantity of each item used. In addition to estimating the amount of each ingredient, the enumerators estimated the total volume of any prepared dish and the volume of left over.

Children (U5) who were breast fed (breast milk only) were not included to the number of household members who consumed vitamin A from other food sources. Estimation of vitamin A was calculated per capita.

Eaten portion sizes were calculated in g or ml units. The quantity of the food eaten was filled in under the appropriate interval of the day, .e.g. breakfast, lunch and snack. The importance of determining meal frequency in such a manner was deemed necessary and appropriate because of the important need for small children to have frequent small meals during the day. All those foods and beverages (food items), which were consumed by households were listed under categories shown in Appendix 2.

3.3.4 Dietary diversity

Dietary diversity was a useful indicator to predict adequate vitamin A intake of selected households in Gairo district, 3 villages were purposively selected to accommodate variation in Dietary diversity score on orange fleshed sweet potato consumption trend for improved nutrition in Gairo.

Respondents were asked series of yes or no questions, and the questions were asked to the person who was responsible for meal preparation and if the person was unavailable another adult who was present and ate in the household the previous day was asked. The questions referred to the household as a whole, not any single member of the household. The respondent instructed to include the food groups consumed by household members in the home, or prepared in the home for consumption by household members outside the home (e.g., at lunch time in the fields).

Dietary diversity refers to the variety of foods consumed by individuals or households (Jones *et al.*, 2013). Dietary diversity can be measured by counting the number of foods or food groups consumed over a certain reference period. These groups can be simply counted or a weight can be attached to them based on their nutritional value. People become wealthier they switch from starch-dominated diets to more varied diets including vegetables, fruit, dairy products, and meat.

Dietary Diversity Scores were calculated in terms of per capita for each village using a set of 15 food groups (cereals, vitamin A rich vegetables and tubers, white tubers and roots, dark green leafy vegetables, other vegetables, fruits, other fruits, meat, eggs, fish, legumes, nuts and seeds, milk and milk products, oils and fats, spices and condiments, salt and sugar. The aim of this study was to determine how well a simple score of food groups can be used to predict adequate vitamin A intake. The choice of the 15 food groups was based on usefulness of different food groupings (Ruel *et al.*, 2004). Since no single food can contain all nutrients, (Labadarios *et al.*, 2011) noted that the more food groups included in daily diet the greater the likelihood of meeting nutrient requirements. With that background, (Kennedy *et al.,* 2009) argued that, a diet which is sufficiently diverse may reflect nutrient adequacy.

The dietary diversity scores for the respondents were therefore estimated using information collected shown on dietary diversity information (Appendix 2). A single point was awarded to each of the food groups consumed over the reference period giving a maximum sum total dietary diversity score of 15 points for each household in the event that responses are positive to all food groups.

3.3.5 Data analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 16.0 computer package for WINDOWS (SPSS Inc. Chicago). Descriptive statistics were used to determine the measures of frequencies and percentages. Analysis of variance (ANOVA) was performed and differences between the two samples means were considered statistically significant at 95% confidence interval ($p<0.05$). Means were separated using Turkey's multiple Range Test HSD ($p<0.05$). Data were presented in tabular and graphical forms.

3.3.6 Ethical consideration

Permission for data collection was obtained from District Executive Director in the respective district and letters were signed to inform respective Heads of departments where the research covered, later to the local leaders of the assigned villages where research was conducted. The study objectives were explained to each participant prior to interview. Study participants were free to refuse or withdraw from the study at any time. Ethical clearance was obtained from the National Institute for Medical Research-NIMR/HQ/R.8a/Vol. IX/2506.

CHAPTER FOUR

4.0 RESULTS

4.1 Overview

This chapter summarizes the findings on the importance of sweetpotato consumption trend for improved nutrition in Gairo. The sampled respondents came from three villages in Gairo district. Results presented in this chapter include distribution of respondents by villages, number of respondents interviewed on the basis of sex, age group, education level, marital status, types of sweet potatoes grown by selected households, consumption of sweet potatoes leaves as vegetables, dietary diversity of foods consumed during weekdays and weekends and 24 hour dietary recall. Knowledge on how to store OFSP and vitamin A intake across villages, recommended intake of nutrients in the formulated food, viscosity measurement of the porridge and sensory evaluation of the porridge from formulations were also investigated.

4.2 Origin of Respondents

The sampled respondents came from three villages in Gairo district (Table 3). More than 60% of the interviewed respondents who were heads of households were females.

Table 3: Distribution of respondents by villages

Village	**Number of households**		
	Female	**Male**	**Total**
Meshugi	17	25	42
Ngiloli	29	15	44
Ihenje	28	17	45
Total	**74**	**57**	**131**

Source: Field survey, 2017

They came from three villages and the sample was of almost equal size as shown in Table 3.

4.3 Demographic Characteristics

4.3.1 Age, sex and marital status

Regarding age, sex and marital status of the respondents, the results were as seen in Table 4.

Table 4: Socio-economic characteristics of the respondents

Characteristics	Frequency (n= 131)	Percentage
Age		
19-48	93	71.0
49-78	37	28.2
≥78	1	0.8
Total	**131**	**100**
Sex		
Male	56	42.7
Female	75	57.3
Total	**131**	**100**
Education level		
No education	39	29.8
Adult education	4	3.1
Primary school	83	63.4
Secondary school	3	2.3
Certificate/Diploma	2	1.5
Total	**131**	**100**
Marital status		
Single	3	2.29
Married	98	74.81
Widowed	16	12.21
Widower	2	1.53
Divorced	12	9.16
Total	**131**	**100**

Source: Field survey, 2017

For age distribution, 71.0% of the respondents were between 19-48 years of age, 28.2% between 49 and 78 years, 0.8% were above 79 years of age. From Table 4, it was evident that majority of the respondents were of age between 19 and 48 years, thus revealing the presence of respondents that were economically active. This implies that the activeness of the farmers could be channeled to a more production of sweetpotato and worth addition in the study area. Some of the respondents (37%) were above 50 years. This could be a result of the rural- urban migration of the youth, which has led to ageing population in the rural areas of Gairo. This group of people remains as policy makers in the society. The remaining (0.8%) of the respondents were above 78 years who could not do any physical activities thus remained at home with small children.

Majority (57.3%) of the respondents were females while the rest (42.7%) were males (Table 4). This indicates the dominance of the females as households' head and female farmers in sweetpotato production. This finding indicated that women were more involved in sweetpotato production. More than 70% of the interviewed respondents were married (Table 4), 12.21% were widowed, 9.16% were divorced followed by 1.53% who are widower and 2.29% were single. It is assumed that married people are expected to be stable, have family responsibilities and enough experience to coordinate and organize their homes and farm operations. These results emphasize that marriage confers some level of responsibilities and commitments on individual who are involved. Also, those who are married need to generate additional income to sustain members of their households.

Results of this study also revealed that a large proportion (63.40%) of the respondents had attained primary school education, 29.80% had no education, 3.1% had attended adult education, and 2.3% had attained secondary school education while only a relatively small proportion (1.5%) of the respondents had attended certificate and diploma courses (Table

4). This showed that a good number of respondents had attained primary school education and this would help in adoption of innovations on sweet potato production, marketing, processing and ultimately value addition of the crop. Education is a viable tool for change and adoption of innovation.

4.4 Types of Sweet Potatoes Grown

Non orange fleshed sweet potatoes were cultivated by 59.54% of the respondents' households (Table 5).

Table 5: Household production and consumption of sweetpotato

Sweet potatoes	**Frequency (n=131)**	**Percentage**
Non- OFSP	78	59.54
OFSP	14	10.69
Both	39	29.77
Total	**131**	**100.00**
Consumption of sweetpotato vegetables		
Yes	111	84.7
No	20	15.3
Total	**131**	**100.00**
Awareness on how to store OFSP		
Yes	21	16
No	110	84
Total	**131**	**100.00**

Source: Field survey, 2017

OFSP were cultivated by only 10.7% of the households and those cultivating both made 29.8% of all the surveyed households (Table 5). Farmers were used to planting non-OFSP thus there was low percentage of OFSP cultivated. OFSP had just been introduced to the farmers because of their source of β- carotene. Also, cream and white fleshed sweetpotato varieties posses' high market price, are high yielding, with early maturity characteristics and are starchy. Non- OFSP consumed in East Africa have white or cream coloured flesh while introduced OFSP are high in β- carotene that the body uses to produce vitamin A. Varieties of sweet potatoes grown in Gairo had white and purple skin, white inside and those which were orange fleshed were cream and yellow fleshed.

Orange fleshed sweet potatoes are white and purple skin colour but inside they are yellow, cream and orange fleshed, of which contain high amount of β-carotene. Samples of OFSP which were analyzed were Kabode and Mataya (OFSP), Naspot1 and Polista (non-OFSP). Leaves of the mentioned sweet potato varieties were also analyzed to determine the amount of β-carotene and minerals they contained. Majority of the respondents (84.7%) consumed orange fleshed sweet potatoes leafy vegetables (Table 5).

The leaves of these OFSPs were also consumed as vegetables (Fig. 3a)

Figure 3a: OFSP leafy vegetables consumed in Ihenje, Gairo

OFSP as vegetables was common in their daily meals. The biggest concern was, however, how they were prepared from farm to the table to get the bioaivailable β-carotene needed as consumption of OFSP in conjuction with small amount of fat can increase β- carotene bioavailability.It was also reported that, to ensure availability of the vegetables throughout the season, home gardening was necessary (Fig. 3b).

4.5 Consumption of Sweetpotatoes

In Gairo, consumption of OFSP leaves as vegetables was higher as more than 80% (Table 5) of the respondents consumed OFSP as vegetables in their daily meals. The problem was how was it prepared from farm to the table to get the bioaivailable β-carotene needed as consumption of OFSP in conjuction with small amount of fat can increase β- carotene bioavailability.

Figure 3b: Door yard sweetpotato leafy vegetable garden

From the interviews it seemed that it was difficult to have enough vegetables to last the whole year. Despite this, few households (16%) stored the vegetables for use during times of scarcity (Table 5).

Orange-fleshed sweet potatoes are generally available in Gairo between March and August. Because seasonality is a limiting factor of OFSP availability and consumption, it is important to understand methods of storing, cooking and processing that will maximize β-carotene retention.

Processing has the potential to help address OFSP tubers' perishability and make their products more acceptable to urban consumers. However, OFSP processing remains in its infancy as most OFSPs in Tanzania are sold in the form of raw tubers.

Few people in Gairo had knowledge on how to process and preserve OFSP for future use. In urban Morogoro, some few people have tried to manufacture products made from OFSPs in season. OFSP products manufactured by SUGECO are available in Morogoro town but this is still by far at a very limited scale. Department of Food Technology, Nutrition and Consumer Sciences has started also making bread with inclusion of OFSP flour.

About 80% of the interviewed respondents had no knowledge on storing OFSP. Fig. 4 shows some of the products that can be obtained from OFSPs in the form of chips (*makewe*) and flour. *Makewe* is a product obtained by peeling, slicing and sun drying sweet potato.

Figure 4: Stored OFSP Products: A (*Makewe*) B (Root flour)

In Tanzania, germinated cereal flour is added to complementary foods consisting of ungerminated cereal or root crop flour and sometimes legumes to reduce bulk and viscosity and increase nutrient density. However, there is no standard procedure for germinated cereal flour preparation and addition to porridge.

2.5.1 Proximate composition of OFSP

The proximate composition of the parts of OFSP included crude protein, crude fat, ether extract, ash content; moisture content, dry matter and carbohydrate were analyzed. The following nutrients were found as shown in Table 6.

Table 6: Proximate composition of OFSP

Parameters	Nutrients (%)			Reference and methods
	Fresh Tubers	**Dried Tubers**	**Fresh leaves**	
Crude Protein(CP)	2.68 - 4.06	3.41 – 8.42	4.09 - 8.43	(920.87:AOAC,1995)
Crude Fibre (CF)	4.02 -9.09	6.05 – 12.97	7.01 - 9.14	(920.86:AOAC,1995)
Ether Extract (EE)	0.29 - 9.66	0.49 - 0.69	0.15 - 1.47	(920.85:AOAC,1995)
Ash content	0.69 - 1.50	2.37 - 4.62	3.19 – 6.96	(940.26:AOAC,1995)
Moisture content	61.07 -78.86	2.21 – 5.99	74.28 – 79.63	(925.10:AOAC,1995)
Carbohydrate	8.72– 23.56	68.35– 82.58	1.38 – 6.62	(AOAC,1995)
Dry matter	21.14-38.93	94.01 -96.64	20.37 -25.72	(Egan *et al.*, 1981)

2.5.2 Protein

The limiting nutritional qualities of OFSP are the low protein content which constitutes about 2.68 to 4.06% of the fresh weight in OFSP tubers and 3.41 to 8.42% of dried tubers of OFSP while fresh leaves make 4.09 to 8.43% (Table 6).

The amino- acid content of root and tubers, unlike most cereals is not complemented by that of legumes as both are limiting in respect of the sulphur amino acids. In order to maximize their protein contribution to the diet, roots and tubers should be supplemented with a wide variety of other foods, including cereals and animal proteins.

2.5.3 Carbohydrates

Roots and tubers have high potential ability on providing high amount of carbohydrate, which is a source of energy (Table 6). The dry matter of orange fleshed sweet potato tuber crop is made up mainly of carbohydrate, which contains 68.35 to 82.58 % and the fresh roots of OFSP have 20-40/100 g dry matter of which fresh tubers contain 8.72 to 23.56% and fresh leaves have 1.38 to 6.62%. Very little amount of carbohydrates found in fresh leaves.

2.5.4 Fat /lipid

Root and tuber crops display very low lipid content. The content ranges from 0.29 to 9.66% of the fresh tubers samples analyzed. Dried samples range from 0.49 to 0.69%, while fresh leaves range 0.15 to 1.47 % (Table 6). The lipid present may influence palatability of the root crops.

Beta carotene content

Beta carotene content of different cultivars was as shown in Table 7

Table 7: Analyzed maize and sweetpotato samples with their beta carotene content

Sample	Colour	Beta carotene (µg/g)
Polista fresh	White fleshed	9.88 ± 1.35^{f}
Naspot 1 fresh	Creamish white	9.20 ± 0.64^{f}
Kabode fresh	Orange fleshed	106.91 ± 0.35^{e}
Mataya fresh	Orange fleshed	147.39 ± 0.88^{de}
Naspot 1 leaves	Green	135.41 ± 5.28^{de}
Mataya leaves	Green	157.72 ± 2.27^{d}
Kabode leaves	Dark Green	878.31 ± 34.37^{a}
Polista leaves	Green	135.62 ± 0.30^{de}
Maize flour	White	2.45 ± 0.15^{f}
Polista dried	White fleshed	5.40 ± 0.17^{f}
Naspot 1 dried	Creamish white	9.99 ± 0.63^{f}
Mataya dried	Orange fleshed	426.39 ± 28.19^{b}
Kabode dried	Orange fleshed	258.38 ± 4.62^{c}

Source: FTNCS Laboratory data (SUA) 2017

Values are expressed as means ±SD (n=2). Mean values with different superscripts in a column are significantly different at $p<0.05$

High amount of carotenoids in Mataya tubers and Kabode were attributed to their yellowish flesh colour.

4.6 Proximate Composition and Energy Content of Different Formulation

The proximate composition of the different formulation flours was as seen in Table 8.

Table 8: Proximate analysis of different formulation in dry basis (DM/100g) as per reference and methods in Table 6

Sample	Moisture%	Ash%	CHO%	DM%	Fat%	Fiber%	Protein%
$MAKAG_1$	6.16±0.007[d]	2.73±0.06[b]	76.07±0.70[d]	93.85±0.00[c]	0.63±0.03[a]	10.39±0.58[a]	4.03±0.03[b]
$MAKAG_2$	7.72±0.007[b]	3.82 ±0.04[a]	72.29±0.00[e]	92.29±0.00[e]	0.51±0.05[b]	9.54±0.007[a]	6.03±0.06[a]
MAG_1	8.04±0.007[a]	1.56±0.58[c]	79.32±0.53[c]	91.97±0.00[f]	0.27±0.01[c]	7.62±0.014[b]	3.20±0.01[c]
MAG_2	6.43±0.007[c]	0.85±0.01[c]	84.04±0.07[b]	93.58±0.00[d]	0.16±0.02[d]	5.42±0.007[cd]	3.09±0.000[c]
KAG_1	5.18±0.007[e]	0.77±0.02[c]	86.92±0.19[a]	94.83±0.00[b]	0.13±0.02[d]	5.02 ±0.13[d]	1.99±0.02[d]
KAG_2	4.19±0.007[f]	0.61 ±0.03[c]	87.04±0.04[a]	95.81±0.00[a]	0.12±0.01[d]	6.09±0.007[c]	1.95±0.01[d]

Values are expressed as means ±SD (n=2). Mean values with different superscripts in a column are significantly different at $p<0.05$

It is seen from this table that there were significant variations ($p<0.05$) in ash, fat, fibre and protein contents of the formulated samples. The energy content also differed significantly ($p<0.05$). Energy in food is that available through digestion. This energy is not a nutrient but is released from food components. Energy yielding nutrients are from carbohydrates, protein and fat. Knowing number of grams of carbohydrate, fat and protein in a food the number of calories in it can be calculated using Atwater factors for carbohydrates, proteins and fats of 4, 4 and 9 kcals, respectively.

4.7 Mineral Contents of the Formulated Food Samples

The iron and zinc contents of the sweet potato samples were as shown in Table 9.

Table 9: Mineral composition of the formulated samples

Sample	Fe (mg/100g)	Zn (mg/100g)
$MAKAG_1$	15.36 ± 0.41^a	3.19 ± 0.02^a
$MAKAG_2$	13.38 ± 0.34^b	8.02 ± 7.03^a
MAG_1	9.88 ± 0.10^c	9.50 ± 0.74^c
MAG_2	3.60 ± 0.03^e	3.56 ± 0.09^a
KAG_1	5.12 ± 0.03^d	5.11 ± 0.03^a
KAG_2	2.17 ± 0.004^f	2.17 ± 0.0003^a

Values are expressed as means ±SD (n=2). Mean values with different superscripts in a column are significantly different at $p<0.05$

From Table 9, it is clear that the samples incorporating $MAKAG_1$ and $MAKAG_2$ were richer in iron and MAG_1 could also serve as a good variety to involve in the formulation. The remaining samples had significantly lower values. MAG_1 and $MAKAG_2$ were also rich sources of zinc as they contained significantly higher values than the rest.

The superior samples singled out in this discussion could benefit a poor community like that in Gairo where income at certain times of the year is a limiting factor in accessing important nutrients in the diet.

Nutrients composition of the formulated food as shown in the Table 10

Table 10: Nutrient composition of the analyzed sample

Sample	Protein (g)	Fat (g)	CHO (g)	Energy (Kcal)	Vit A (µg)	Iron (mg)	Zinc (mg)
$MAKAG_1$	4.03	0.63	76.07	326.07	1132.84	15.36	3.19
$MAKAG_2$	6.03	0.51	72.29	317.87	1648.67	13.38	8.02
MAG_1	3.20	0.27	79.32	332.51	485.85	9.88	9.05
MAG_2	3.09	0.16	84.04	349.96	597.82	3.60	3.56
KAG_1	1.99	0.13	86.92	356.81	854.79	5.12	5.11
KAG_2	1.95	0.12	84.04	345.04	549.81	2.17	2.17

Some of the compositions of nutrients of the formulated samples (Table 10) were reflected in the recommended RDA required by children aged 6-24 months. Analyzed energy content was inadequate in all the formulated food samples. Contents of protein and fats were low compared to the recommended levels of intake.

Carbohydrates mainly from cereal based foods contributed to the highest proportion of the energy needed compared to other sources. Micronutrients composition was adequate in the most accepted food formula ($MAKAG_2$).

The characteristics of the consumers of the porridges were as shown in Table 11.

Table 11: Characteristics of the consumers (N=49)

Characteristics	Category	Frequency	Percent
Gender	Male	26	53.06
	Female	23	46.94
	Total	**49**	**100.00**
Age group	20 – 24	28	57.1
	25 – 29	16	32.7
	30 – 34	4	8.2
	35 – 39	1	2.0
	Total	**49**	**100.00**
Education level	Master's degree	4	8.2
	Bachelor degree	42	85.7
	Diploma	3	6.1
	Total	**49**	**100.00**

Gender representation in this assessment seems balanced, composed of age between 20 and 29 years and studying mostly for Bachelor degree.

Mean hedonic scores for the formulated foods/porridges were significantly different ($p< 0.05$) (Table 12).

Table 12: Acceptability scores for formulated porridges

Formulation Sample	**Acceptability scores**				
	Colour	**Aroma**	**Taste**	**Mouth feel**	**Overall acceptability**
KAG_1	6.08 ± 1.98^b	6.69 ± 1.52^b	6.49 ± 1.71^{ab}	6.76 ± 1.45^{ab}	6.71 ± 1.53^b
$MAKAG_2$	6.98 ± 2.02^{ab}	7.63 ± 1.70^b	7.16 ± 1.72^a	7.43 1$\pm.1.49^a$	7.53 ± 1.63^a
MAG_2	7.18 ± 1.36^a	7.12 ± 1.63^{ab}	5.80 ± 1.86^b	6.27 ± 1.78^b	6.69 ± 1.36^b
$MAKAG_1$	6.49 ± 1.95^{ab}	7.45 ± 1.52^{ab}	7.06 ± 1.38^a	6.90 ± 1.31^{ab}	7.39 ± 1.13^{ab}
KAG_2	6.20 ± 1.41^{ab}	7.06 ± 1.55^{ab}	6.49 ± 1.50^{ab}	6.53 ± 1.71^{ab}	6.76 ± 1.28^{ab}
MAG_1	7.10 ± 1.40^a	6.98 ± 1.49^{ab}	6.92 ± 1.30^a	6.82 ± 1.65^{ab}	7.16 ± 1.39^{ab}

Values are expressed as means ±SD (n=2). Mean values with different superscripts in a column are significantly different ($p<0.05$).

Subjective ranking 1= Dislike extremely 9 =Like extremely 5 = neither like nor dislike

Overall acceptability of the porridges ranged from 6.69 to 7.53 as shown (Table 12). The general acceptability of $MAKAG_2$ porridge was based on the different attributes of $MAKAG_2$ blend. Attributes which added scores to the acceptability of $MAKAG_2$ were aroma, taste and mouth feel. This study showed that a possibility exists for the use of $MAKAG_2$ porridge as palatable and acceptable product. Aroma ranged from 6.69 for KAG_1 to 7.63 for $MAKAG_2$. Taste ranged between 5.80 for KAG_2 and 7.16 for $MAKAG_2$. Mouth feel ranged from 6.27 for MAG_2 to 7.43 for $MAKAG_2$ and overall acceptability from 6.69 (like slightly) for MAG_2 to 7.53 (like moderately) for $MAKAG_2$. Colour mean scores ranged between 6.08 for KAG_1 and 7.18 for MAG_2. The findings showed that in KAG_1 there was no addition of OFSP root flour in the formula, while in MAG_2 there was also no addition of OFSP vegetable flour. Hence, the colour of the porridge was appealing. The findings showed that overall acceptability of the formulated porridges increased with increase in amount of germinated maize and OFSP root flour and decrease of OFSP vegetable flour.

4.8 Viscosity Measurements

Viscosity is an important for the acceptability of porridge. Results (Table 13) showed that apparently viscosity values increased very rapidly with the starch rich composition.

Table 13: Viscosity measurements of formulated porridge

Sample	Measurements (d Pas)
$MAKAG_1$	4.50 ± 0.71^{bc}
$MAKAG_2$	9.00 ± 1.41^{ab}
MAG_1	3.00 ± 1.41^{c}
MAG_2	7.00 ± 1.41^{abc}
KAG_1	11.00 ± 1.41^{a}
KAG_2	5.00 ± 1.41^{bc}

Values are expressed as means ±SD (n=2). Mean values with different superscripts in a column are significantly different (p<0.05).

Samples KAG_1 and $MAKAG_2$ had high viscosity (11 and 9 dPas, respectively) while MAG_2 and KAG_2 had 7 and 5 dPas followed by $MAKAG_1$ and MAG_1 having 4.5 and 3 dPas, respectively.

4.8.1 Nutritional requirements for children aged 6-24 months

Children consumed predominantly refined maize flour porridges (*uji*) which were bulky and low in energy and key nutrients for growth. Complementary foods that Gairo mother gave to their children were the same as those prepared for the older family members like the starchy side dish of stiff porridge (*ugali*), tea with doughnuts which do not meet their RDA (Fig. 5).

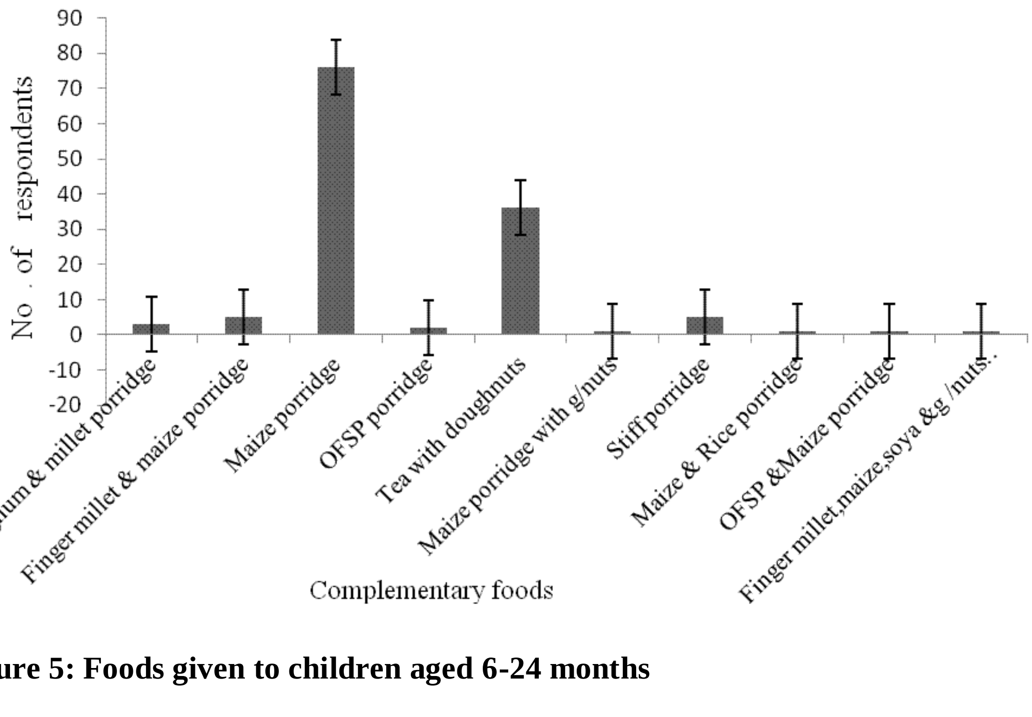

Figure 5: Foods given to children aged 6-24 months

4.9 Household Dietary Diversity

Dietary diversity is essential to nutrient adequacy as there is no single food, other than breast milk for the first six months of life that contains all of the nutrients required to maintain good health and nutritional status. Consuming a wide variety of foods among and within food groups is a recommended strategy to help ensure adequate intake of micronutrients. Therefore, it is a key element of high quality diets and the recommendation to consume a variety of foods appears in many nutritional guidelines.

Categories of DDS as defined as Low DDS which is found between (0-3) Medium DDS (4-6) and High DDS (7-15) as per food groups obtained.

The DDS data during weekdays for the surveyed villages was as shown in Fig. 6a

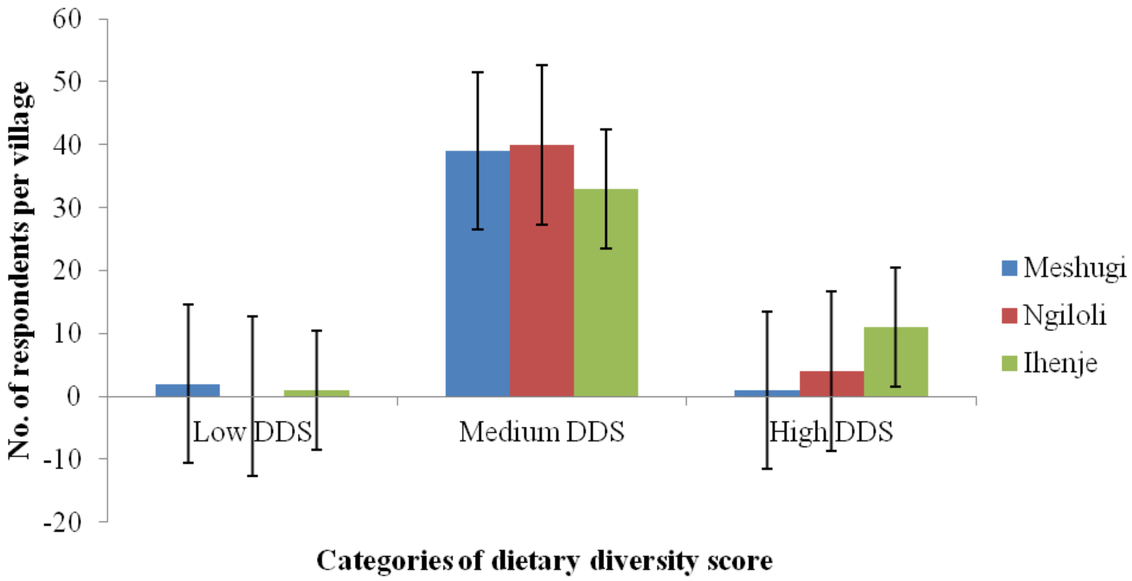

Figure 6a: Household dietary diversity score during weekday

In all the three villages, majority of consumers belonged to medium DDS, which were between 4 and 6 groups of foods consumed per day. There were differences in consumption of Low DDS and High DDS while in Medium was nearly the same among villages.

Consumption during weekends was different from that of weekdays, although still majority were between 4 and 6 food groups per day (Fig. 6b). Low DDS group (0-3) diminished while high DDS group (7-15) increased. There was no difference in consumption of Low DDS, while High DDS was found difference in consumption and Medium DDS was found at least different among villages.

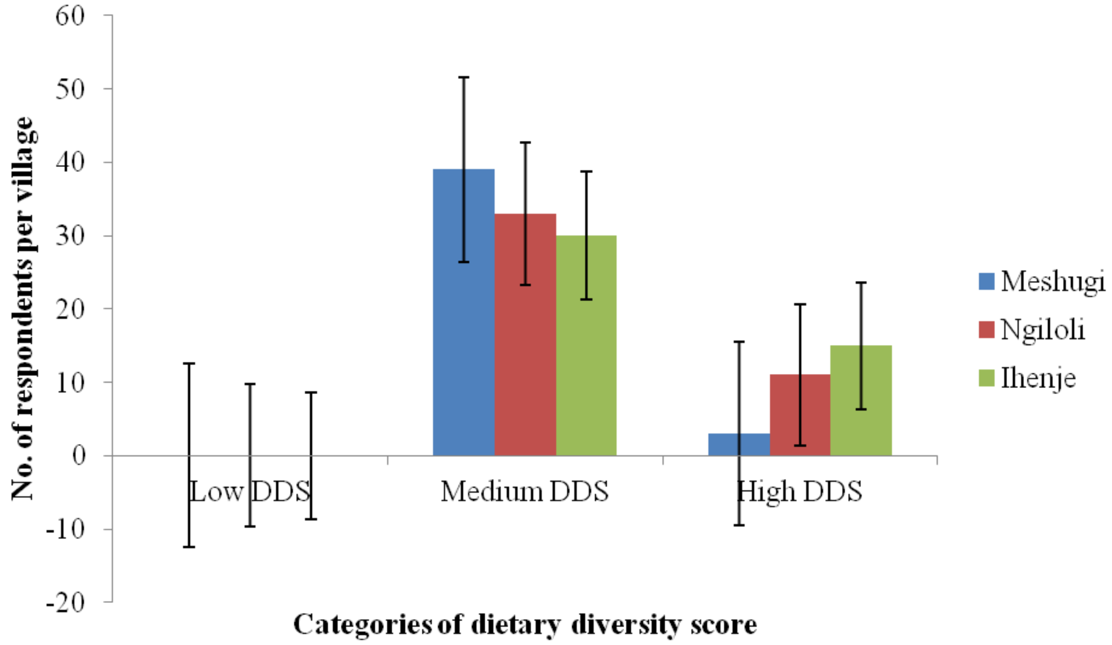

Figure 6b: Household dietary diversity score during weekend

Detailed information of mean values of the different villages is shown in Table 14.

Table 14: HDDS consumption in the Surveyed villages

Village	Weekday							
	Mean	**SD**	**IQR**	**0%**	**25%**	**50%**	**75%**	**100%**
Ihenje	5.7	1.1	1.5	3.0	5.0	6.0	6.5	8.0
Meshugi	5.0	0.9	2.0	3.0	4.0	5.0	6.0	7.0
Ngiloli	5.7	0.6	1.0	5.0	5.0	6.0	6.0	7.0
	Weekend							
Ihenje	6.2	0.9	1.0	5.0	6.0	6.0	7.0	9.0
Meshugi	5.6	0.7	1.0	4.0	5.0	6.0	6.0	8.0
Ngiloli	5.7	0.9	1.2	4.0	5.0	6.0	6.2	8.0

IQR- Inter Quartile Range

Table 14, shows the descriptive statistics of Household Dietary Diversity in the surveyed households during weekday and in the weekend. The mean HDDS during the weekdays was 5.7 food groups in Ihenje and Ngiloli villages whereas it was 5 food groups in Meshugi village. In comparison, the HDDS in the households of Ihenje (6.2) and Meshugi (5.6) showed an increasing trend during weekend, whereas in Ngiloli (5.7) it remained the same as that of weekdays. The standard deviation (SD) shows that during weekdays the variation of HDDS in the surveyed households was highest in Ihenje (1.1) and lowest in Ngiloli (0.6); and during the weekends, less variation was noted in Meshugi (0.7).

During the week day the Minimum Quartile (0%) was 3 in Ihenje and Meshugi, meaning that households which consumed the lowest diversified diet in the two villages consumed three food groups. In Ngiloli however, Minimum Quartile was 5 meaning that households which consumed the lowest diversified diet in the village consumed five food groups.

During the weekend, the Minimum Quartile (0%) increased to 5 and 4 in Ihenje and Meshugi respectively, whereas in Ngiloli it decreased to 4. The Lower Quartile (25%) was 5 in Ihenje and Ngiloli meaning that 25% of surveyed households in those villages consumed not more than five food groups. In Meshugi however, the lower quartile was 4 meaning that HDDS of 25% of surveyed households in that village was not more than four food groups. During the weekend, the Lower quartile (25%) increased to 6 and 5 in Ihenje and Meshugi, respectively meaning that 25% of surveyed households consumed not more than 6 and 5 food groups respectively; whereas in Ngiloli it remained at 5 similar to that of weekday.

Further results showed that during weekdays the Median Quartile (50%) was 6 in Ihenje and Ngiloli meaning that HDDS of 50% of surveyed households in those villages was not more than six food groups. In Meshugi however, the median was 5 meaning that HDDS of 50% of surveyed households in that village was not more than five food groups. During the weekend, the median (50%) was 6 in all villages meaning that half of the households consumed not more than 6 food groups. In addition, Table 14 shows that during the weekday the Upper Quartile (75%) was 6 in Meshugi, Ihenje and Ngiloli meaning that HDDS of 75% of surveyed households in those villages was not more than six food groups. During the weekend, the Upper Quartile (75%) increased to 7 Ihenje meaning that HDDS of 75% of surveyed households in that village was not more than 7 food groups. During the weekend, the 75% of households in Meshugi and Ngiloli consumed less than 6 food groups. The Maximum Quartile (100%) during weekday was 8 in Ihenje and 7 in both Meshugi and Ngiloli; whereas in weekend it increased to 9 in Ihenje and 8 in both Meshugi and Ngiloli.

Mean HDDS across villages during weekday and weekend differed statistically during weekday ($p < 0.001$) and during weekend ($p < 0.01$).

Table 15: Comparison of HDDS during weekday and weekend

Day	**Variable**	***df***	**Sum Sq**	**Mean Sq**	***F* value**	***P***
Weekday	Treatment (Village)	2	14.3	7.2	8.692	0.000^{***}
	Residuals	126	103.8	0.8		
Weekend	Treatment (Village)	2	6.4	3.2	4.087	0.019^{*}
	Residuals	126	99.2	0.8		

Source: Field survey, 2017

Note: *** = Statistically significant at 95% level of confidence ($p< 0.001$)

df = degree of freedom

4.9.1 Per capita vitamin A consumption

Per capita vitamin A intake across villages was as shown in Fig. 7.

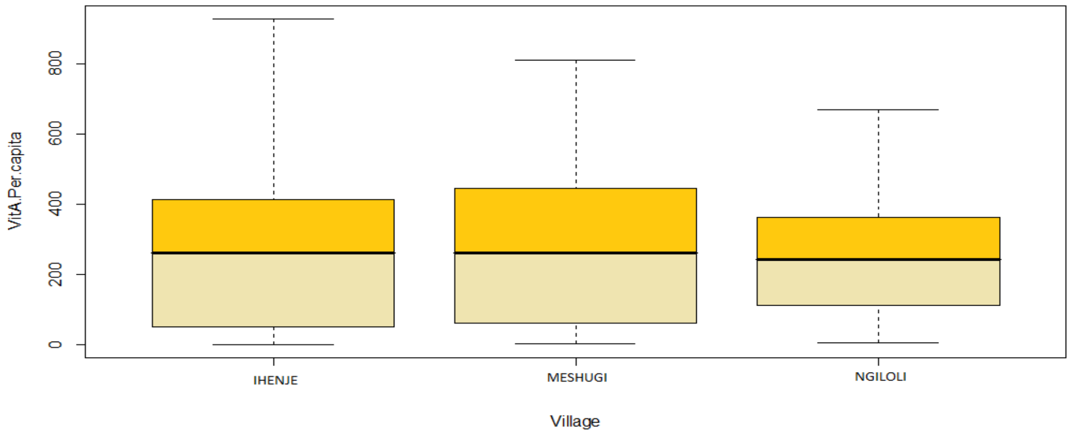

Figure 7: Per capita vitamin A intake across villages

Variation of per capita vitamin A intake across villages shown in Fig. 7 implied that the wider the box plot, the higher the variation and the narrower the box plot the lower the variation. The colored box is the same as IQR, which is equal to Higher Quartile (75%) minus the Lower Quartile (50%). The highest mark or line of the box plot is the Maximum Per Capita Vitamin A intake, and the lowest mark or line is the Minimum intake. The heavy line in the middle of the box plot is the Median or 50% Quartile. It can be seen that Ngiloli had the narrowest box plot, which implies that there was least variation in terms of per capita vitamin A consumption in that village as compared to other villages. Meshugi village had the widest box plot, which implies the highest degree of heterogeneity across households in terms of per capita vitamin A intake as compared with other villages. The Median Quartile appears to demarcate the households at relatively equal distance between the upper and lower part of the IQR. This signifies that there was nearly equal proportion of households with above median per capita vitamin A intake as those whose intake was below the average value (Fig. 8).

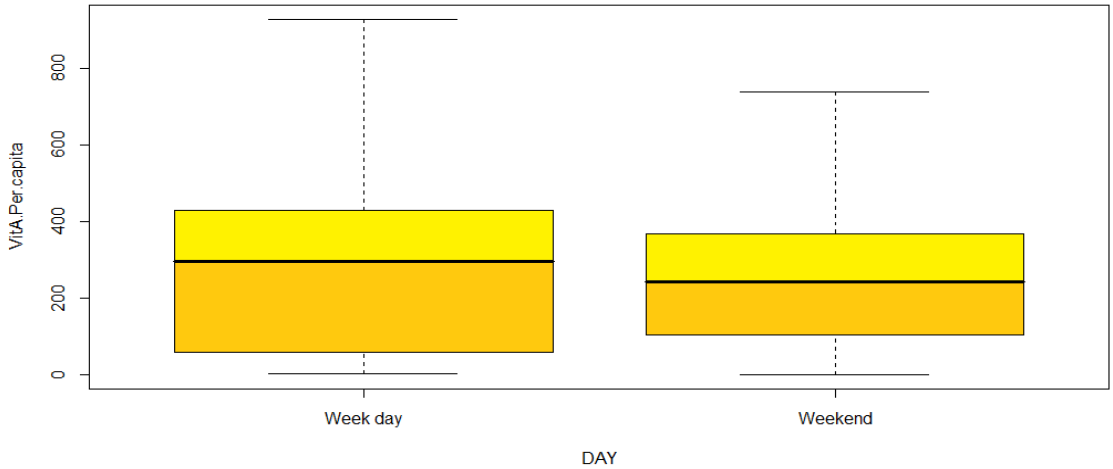

Figure 8: Per capita vitamin A intake variations during weekday and weekend

Based on variation of per capita vitamin A intake in weekday and weekend, it can be seen that the box plot for week day was wider than that of weekend. This showed that during weekdays there was higher variation in terms of per capita vitamin A consumption as compared to weekends. Also, Median Quartile line appears to be close to the upper part of the IQR. This implies that there were more households below the median per capita vitamin A intake as compared to those whose intake was above (Fig. 9). The figure shows less variation in terms of per capita vitamin A intake during weekend, and nearly equal proportion of households with intake above and below the median.

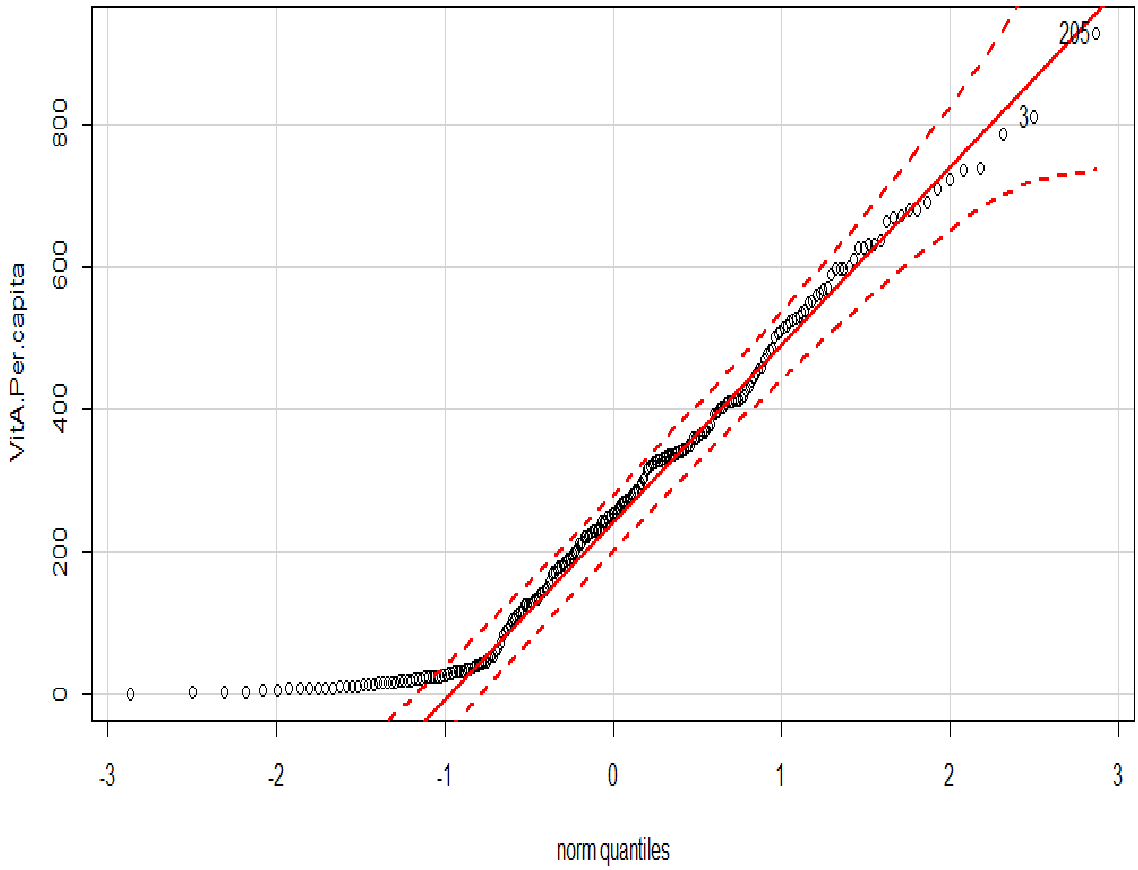

Figure 9: Q-Q Plot of per capita vitamin A intake

Figure (9) above shows Quartile-Comparison Plot (Q-Q Plot) of per capita vitamin A intake in the surveyed villages. The figure shows that most data lied within the parallel line of normal quartiles indicating that the data were normally distributed to a large extent.

Figure (10) shows residual plots of fitted lines of per capita vitamin A intake in the surveyed villages. The figure shows that the length of data concentration in the three villages was nearly the same. There was no fanning out of the data for the three concentration point (each representing one of the three surveyed villages). With this evidence it is verified that the assumption of constant variance for per capita vitamin A intake across villages is tenable.

Since it is evident that the per capita vitamin A consumption data were normally distributed, and the assumption of equal variance for the intake across village is verified.

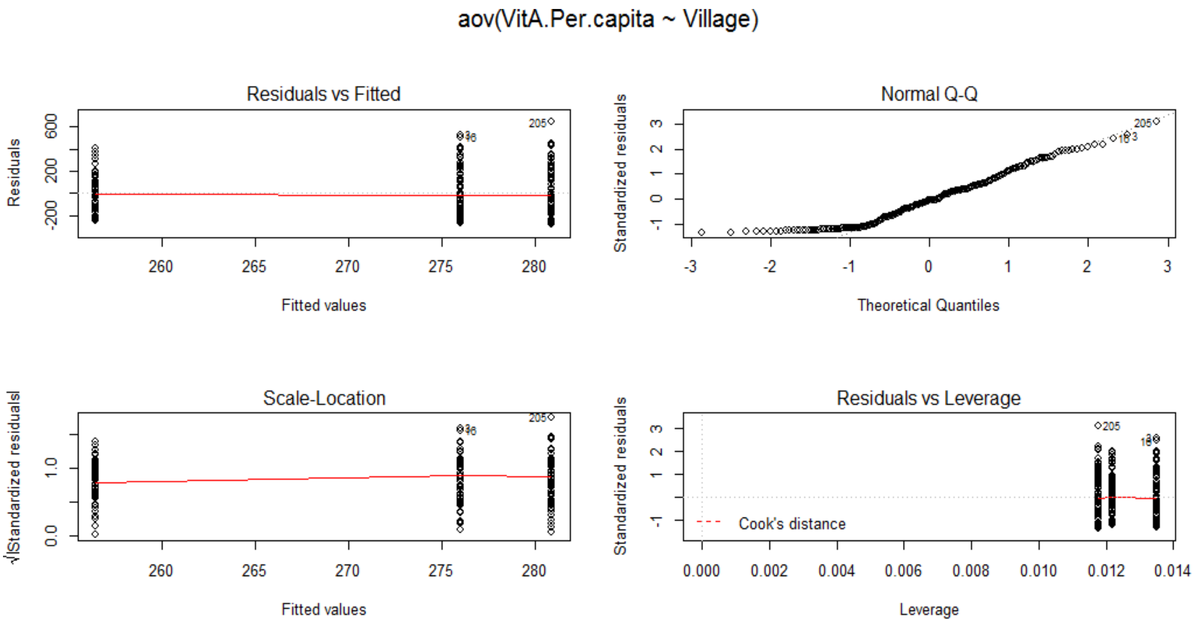

Figure 10: Evidence of constant variance for per capita vitamin A intake across villages

4.9.2 Dietary assessment

4.9.2.1 Consumption of meals between villages

The dietary assessment was performed by the use of 24 hour recall in the selected households. This was done during weekday and during weekend to see the difference in the meals consumption by respondents. In comparison, both villages consumed three meals except for Ngiloli village the number of consumption of meals reduced during weekend (Fig. 11a).

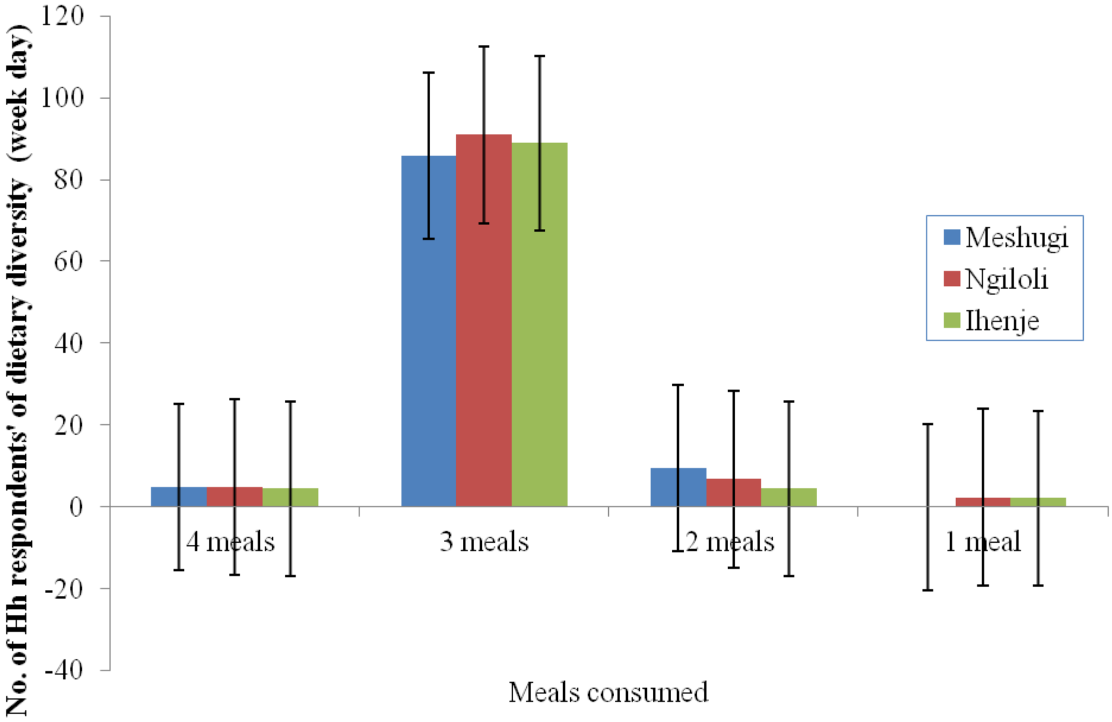

Figure 11a: Number of meals consumed during weekday

Very few households consumed four meals, due to economic status and knowledge on the dietary intake of meals and food storage. It shows that during weekends (Fig. 11b), consumption of two meals in Ngiloli was higher compared to other villages. For Meshugi, consumption remained the same while in Ihenje the consumption of four meals decreased.

Few households consumed one meal due low economic status they had, members had no money to buy food and also had no food stored as the place was dry hence food production was low thus leading to food scarcity.

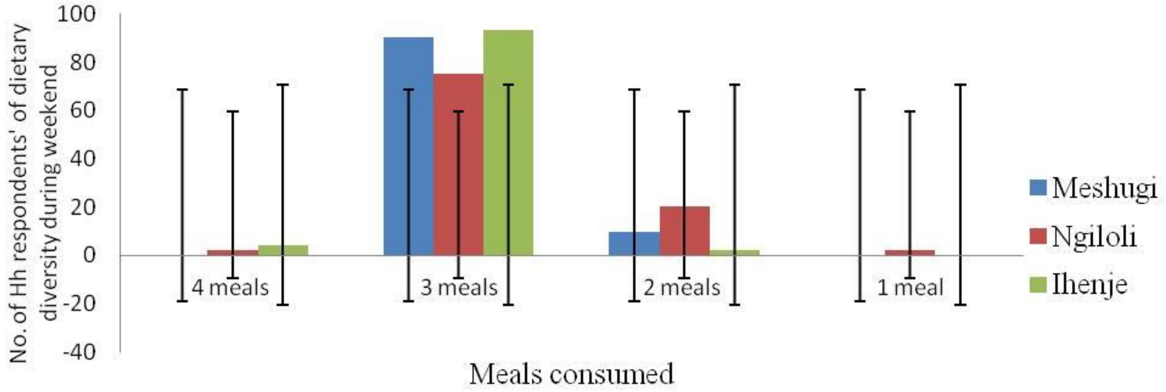

Figure 11b: Number of meals consumed during weekend

From the results (Fig. 12), in both villages the highest food groups consumed were cereals, dark green leafy vegetables, other vegetables, oils and fats and salt and sugar.

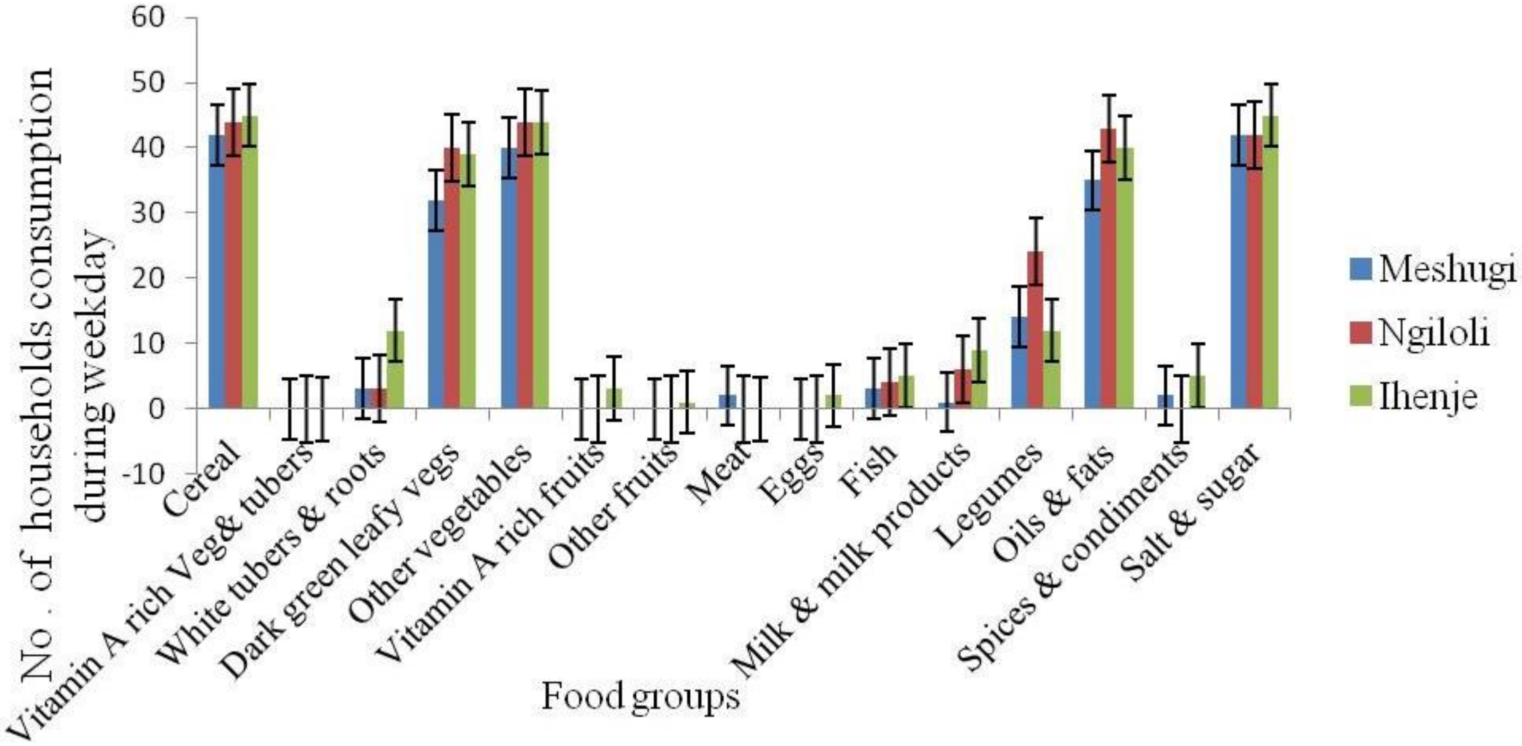

Figure 12: Consumption of food groups during weekdays

Wild vegetables were found somehow bulky during the dry season. Animal foods which were vitamin A sources such as meat, eggs and fish were consumed in low quantity and other villages did not consumed at all. Consumption of milk and milk products was low in Ihenje and Ngiloli. Animal food sources are expensive hence respondents with low socio-economic status could not afford to buy. Vitamin A rich vegetables and tubers were not consumed at all. The same applied to spices and condiments. Consumption was minor due to low knowledge on habitual intake of OFSP and the available micronutrients. Also, respondents had low knowledge on the importance of consuming spices and condiments.

Consumption of food groups during during weekend was as shown in Fig. 13.

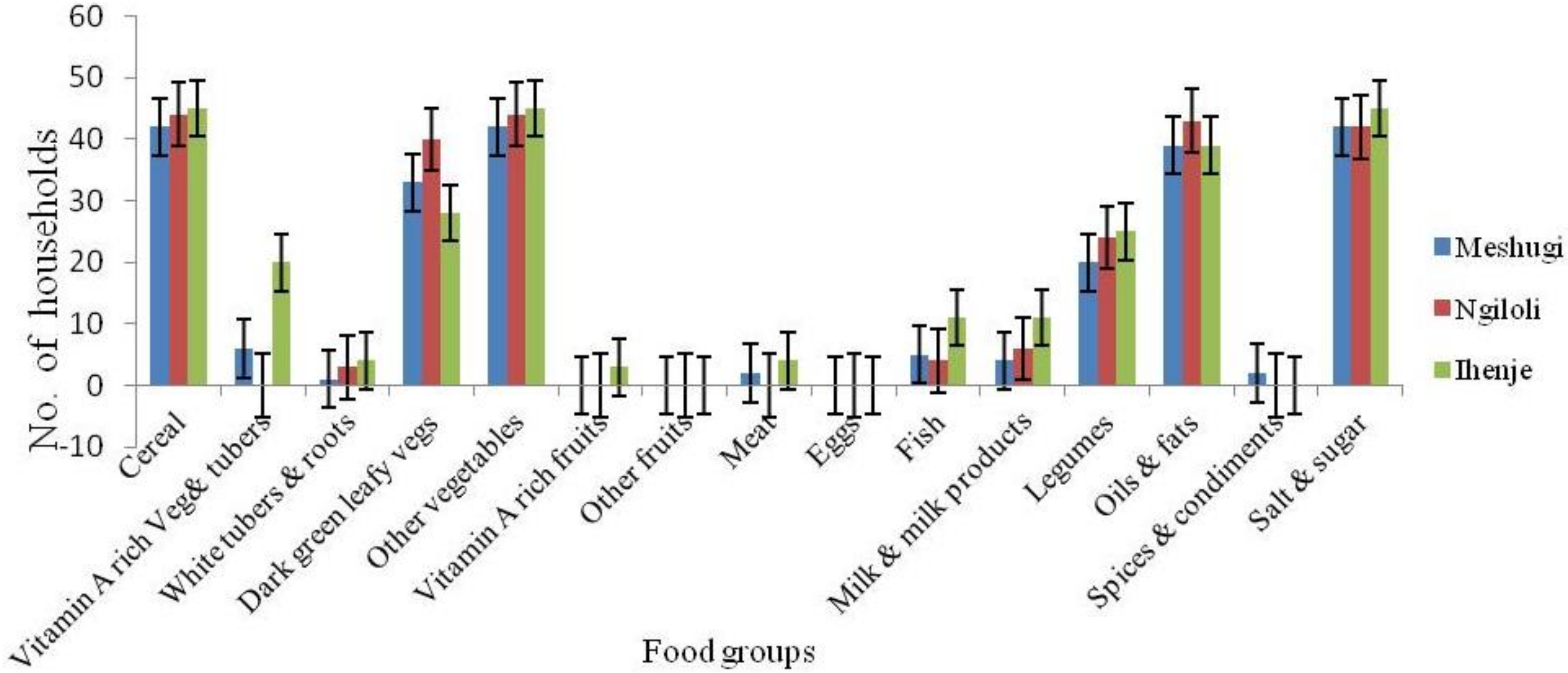

Figure 13: Consumption of food groups during weekend

The results show that, highest food groups consumed during weekend were cereals, dark grren leafy vegetables, other vegetables, oils and fats and salt and sugar. Cereals either cooked rice, thin porridge (*uji)* and stiff porridge (*ugali)* from maize, millet or sorghum flour were consumed positively high. Vegetables and oil reflecting the fact that vegetables were typically fried or cooked in oil or nuts were mixed with vegetables. Sugar and salt had to to be bought by most households and used everyday.

Compared to Meshugi and Ihenje, at least in Ihenje, consumption of vitamin A rich vegetables and tubers were improved during weekend. Vegetables contributed little as their consumption was minor and knowledge was low on the importance of consuming vegetable rich sources in vitamin A.

Consumption of milk and milk products has been shown to improve in both villages, respectively compared to weekdays. Consumption of food groups which are vitamin A rich animal sources such as meat, eggs and fish increased in Ngiloli and Ihenje for the cases of fish and meat and few for eggs consumption in Meshugi. Animal foods consumption was low due to poor economic status of households. Very few households kept domestic animals.

CHAPTER FIVE

5.0 DISCUSSION

This study investigated the extent to which sweet potatoes particularly OFSP as a component of daily dietary intake contributed to improve nutrition in Gairo district. The investigation focused on assessing the following aspects; proximate composition of fresh and processed OFSP tubers and vegetables, mineral analysis, β- carotene, feeding formula, food energy, sensory evaluation, viscosity measurement, 24- hour dietary recall and dietary diversity.

5.1 Proximate Composition

The proximate composition included dry matter, protein, fat, carbohydrates, ash, and fibre. The levels of nutrients in food depended on natural sources of variation in the species, nature of the soil, genetic diversity, seasonality, maturity stage and effect of processing (Kuhlein, 2000).

5.1.1 Dry matter

The dry matter of the fresh OFSP varieties ranged from 21.14 to 38.93% and that of dried tubers was found to be 94.01 to 96.64%. OFSP vegetable leaves ranged from 20.37 to 25.72% dry matter. Ellong *et al*. (2014) in Martinique reported 29.56 to 39.32% dry matter of the fresh tubers and Sanoussi *et al*. (2016) reported (25.09 to 46.12%), which is higher than those reported by Laurie *et al*. (2012) in South Africa (18.5 to 30.5%). Tomlins *et al*. (2012) reported that OFSP varieties with high carotenoid content tend to have lower dry matter contents. Dry matter contents relate to good cooking qualities and extended storage lives (Eleazu and Ironua, 2015).

5.1.2 Crude protein

The protein content of the fresh OFSP varieties ranged from 2.68 to 4.06% and that of dried OFSP was from 3.41 to 8.42% and OFSP vegetable leaves ranged lied between4.09 and 8.43% compared to that of 1.91 to 8.83% reported by Mohammad *et al.* (2016) and 3.69 to 5.70% of Aina *et al.* (2009) and of Kihinga (2007) who reported 1.39 to 2.77%. Kabode variety showed an unusually higher content of protein (8.41%) than other varieties. In comparison with the leaves protein content (15.10 to 27.10%) as reported by Nkongho *et al.* (2014), the storage roots exhibited lower protein content, hence indicating the necessity of encouraging the promotion and consumption of composite foods, mixing sweet potato storage root and leaves for balanced diet. This suggested that coloured flesh (yellow and orange) sweet potato cultivars, in addition to their probable highest β-carotene content, could be better sources of protein than white flesh varieties. Therefore, they could be recommended as good food for alleviating protein-energy malnutrition and vitamin A deficiency.

Protein content in the diets of the low income population in developing countries like Tanzania is derived mostly from foods of plant origin. However, OFSP is not a good source of protein, suggesting that it has to be supplemented with relatively protein rich foods like fish (sardines) cereals and vegetables. Other varieties of sweet potato leaves have been recognized to be rich in protein (essential amino acids lysine and tryptophan, which are limiting in cereals). Therefore, sweetpotato leaves can easily complement cereal based diets in the region (Mwanri *et al.*, 2011; Oloo *et al.*, 2014). The typical total protein content of sweet potato is as low as 1.5% and as high as 5% (dry weight (DW) basis.

5.1.3 Crude fibre

In this study, crude fibre from fresh OFSP ranged from 4.02 to 9.09% and that of dried OFSP ranged from 6.05 to 12.97% while that of OFSP was 7.01 to 9.14%. Aina *et al.*

(2009) reported 3.68 to 4.28%. Ingabire and Vasanthakaalam (2011) reported 0.11 to 0.14% in the Rwandan varieties in their study. Ellong *et al*. (2014) in Martinique reported 3.30 to 5.40%.

Dietary fibre has recently received much importance. It increases satiety and facilitates weight loss and is good for diabetic people (Manzoni *et al*., 2008). Recent studies have shown that dietary fibre helps to reduce postprandial blood glucose, insulin and triglyceride concentrations (Ma and Mu, 2016). It can lower blood cholesterol levels. According to Trinidad *et al*. (2013) dietary fibres are important in preventing cardiovascular diseases and diabetes mellitus and they are also efficient in reducing the incidences of colon cancer and certain digestive diseases (Ingabire and Vasanthakaalam, 2011).

5.1.4 Carbohydrates

The results obtained from this study showed the carbohydrate content of fresh OFSP was 8.72 to 23.56% and that of dried OFSP was 68.35 to 82.58%. OFSP leaves were in the range 0.48 to 6.61%. Kihinga (2007) reported 29.29 to 41.09%. Mohammad *et al*. (2016) showed carbohydrate content between 21 to 25% and Aina *et al*. (2009) in their study found a content of 85.8 to 90.17%. Sanoussi *et al*. (2016) reported 14.86 to 38.92%. Thus, less carbohydrate in fresh OFSP compared to these studies could be due to factors like varieties of OFSP grown in a certain area and stages of maturity of the roots. It is well recognized that foods with carbohydrates that break down quickly during digestion and release glucose rapidly into the bloodstream tend to have a high glycemic index and foods with carbohydrates that break down more slowly, releasing glucose more gradually into the bloodstream, tend to have a low glycemic index Brand-Miller *et al*. (2003).

Furthermore, studies need to be done to identify types of carbohydrates found within these cultivars, which will be suitable for diabetes management.

5.1.5 Moisture content

The moisture content of the selected fresh OFSP varieties ranged from 61.07 to 78.86%. Moisture content of dried OFSP was between 2.21 and 5.99% and that of OFSP leaves ranged 74.28 to79.63%. A study done in Bangladesh by Mohammad *et al*. (2016) reported fresh sweet potatoes had moisture content 70.95 and 72.96%. Aina *et al*. (2009) reported moisture content 69.4 to 73% while Kihinga (2007) in Tanzania reported 55.00 to 72.44%. Variations in the moisture content among sweet potatoes varieties can be due to the differences in the genetic composition and cultivation practices. In comparison with other roots and tubers, the sweet potatoes have high moisture content and thus, low dry matter content. The normal dry matter is around 30% but differs widely depending on the aspects of variety, geographic area, climate, amount of light, soil type and cultivation practices. Several authors have reported that application of fertilizer significantly reduces the moisture content (Gichuhi *et al.*, 2014). The low moisture content signifies high dry matter content and thus more carbohydrate and consequently, higher energy content (Gichuhi *et al*., 2014). OFSP varieties with high dry matter content are mostly acceptable to consumers.

5.1.6 Fats/lipids

The fat content of the selected fresh OFSP varieties ranged from 0.29 to 9.66%. Mataya variety showed an unusually higher content of fat (9.66) than other varieties reported in the literature. Fat content of the dried sample ranged from 0.49 to 0.69% and that of OFSP leaves ranged 0.15 to 1.47%. Sanoussi *et al*. (2016) showed content of 8.88% which was lower compared to that of Mataya variety. Like other roots and tubers, sweet potato is well recognized for its low fat content. The results of fat content were similar to other study findings Mu *et al*. (2009) found 0.6% fat for sweet potato while Tumuhimbise *et al*. (2013) reported the fat content ranged 0.2 and 0.17%, Kihinga (2007) in Tanzania reported 0.03 to 0.92%. Knowing that vegetable oils provide essential fatty acids, it will be interesting to know the fatty acid profile of this sweet potato variety and especially its essential fatty acids content. Fats function in the increase of palatability of food by absorbing and retaining flavours (Antia *et al*., 2006) is well recognized. Lipids are very important food substances since they are vital to the structure and biological function of cells and contribute significantly to the energy value of foods (Eleazu and Ironua, 2015).

5.1.7 Ash Content

The ash content of the fresh roots of tested Sweetpotato varieties ranged from 0.69 to 1.50% and that of dried roots was 2.37 to 4.62%. The Sweetpotato leaves ash content ranged from 3.19 to 6.96%. This was higher than the 0.40 and 0.44% reported by Ingabire and Vasanthakaalam (2011) in their study. Kihinga (2007) in Tanzania reported 0.98 to 0.99%. Sanoussi *et al.* (2016) reported ash content varied from 2.56 to 4.70% and was higher than that 0.40 to 2.35% generally presented in fresh weight basis in literature (Eleazu and Ironua, 2015; Ellong *et al.*, 2014). High ash content indicates that cultivars are rich in some mineral salts, which could be promoted for preventing and curing hidden hunger especially among children, pregnant and lactating women (Ukom *et al*., 2009). There are factors that influence total ash content. One possible factor could be the use of fertilizer. Application of fertilizer together with sufficient irrigation can influence the nutrient content of OFSP, especially the mineral content (Gichuhi *et al*., 2014). Besides fertilizer, the ash content of sweet potato varieties can also be influenced by other aspects, like soil and climatic conditions (Abbasi *et al*., 2011).

Proximate analyses of formulated porridge differed from that of a single sample. This was due to cooking process and others factors, which increased and decreased some nutrients. Moisture content of the sample ranged from 64.85% in $MAKAG_1$ to 66.83% in $MAKAG_2$. This implies that formulated $MAKAG_1$ had high dry matter content of OFSP root flour compared to $MAKAG_2$ whose flour has low dry matter content and cooking slightly increased moisture content.

Crude protein ranged from 8.83 of KAG_2 to 11.16% of KAG_1. Normally, plant food sources are not good sources of protein. Fat content ranged from 0.19 of MAG_2 and 0.53% of $MAKAG_2$. Sweet potatoes have low fat content.

Fibre content ranged from 0.67% of MAG_1 to 3.13% of KAG_2. Most of the sweet potatoes have high amount of dietary fibre. Cooking process made them more soluble hence the value of fibres had decreased. Ash content ranged from 1.72 of KAG_2 to 4.27% of $MAKAG_2$. Increased ash content was due to the reason that high content of ash determine high content of minerals in a particular sample. OFSP roots and leaves contain high amount of minerals. Amount of carbohydrate ranged from 15.39 of $MAKAG_2$ to 22.22% of MAG_1. Cooking process reduces amount of carbohydrate due to its solubility in the water. It also contains mostly vitamin Bs, which are soluble in water. Maturity of roots and vegetables can deter content of carbohydrate and variety of sample itself can deter amount of carbohydrates. Others have high amount and vice versa.

5.1.8 Minerals

Mineral content varied from one variety to another. Only varieties with high content of β-carotene in roots and leaves were analyzed for iron and zinc content. Content of iron in $MAKAG_1$ flour was 15.36 mg/100g while in KAG_2 flour was 2.17 mg/100g. Mwanri *et* *al*. (2011) reported 15.22 mg/100g in GMSPL and 17.48 mg/100g in PMSPL. Oloo *et al.* (2014) reported 84 mg/kg, 87 mg/kg and 86 mg/kg for Zapallo, Nyathiodiewo, and SPK004/06, respectively. The values for zinc were reported as 18, 25, and 25 mg/kg for Zapallo, Nyathiodiewo, and SPK004/06 respectively. Kihinga (2007), in Tanzania reported Japon variety had highest (0.37 mg/100g) and Zapallo lowest (0.29 mg/100g) zinc content. Carrot Dar had 0.78 mg/100g and Japon 0.61 mg/100g of iron. Laurie *et al.* (2012) in South Africa reported 0.73 to 1.26 mg/100g of iron in cultivars they analyzed, which was low compared to the amount found in $MAKAG_1$ and KAG_2 flour. Variation of iron results observed could be due to genotype variations. Lack of iron is known to be responsible for anemia, which is among the most terrible micronutrient deficiencies in children as well as vitamin A deficiency (Sanoussi *et al*., 2016).

Zinc content was 2.17 to 9.50 mg/100g in the formulated foods and which was higher compared to Sanoussi *et al*. (2016) who reported 0.27 mg/100g of zinc in all cultivars they analyzed. WHO (2005) recommends RDA intake of iron and zinc to 7 and 3 mg/100g for children aged 6-24 months. The values obtained here were higher than recommended dietary allowance per day for zinc for targeted children, hence indicating that the cultivars analyzed are good in zinc. Incorporation using of MNP helped to meet the RDA recommended.

5.2 Beta Carotene

5.2.1 Beta carotene in leaves

Sweet potato leaves especially the β-carotene rich/fortified varieties are rich in functional macro and micronutrients such as dietary fibre, antioxidants and other micronutrients deficient in the predominantly starchy staples of most nutritionally vulnerable Africans.

Kabode leaves had higher amount of β-carotene (878.31 μg/g) content in comparison with the rest. Leaves are moderate sources of β-carotene (550 mcg/100 g), rich source of lutein, higher levels of anthocyanins and phonolic acids that protect against diseases such as cancer, allergies and cardiovascular disease Low (2013). Total carotenoids varied from 1483.4 to 3154.5 μg/g in OFSP vegetable leaves (Nkongho *et al.*, 2014). Mwanri *et al.* (2011) reported 44.18 mg/100g and 53.32 mg/100g in GMSPL and PMSPL, respectively. Consumption of OFSP leaves as vegetables was not really practised. Very few places consumed OFSP leaves as vegetables in the diet. More effort is focused on roots not leaves, yet leaves are very nutritious and very popular in some African countries (Zambia and Sierra Leone (Jaarsveld *et al.*, 2005). OFSP leaves are often considered to have no economic value and are discarded following their harvest.

5.2.2 Beta carotene in roots

Carotenoid pigments are responsible for the cream, yellow, orange or deep orange flesh colours of sweet potato roots. Amount of β- carotene ranged from 7.88 to 147.39 μg/g for the varieties analyzed. Mataya flour had the highest amount of β- carotene and Polista the lowest. Kihinga (2007) in Tanzania reported 88.31-1620.07 μg/g and it was noted that Carrot Dar variety had the highest total carotenoid and Polista had the lowest.

The use of OFSP as a source of energy and means of fighting vitamin A deficiency in Tanzania and other African countries has been of significance (Waized *et al.*, 2015). Incorporation of OFSP vegetable flour, which is a good source of carbohydrate, protein, minerals and fats together with germinated maize, can be used to lessen VAD in the targeted group.

5.3 Recommended Beta Carotene Intake

Dietary guidelines recommend increased consumption of varieties of foods that will supply nutrients to targeted age children group (6-24 months), which are proteins, minerals (iron and zinc), vitamin A and carbohydrates . All of these nutrients are supplied with the intake of diversity of foods. The findings showed that $MAKAG_2$ was the most accepted with composition of Mataya flour, Kabode flour and germinated maize, which supplied protein (10.44 g), iron (13.38 mg), zinc (8.02 mg), energy (108.08 kcal) and vitamin A in terms of β-carotene (1648.67μg/g). Beta carotene plays a crucial role in human health; whenever analysis is performed vitamin A is in short supply. It is a major, most active precursor of vitamin A. WHO (2005), recommends RDA intake of vitamin A of 400μg where by findings showed 1648.67 μg/g. High intake of beta carotene is not toxicity. Amount consumed must be at least 15mg of beta carotene per day; carotedermia (a yellowish discoloration of the skin) will appear if people take supplements of 30 mg per day (Diplock, 1995). Beta carotene is approved for human consumption and has been used for food colorant (Burri, 1997).

While high doses of vitamin A can be toxic, the use of β-carotene as a source of vitamin A is safe. The conversion of β-carotene ─ also called 'pro vitamin A' to vitamin A is influenced by the vitamin A status of the individual (During and Harrison, 2004).

Transformation of β-carotene appears to be inhibited when vitamin A stores are high. This may explain why high doses of beta-carotene have never been found to cause vitamin A toxicity. High doses of beta-carotene (up to 180 mg/day) have been used without toxic side effects (IMFNB, 2000).

5.4 Food Energy

Calorie value was estimated following Etong *et al*. (2014) using Atwater factors by multiplying the proportion of protein, fat, and carbohydrate by their respective physiological fuel values of 4, 9, and 4 kcals, respectively and taking the sum of the products. Energy is used for basal metabolism, physical activities and is used for metabolizing foods. Estimated energy obtained from formulated food varied from 108.08 to 130.13 kcal which was lower compared to recommended daily allowance (RDA). This is due to high moisture content found in the formulated food, which resulted in low dry matter content and solubility of vitamin Bs. Energy yielding components in the formulated foods were low and resulted into low energy content. Incorporating of MNP and intake of other cereals foods will provide sufficient energy, which is recommended by WHO.

5.5 Viscosity Measurement

All mixtures containing germinated flour had a tendency of reducing consistency due to amylolytic activities of germinated maize, which may have degraded the starch in the other flour used in the mixture, but viscosity in other porridge samples was high due to composition of the OFSP flour tubers and vegetables. Viscosity increased as the porridge was cooled so it is therefore important to perform viscosity tests under thermostatically controlled conditions. In viscosity measurement temperature should be set close to the temperature at which the porridge is usually consumed by infants/children.

The consumption temperature generally ranges from 40ºC to 50ºC, but varies slightly in different geographical contexts. In literature, the most common temperature at which viscosity measurements are performed is at 40ºC. However, according to (Amagloh *et al.*, 2013) sweet potato-based formulations have lower starch content and higher sugar content, and therefore a lower apparent viscosity at 45ºC.

5.6 Dietary Diversity

The study observed no dietary diversity in vitamin A rich vegetables and tubers, vitamin A rich fruits, other fruits, animal foods and products. Therefore, this was an indication of how respondents did not consume OFSP and concentrated on the cereal based foods. Cereals were the most frequent food group consumed. Dietary diversity has been shown to increase intake of energy as well as micronutrients in developing countries (Gina *et al.*, 2007) though in Gairo intake of monotonous diets had been practiced as observed in the result section as majority of foods taken were from cereals and non-vitamin A sources. The findings correspond with the observation of Dufour *et al.* (1997). The high percentage of households which consume cereals may mean that surveyed households were not meeting their micronutrient needs, especially vitamin A. Consumption of animal foods such as fish and meat was low. Also, intake of vitamin A rich vegetables and tubers was low; indicating that socio- economic status of the households was so poor that they could not afford buying animal food sources.

Basing on the Inter Quantile Range (IQR), during weekdays highest variability in term of HDDS was noted in Meshugi while the lowest variation was in Ngiloli. In contrary, during weekends IQR was highest in Ngiloli. There was an increase in dietary diversity associated with socio- economic status (FAO, 2012). During weekdays the Maximum Quartile (100%) was in Meshugi and Ngiloli meaning that households which consumed the highest diversified diet in the two villages consumed three food groups.

In Ihenje however, Maximum Quartile was high, meaning that households which consumed the highest diversified diets in the village consumed not more than 6 food groups. A study done in Colombia showed that consumption of eggs was low and same applied to Gairo (INEC, 2006). There is a positive relationship when measuring dietary diversity as it depends on season, rural or urban environment and sometimes recall period. In Meshugi, it was very dry hence there was no food. This was followed by Ngiloli, where many people were in preparation of their fields while there was no rain. During the weekend, the Maximum Quartile (100%) increased in Ihenje village compared to Meshugi and Ngiloli villages. In general, the degree of homogeneity in terms of food groups consumed by households during the weekend was higher than during weekdays. Similarly, the households seemed to consume more diversified diet during the weekends as compared to weekdays.

5.7 24 Hour Dietary Recall

The number of meals consumed by each household was analyzed and results showed that meal intakes between households were similarly related but differed in few meals intake. Dietary intake of meals between normal days showed that Ngiloli village had highest of three meals (breakfast, lunch and dinner), followed by Ihenje and Meshugi. Majority consumed cereal based foods and other vegetables mostly wild vegetables. Consumption of oils and fats was high as respondents used groundnuts and sunflower oil during cooking of vegetables.

There were other households which consumed two and one meal per day due the low socio-economic status they had and sometimes due to seasonality. The Ngiloli respondents were busy preparing their fields, so they left early in the morning and came back in the evening and others were busy doing business along the road. So, they could not have time to prepare food. Some households consumed only one meal due to their low socio- economic status. They did not have food in their houses, no money to buy food and sometimes a house was left with the old (elderly) with small children who can’t work while parents were away to town looking for job.

There was little consumption of vitamin A rich foods, especially those from animal origin such as fish, meat, milk and milk products, chicken and eggs. Even though many households had chicken, people were not consuming due to the reason that eating eggs was the same as consuming chicken as these eggs would produce chicken in few months to come. Consumption of chicken and meat was during holidays or at certain festivals. Chicken were sold to get money to buy medical drugs, other foodstuffs or meet other special household requirements (Kinabo *et al.*, 2016).

Breakfast was not prepared in all households. In the households where they ate breakfast, porridge with or without sugar was the most common food. Tea with buns (*maandazi*) (similar to doughnuts) was also provided. A similar finding was reported in Rukwa, Tanzania (Nordang, 2011).

5.8 OFSP Based Feeding Formula for Reducing Vitamin A

Formulated food formula will help to address Vitamin A deficiency in Gairo. The WHO and UNICEF recommends production of low cost, complementary foods from locally available materials (UNICEF and WHO, 2008) as was done successfully in Latin America (Scrimshaw, 2007). Incorporation of OFSP flour and its vegetable flour with germinated maize are of low cost and are mostly available in Gairo and most of the people cultivated them. The under-nutrition in Gairo was associated with poverty and poor nutrition knowledge, which results in early feeding of infants and children, delayed introduction of complementary foods, low protein and vitamin A diets and severe or frequent infections (Ijarotimi and Olopade, 2009).

Mothers in Gairo typically used white refined maize porridge as a complementary food. Cereal porridges made from maize have low energy and nutrient content (Hotz and Gibson, 2001). Highly refined and unfortified complementary cereals can contribute to the high prevalence of under-nutrition (Hotz and Gibson, 2001). The researchers also found out that children consumed predominantly refined maize flour porridges which were bulky and low in energy and key nutrients for growth. Gairo women gave to their children complementary foods that were the same as those prepared for the older family members, like the starchy side dish of *maandazi* (doughnuts) with tea and ugali (stiff porridge) with *mlenda* (slippery cooked vegetables). Such complementary foods given to them were deficient in Vitamin A needed by these children.

Formulated complementary foods currently available were not accessible to many low income mothers because they contained a large proportion of milk, which makes these foods too expensive for less privileged populations (Obatuli, 2003). The inaccessibility is due to both the high cost of production and limited availability of culturally acceptable food materials used in the formulations (Agbede and Aletor, 2003). Mothers with children, who have vitamin A deficiency, cannot afford the costly foods. To increase the affordability of complementary foods, it is important to explore the nutritional strength of alternative low cost vitamin A sources such as OFSP.

Inclusion of vegetables in feeding formulation can help to reduce vitamin deficiency because they contain vital micronutrients including vitamin A, which is required for improved health status. The vegetables used were OFSP leaves, whose selection was based on richness in micronutrients, local availability and consumption in Gairo and their underutilization status particularly in processed form. This research is unique in that it used locally available foods in Gairo to make nutritious, affordable and culturally acceptable formulated foods for targeted young children.

5.9 Challenges

The big challenge in this study goes to sources of agricultural data, which do not distinguish between OFSP and WFSP varieties; hence the data reported in various studies are largely for sweet potatoes as a whole.

Moreover, despite efforts by the Tanzania government is supporting vitamin A capsules for vitamin A supplementation (WHO and UNICEF) and has announced importance of doing fortification, large food manufacturing industries (e.g., The Bakhresa Group of Companies (Azam wheat flour), Azania Company (wheat flour), Sunkist (wheat flour), MeTL Group (cooking oil) and some medium scale manufacturing industries in Morogoro, Singida, Shinyanga and Manyara) have started fortifying their food products such as cooking oil, wheat and maize flour, there is little effect on the prevalence of VAD. This is possibly because poor rural families cannot access facilities where supplements are distributed and they do not have money to buy fortified foods. Still people use local manufactured oil which is cheaper and mostly kept long on the sun along highways where deterioration of the oil may take place.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

From this study it was observed that:

There was low consumption of OFSP among visited households and low practices of using dietary diversified foods; hence people consumed medium food groups which were mostly based on cereal foods.

Consumption of OFSP was low among visited study households in all villages due to the reason that WFSP were local varieties that households were used to planting and consuming while OFSPs had just been introduced to them because of their high β-carotene content.

There was low intake of vitamin A rich food sources and inadequate knowledge on the benefits of intake of OFSP, preparation and processing of tubers and vegetables. This led to low consumption of food groups rich in vitamin A.

Women had limited knowledge on the preparation of complementary foods. Children consumed refined maize flour porridge (*uji),* which was bulky. Consumed foods were the same as those prepared for older family members, which did not meet their RDA.

6.2 Recommendations

Based on the results of the study, OFSP need to be promoted to increase consumption of β-carotene in communities in Gairo district therefore:-

i. Consumption of OFSP tubers and vegetables and other dietary diversity foods should be advocated to as this will supply vitamin A and micronutrients (minerals and vitamins) needed for healthy people in the community of Gairo people.

ii. OFSP yields or profitability should be equal to a greater than that of WFSP and training in viable methods for vine conservation, especially when OFSP can be grown for only one season a year seem essential. Both OFSP tubers and leaves should be included in their daily meals.

iii. Awareness and nutrition education on intake of vitamin A food groups should be increased to create high demand for planting more vitamin A rich food sources and keep domestic animals and birds, which will raise awareness of dietary intake of vitamin A and OFSP.

iv. The use of OFSP in complementary foods should be encouraged as it has potential to have significant nutritional benefit among people of Gairo and low income countries. The accepted food formulation should be used in Gairo based on its ingredients and ratios.

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APPENDICES

Appendix 1: Beta carotene standard calibration plot for cultivars

Absorbences of the diluted standards were read and standard calibration plot constructed (Appendix. 1), the linear regression equation obtained (Y=0.093K - 0.007) was used to calculate the β- carotene content of samples (Rasaki and Abimbola, 2009).

Calculation

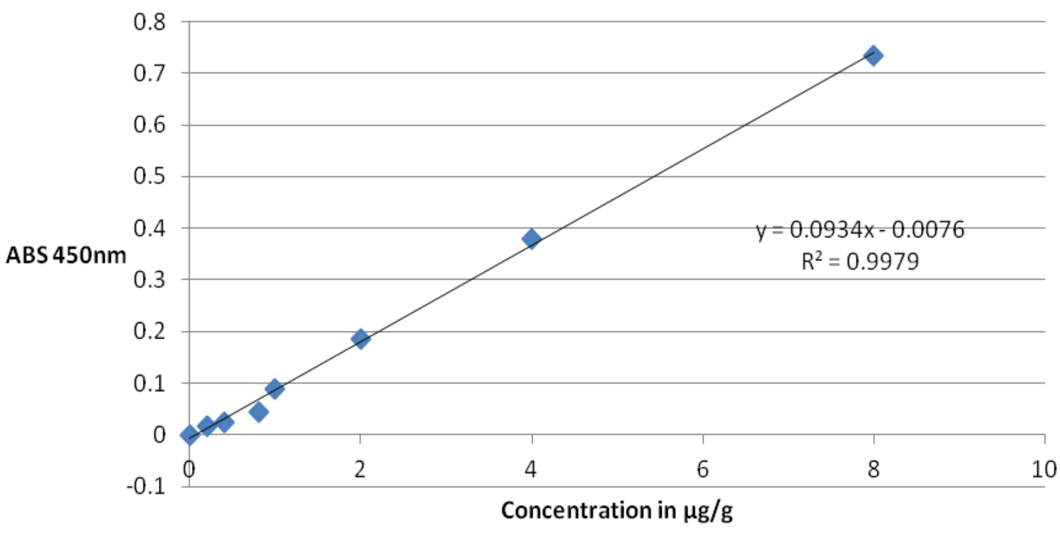
$$\beta\text{- carotene content } (\mu g/g) = \frac{K \times V_1}{S} \quad \ldots\ldots(7)$$

Where;

K = is the sample concentration in (µg/g) as calculated using linear regression equation.

V_1= Extraction volume made (ml)

S = Amount of sample taken (g)



Appendix 2: Sample size determination as per (Bailey, 1994)

The following formula was used to select sample

$n=Z^2Pq/d^2$

Where by n = desired sample size

Z = standard normal deviation at required confidence interval usually 1.96 at 95% C.I

d = degree of accuracy desired, 5% = 0.05

P = the proportional of the villages which cultivate OFSP to which have been supplied with vines by project are 4 out 50 which gives us 0.08

q= 1-p

$$n=\frac{1.96^2 \times 0.08 \times 0.92}{0.05^2} = 113$$

And proportionality of how many households were surveyed was 113/3= 37.6 approximately to 38 households per village were surveyed.

Appendix 3: Questionnaire to Evaluate OFSP consumption behavior in Gairo

ORANGE FLESHED SWEET POTATOES CONSUMPTION FOR IMPROVED NUTRITION IN GAIRO

A. Demographic Information

SURVEY IDENTIFICATION		CODE	ENTER CODE		
1	Date	Enter date as dd –mm -yy			
2	Household ID	Eg.01,02 etc			
3	Household Head Name	………………………………			
4	Sex	1=Male 2= Female			
5	Age	Enter age in years			
6	Marital Status	1=Single 2=Married 3=Widowed 4=Widower 5=Divorced 6=Others(specify)			
7	What is your education level	1=No education 2=Adult Education 3=Primary School 4=Secondary School 5=Certificate/Diploma 6=University			
8	What is your occupation	1=Farmer (OFSP) 2=Farmer 3=Employed in formal sector 4=Self employed 5=Other(specify)			
9	Total number of members in this HH	Enter number		**F**	**M**
10	Total number of children below 5 years age	Enter number			

B. KNOWLEDGE ON BEHAVIOURAL DIETARY INTAKE OF ORANGE FLESHED SWEET POTATO

SURVEY IDENTIFICATION		CODE	ENTER CODE
1	Have you ever heard about OFSP?	1= Yes 2= No When was this …………….	
2	Types of sweet potato that are growing in your area	1=Traditional sweet potato varieties 2=OFSP	
3	Have many times do you harvest in a year?	1=one time 2= twice 3= Thrice	
4	After harvesting do you sell them all or do you use for your home consumption	1=Sell them all 2=Use some for home consumption 3=Both sell them and use for home consumption	
5	Do you use OFSP in your dishes?	1=Yes 2=No If no, why………………………..	
6	If yes (Qn5) how many times in a day	1= Once 2=Twice 3=Several times Specify……………………………..	
7	Do you prepare OFSP dishes for your children?	1= Yes 2=No If yes mention them…………. If no why……………………………………	
8	In which form do you prepare?	Explain……………………………………………	
9	Do you use OFSP leaves as vegetable? Probe	1= Yes 2 = No If no why ……………………...	
10	What is your preference on OFSP?	1= Shape and size 2=Colour 3= Taste	
11	Do you store OFSP? In which form? Probe	1= Yes 2= No mention ………………………	

<table>
<tr><td>12</td><td>Has there been any promotion on consumption of OFSP? Probe</td><td colspan="3">1= Yes 2 = No explain………………..</td><td></td></tr>
<tr><td>13</td><td>Do pregnant and lactating mothers consume diet with OFSP?</td><td colspan="3">1= Yes 2 = No if no why……………………</td><td></td></tr>
<tr><td>14</td><td>How frequent do children of 6- 23 months consume OFSP?</td><td colspan="3">1= Once 2= Twice 3 = More than twice</td><td></td></tr>
<tr><td>15</td><td>What are complementary foods given to above group</td><td colspan="3">Mention them ……………………….................</td><td></td></tr>
<tr><td>16</td><td>Do you include animal foods, fruits and vegetables in your dishes? Probe</td><td colspan="3">1= Yes 2= No</td><td></td></tr>
<tr><td rowspan="5">17</td><td rowspan="5">If yes what are these animal foods and quantity consumed per day</td><td>Animal food</td><td>Frequency per day</td><td>Quantity</td><td rowspan="5"></td></tr>
<tr><td>Milk</td><td></td><td></td></tr>
<tr><td>Eggs</td><td></td><td></td></tr>
<tr><td>Meat</td><td></td><td></td></tr>
<tr><td>Fish</td><td></td><td></td></tr>
<tr><td>18</td><td>Do you see any need to increase demand of OFSP</td><td colspan="3">1= Yes 2= No</td><td></td></tr>
<tr><td>19</td><td>Compare to traditional WFSP which one do you prefer?</td><td colspan="3">Explain why ……………………………………..</td><td></td></tr>
<tr><td>20</td><td>Which is not your preference in OFSP? Probe</td><td colspan="3">Mention and explain……………………………
……………………………………………………</td><td></td></tr>
<tr><td>21</td><td>What dishes are prepared from OFSP? Probe varieties</td><td colspan="3">Mention……………………………………..</td><td></td></tr>
</table>

22	What is the main different between traditional and OFSP	Explain……………………………………………	
23	What are the factors influencing consumption of OFSP	Mention them (a)……………………………………………. (b)…………………………………………….. (c)…………………………………………….	
24	Have you ever received nutrition education on consuming OFSP? Probe	1= Yes 2= No Mention…………………………………………	

C. HOUSEHOLD DIETARY DIVERSITY SCORE

	Food Group	**Cereal/grain**	**Form of consumption**	**Yes=1 No=0**
1	CEREALS E.g. Maize, rice, sorghum, millet or food made from these cereals	1.Maize	Ugali	
			Porridge	
		2.Rice	Rice	
		3.Sorghum	Ugali	
		4.Millet	Ugali	
		5.Others		
2	VITAMIN A RICH VEGETABLES AND TUBERS E.g. Pumpkin ,carrot, squash, orange fleshed sweet potato, local vegetable	Pumpkin		
		Carrot		
		Squash		
		OFSP		
		Local vegetable(specify)		
		Others		
3	WHITE TUBERS AND ROOTS E.g. White potatoes, white yams ,cassava, sweet potatoes, taro, cocoyam	White potatoes		
		White yams		
		Cassava		
		Sweet potatoes		

		(OFSP)		
		Taro (*magimbi maji*)		
		Cocoyam (*majimbi yanayolimwa sehemu kavu*)		
4	DARK GREEN LEAFY VEGETABLES E.g amaranth, cassava leaves, *mlenda, matembele ,mchunga ,mnavu* etc	Amaranth		
		Cassava leaves		
		Mlenda		
		Matembele		
		Mchunga		
		Mnavu		
		Others		
5	OTHER VEGETABLES E.g. Tomatoes, onions, *nyanya chungu*, eggplant, edible wild vegetables	Tomatoes		
		Onions		
		Nyanya chungu		
		Eggplant		
		Edible wild vegetable (specify)		
6	FRUITS E.g. Ripe mangoes, papaya, bananas, pineapples ,oranges etc	Ripe mangoes		
		Papaya		
		Bananas		
		Pineapples		
		Oranges		
		Others		
7	OTHER FRUITS E.g. tamarind, baobab fruits	Tamarind		
		Baobab fruits		
		Others		

8	MEAT E.g. Beef, lamb, offal, pork, rabbit, chicken, duck, guinea fowl	Beef		
		Lamb		
		Offal		
		Pork		
		Rabbit		
		Chicken/Duck		
		Guinea fowl		
9	EGGS E.g. Chicken, duck, guinea fowl or any other related eggs	Chicken		
		Duck		
		Guinea fowl		
		Others		
10	FISH E.g. fresh or dried, smoked, sardines	Fresh		
		Dried		
		sardines		
		smoked		
11	LEGUMES, NUTS AND SEEDS E.g. Beans ,green peas ,lentils, nuts, seeds or food made from these	Beans		
		Green peas		
		Lentils		
		nuts		
		seeds		
12	MILK AND MILK PRODUCTS E.g. Milk, cheese, yogurt	Milk		
		Yogurt		
		Cheese		
13	OILS AND FATS E.g. oil, fats, butter	Cooking oil		
		Fat		
		Butter		
14	SPICES,CONDIMENTS E.g. Black pepper, garlic, cardamom, cinnamon ,ginger, chilies	Black pepper		
		Garlic		
		Cardamom		
		Cinnamon		
		Ginger		

		Chilies		
		Others		
15	SALT,SUGAR E.g. sugar, honey, local made salt, iodized salt	Sugar		
		Honey		
		Local made salt		
		Iodized salt		

D. 24 HOUR DIETARY RECALL: Mothers/caregivers are responsible for food preparation DAY……………………..

Meal time(as determined by respondent)	Name of the food or dish (list one food per line	Ingredients	Amount/portion served (cups, spoons, scoop/ bowl/tablespoonful	Amount not consumed	Amount consumed	Units (gm/mls etc)	How was consumed (1=cooked 2=raw)
Breakfast							
Late morning/snack							
Lunch							
Snack							
Dinner							
Post dinner							
Probe for alcohol				**1= Yes 2= No**			
Probe for cigarette smoking				**1= Yes 2 =No**			
Abbreviations: Tablespoon=Tbsp, Tea spoon=tsp, Cup standard=c, glass standard=g, plate standard=pl							

Thank you for your cooperation

Appendix 4: Hedonic scale

HEDONIC SCALE

Acceptability test

Panelist sex …………………………… Age………………… Date ……………….

Sample No …………	1.Dislike extremely	2.Dislike very much	3.Dislike moderately	4.Dislike slightly	5.Neither like nor dislike	6.Like slightly	7.Like moderately	8.Like very much	9.Like extremely
Colour									
Aroma									
Taste									
Mouth feel									
Overall acceptability									

Thank you for your cooperation

Appendix 5: Ethical clearance certification

THE UNITED REPUBLIC OF TANZANIA

National Institute for Medical Research
3 Barack Obama Drive
P.O. Box 9653
11101 Dar es Salaam
Tel: 255 22 2121400
Fax: 255 22 2121360
E-mail: headquarters@nimr.or.tz

Ministry of Health, Community Development, Gender, Elderly & Children
6 Samora Machel Avenue
P.O. Box 9083
11478 Dar es Salaam
Tel: 255 22 2120262-7
Fax: 255 22 2110986

NIMR/HQ/R.8a/Vol. IX/2506

06th June 2017

Sakina Magadi Mustafa
Sokoine University of Agriculture
P.O. Box 3001
Morogoro

CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Orange fleshed sweet potato consumption trend for improved nutrition in Gairo district (Mustafa S. *et al)* has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine as per NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Site: Morogoro.

Approval is valid for one year: 06th June 2017 to 05th June 2018.

Name: Prof. Yunus Daud Mgaya

Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Prof. Muhammad Bakari Kambi

Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY DEVELOPMENT, GENDER, ELDERLY & CHILDREN

CC: RMO of Morogoro
DMO/DED of Gairo

Appendix 6: Gairo district research permit

HALMASHAURI YA WILAYA YA GAIRO

[Baruazotezipelekwe kwa MkurugenziMtendaji wa Wilaya]

Simu: 255 - 23 -
Nukushi: 255 - 23 -
Baruapepe: ....
Tovuti: ....
Unapojibutafadhalitaja:
Kumb. Na. GDC/T.20/2/VOLL II/36

UKUMBI WA HALMASHAURI,
S.L.P. 40,
GAIRO.

Tarehe: 14 Disemba, 2016

Afisa Kilimo Umwagiliaji na Ushirika (W),
S. L. P. 40,
GAIRO.

YAH: UTAMBULISHO WA NDUGU SAKINA MAGADI MUSTAFA.

Tafadhali husika na somo tajwa hapo juu.

Napenda kumtambulisha kwako Ndugu Sakina Magadi Mustafa Mwanafunzi katika Chuo Kikuu cha Sokoine ambaye anasomea Mafunzo ya Shahada ya Uzamili katika Lishe ya Mwanadamu (MSc Human Nutrition). Anafanya Utafiti katika maswala yanayohusiana na Matumizi ya Viazi lishe.

Hivyo namuongoza katika ofisi yako ili umpatie huduma anayohitaji ikiwa ni pamoja na kumtambulisha kwa Watendaji wa Vijiji ambavyo utamshauri akatembelee ili awaze kukamilisha utafiti wake kwa wakati.

Nakutakia kazi njema.

Halima Sendoro
KNY: MKURUGENZI MTENDAJI (W)
GAIRO.

MKURUGENZI MTENDAJI (W)
GAIRO

Nakala.

Ndg. Sakina Magadi Mustafa
CHUO KIKUU SOKOINE