ASSESSMENT OF NUTRIENT CONTENTS OF FOODS WIDELY GROWN AND CONSUMED IN MOROGORO MUNICIPALITY

BY

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ABSTRACT

Nutrient contents of foods widely grown and commonly consumed in Morogoro Municipality were determined, aiming at establishing nutrient composition databases of foods in the study area. Data was collected in dry (July to September) and wet (January to March) seasons. A total of 144 respondents were selected from eight wards using simple random technique. Selected nutrient contents of raw and cooked foods were analyzed according to the Association of Official Analytical Chemists (AOAC, 2000). Results show that majority (93.06%) of the households grew maize and variety of green leafy vegetables namely pumpkin leaves (90.28%), cowpeas leaves (88.89%) and sweet potato leaves (78.47%). Green leafy vegetables are consumed daily (95.13%) with stiff porridge (*ugali*) (93%) made from refined maize flour as a staple dish sometimes with beans, a major source of protein in the area. Majority (83%) had two meals per day; the rest had three meals a day. Nutrient contents of selected foods compare well with those reported elsewhere, however, major differences were found in carbohydrate contents in raw maize flour (67%), and cooked green banana variety *mtwike* (18%), these values were lower than reported. Calcium and iron contents were higher in raw amaranthus (0.74%) and cassava leaves (0.012%) than reported (0.011% and 0.003%, respectively). Content of nutrients also differed between raw and cooked food. This was so apparent in leafy green vegetables, whereby difference was found between raw amaranthus (739 mg/100g calcium) and cooked amaranthus (292 mg/100 g calcium). The loss could be due to the practice of throwing away cooking water before the final steps of cooking. Based on these findings, it can be recommended that further studies on

determination of nutrient contents of foods produced in different zones of the country need to be conducted to enable people to choose foods appropriately based on their nutrients and energy needs.

DECLARATION

I, Jane Paul Kailembo, 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 has neither been submitted nor being concurrently submitted in any other Institution.

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Jane Paul Kailembo **Date**

(MSc Candidate)

The above declaration is confirmed by

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Dr. (Mrs.) Dorothy M. Gimbi **Date**

(Supervisor)

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This dissertation is dedicated to my parents; my late father Simon Stephano Ndamugoba and my late mother Pascazia Pastory Mabugo as every step of my success depended on them.

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LIST OF ABBREVIATIONS

A	Titre of acid used in milliliters
AC	Ash Content
AOAC	Association of Official Analytical Chemists
Bns	Beans
carbohy	Carbohydrate
CF	Crude Fibre
ckd	Cooked
CP	Crude Protein
DF	Dilution Factor
DNA	Deoxyribonucleic Acid
ECSA	East Composition Society Association
ESRF	Economic and Social Research Foundation
FAO	Food and Agriculture Organization
fd	Food
g	Grams
Grn	Green
HIV	Human Immunodeficiency Virus
MAFC	Ministry of Agriculture Food Security and Cooperative
MALDO	Municipal Agriculture and Livestock Development Officer
MC	Moisture Content
MKUKUTA	Mpango wa Kuinua Uchumi na Kuondoa Umasikini Tanzania
ml	Milliliters
MMOH	Morogoro Municipal Health Office
N	Total Nitrogen
^{o}C	Degrees in Centigrade
PER	Protein Energy Ratio
ptato	Potato
R	Reading in
RNA	Ribonucleic Acid
S	Sample weight
Sel	Selected
SPSS	Statistical Package for Social Sciences
Swt	Sweet
TFCT	Tanzania Food Composition Table
TFNC	Tanzania Food and Nutrition Centre
Tshs	Tanzanian shillings
U.V	Ultra Violet
USA	United States of America
USDA	United States Department of Agriculture
var	Variety
W	Weight
WHO	World Health Organization
%	Percent

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Information on the concentrations of nutrients in foods and their nutritional values is a base of quantitative study of human nutrition (Kinabo *et al*., 2006; Church, 2006). Its application relies on the treatment, management of disease and the provision of appropriate diet for individuals and population. The availability of nutrient content of food data collected at individual level in various sections of the population is crucial to characterize food consumption patterns. These data are needed to perform a number of research and surveillance activities in the area of consumer science, nutrition and food safety (Branca *et al*., 2007; Leclercq *et al.,* 2007). The nutrient content of the food is the complete pool of rigorously scrutinized data from the food of which all values have to be converted into standard units and nutrients are expressed uniformly (Church, 2006).

Many countries, both developed and developing, still lack appropriate national food composition tables (Church, 2006; Branca *et al*., 2007). This has entertained the use of tables from other countries with more accurate or complete information, either as the local database reference for nutritional data analysis or for the substitution of missing values in specific nutrients (Leclercq *et al.,* 2007). These tables present increasing trend in nutritional problems as a major source of errors in the estimation of nutrient intake levels (Lukmanji *et al*., 2008). Errors are also found when different nutrient databases based on the same national food composition table are compared (Lukmanji *et al*., 2008). These lead not only to food composition databases that differ substantially in form, content and relative interpretation of diet–disease relationships (Gibson *et al.,* 2006). Due to the complexity of developing and compiling data for food composition tables, the problem becomes more difficult when the data available are relatively old (Church, 2006).

In East Africa the food composition table was established in the 1980s by East Composition Society Association (ECSA) FOODS. Recently Tanzania developed food composition table which does not indicate regional food composition. Nutrient contents of food may vary according to soil type, geographic location of the area and cooking method employed on the same food type and same variety (Church, 2006). The study sought to assess nutrient content of foods widely grown and consumed in Morogoro Region. This may be used as a tool when one is prescribing food for nutritional guidelines; also in the interpretation of diet-disease relationships. Judgments in taking food are worth to put into account both the content size and consumption pattern. A good source of a component is a food that has a high concentration of the component, or if the concentration is low, it is eaten in fairly large amounts (Wardlaw and Smith, 2008).

1.2 Problem Statement and Justification

In developing countries, macro and micro nutrient deficiency diseases press a heavy burden of frequent reproductive cycling (one cycling being conception, pregnancy, lactation/postpartum) combined with under nutrition and overexertion and its impact on a woman’s health and nutritional status and that of her offspring (Bowman and Russell, 2001). The information on the quantification of these nutrients in foods is required for addressing the treatment and related disease control. The decisions on the treatment and intervention are based on this information (Vahatalo, 2005; Church, 2006; Sevenhuysen, 2008; Lukmanji *et al*., 2008; USDA, 2008; Black *et al*., 2009; Levy, 2009**).**

The nutrients of foods are also essential resource for understanding and analyzing dietary intake data for both individuals and communities, and for developing healthy recipes and food products (Church, 2006). Nutritional assessment of specific populations, food labeling, food fortification and food composition data from various countries are more useful. However, the use of foreign chemical composition data presents increasing trend in nutrition problems as a major source of error in the estimation of nutrient intake levels (Lukmanji *et al*., 2008). Differences and errors are also found when different nutrient databases based on the same national food composition table are compared (Lukmanji *et al*., 2008). These lead not only to food composition databases that differ substantially in the form, content and relative quality, but also to bias in the interpretation of diet-disease relationships (Gibson *et al.*, 2006; Wardlaw and Smith, 2008). Due to the complexity of developing and compiling data for food composition tables, the problem intensifies when the data available are relatively old (Church, 2006).

Most food composition tables for raw foods were established according to their geographical location in relationship to soil type (Church, 2006; Lukmanji *et al*., 2008; USDA, 2008). In addition tables were established according to the effects of different types of cooking methods, equipment, surface area of food contact exposure, length and temperature of cooking, volume of product on the yield factors, retention factors, water/fat, and loss/gain factors (Branca *et al*., 2007; Leclercq *et al.*, 2007; USDA, 2008). Furthermore, some tables were published only for certain nutrients (Leclercq *et al.,* 2007*)*.

Tanzania, like other developing countries in sub-Saharan Africa, is faced with challenges of both under- and over nutrition (Lukmanji *et al*., 2008). Under nutrition comprises of a number of nutritionally related conditions such as protein-energy malnutrition and micronutrient deficiencies, including those of vitamin A, iron, and iodine (Faber, 2004; Le and Jacques, 2005; Mamiro *et al*., 2005; Dewey and Adu-Afarwuah, 2008; Hu, 2008; Peneau *et al.*, 2008; Lukmanji *et al*., 2008; Raschke *et al.*, 2008). It was also found that, many Tanzanians appear to be deficient in energy and unable to sustain their expected level of physical activity (Eduardo *et al*., 2005; Dewey and Adu-Afarwuah, 2008; Lukmanji *et al*., 2008). At the same time, over nutrition-related diseases such as obesity, diabetes, and hypertension are rapidly increasing among the adult population (Fishbanes, 2006; Lukmanji *et al*., 2008; Raschke *et al.,* 2008), most conspicuously in urban centers (Vahatalo, 2005), but also in rural areas (Lukmanji *et al*., 2008). Information of the concentrations of nutrients in indigenous foods may be important components of quantitative studies in human nutrition and nutrition intervention programmes (Church, 2006; Lukmanji *et al*., 2008).

Therefore, this study seeks to assess nutrient content of selected widely grown and consumed foods in Morogoro Municipality. Information to be obtained is critical to our rational understanding of choice on people’s diet, economical, safe and nutritious crops to be produced. Findings of this study provide a documentation that may be useful information in prescribing food for individual nutritional guideline and also in the interpretation of diet-disease relationships. The findings further help to establish food composition table presenting the food produced and consumed in the region.

1.3 Objectives

1.3.1 Overall objective

To assess nutritional composition of foods commonly consumed and crops widely grown and in Morogoro Municipality for documentation that would be useful information in prescribing food for individual nutritional guideline and in the interpretation of diet-disease relationships.

1.3.2 Specific objectives

i. To identify foods widely grown and commonly consumed in Morogoro Municipality,

ii. To find out recipes of foods widely used in Morogoro Municipality,

iii. To determine nutritional composition of some selected raw and cooked foods widely consumed in Morogoro Municipality, and

iv. To establish a data base of selected food dishes for Morogoro Municipality.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Food Composition

Food composition is a reference data base, which might give information on all foods and all food components. The necessary information is the name of the food item, description of the sampling procedure, number of samples and method(s) of analysis (Church, 2006; Mandala, 2006; Holden, 2009).

2.2 An Overview of Food Composition Data Bases

World wide food composition data provide detailed information on the nutritional composition of foods. Quality food composition databases are the cornerstone of nutrition research and public health nutrition, providing data for diet-related epidemiological studies, policy making, consumer education and the food industry on nutrition labeling and product innovation (Church, 2006; Black *et al.*, 2009). It determines its safety, nutrition, physiochemical properties, quality attributes and sensory characteristics. Most foods are compositionally complex materials made up of a wide variety of different chemical constituents (Mandala, 2006), their composition can be specified in a number of different ways depending on the property that is of interest to the analyst and the type of analytical procedure used (USDA, 2005; Lukmanji *et al.*, 2008; Holden, 2009).

In other countries food composition databases rely on nutritional and toxicological analyses conducted by government, academia and industry to determine the potential contributions of foods to the diet, determine its compliance with regulations concerning composition, quality, and safety labeling and ongoing monitoring of the food supply. All of these compositional studies produce data that can be considered for entry into a food composition database (Holden, 2009; USDA, 2005; Church, 2006 Mandala, 2006**;** Lukmanji *et al*., 2008; Sevenhuysen, 2008).

2.2.2 East Africa food composition tables

The present east food composition table was prepared and compiled by Wageningen Agricultural University (West *et al.*, 1988) on behalf of East Composition Society Association (ECSA) authority. These food tables had data from other sources borrowed to accomplish their work and some data were missing. In this study determination of nutritional composition of some selected raw and cooked foods, widely consumed in Morogoro Municipality was done and database was established.

2.2.3 Importance of food composition data

Food composition data are used primarily for the assessment and planning of human energy and nutrient intakes for good nutrition and health (Wardlaw and Smith, 2008). These leads to enhanced quality of life (Church, 2006) and also increase potential of human resources which is vital for national socio-economic development, rapid economic growth and technological advances in most countries (Mandala, 2006).

Selected nutrients can be produced for people with special dietary needs or interests. Such data and databases might be produced showing foods with a range of nutrients with high, medium and low levels. Data could also be given in other useful units such as sodium and potassium in mill moles for renal patients. In both cases, the approach is most useful when applied to groups rather than individuals (Holden, 2009).

Nutrient content data are very important resources used by professionals working in areas such as food trade, food control, nutrition research and health (Sevenhuysen, 2008; USDA, 2008). Food composition data therefore have a wide application in both clinical and public health practice (Church, 2006; Black *et al.*, 2009). In addition, food composition tables are often a common tool when several methods of nutrient intake estimation are compared. Thus should be reliable in estimating nutrient intakes, the tables themselves are also subjected to validation studies (Mandala, 2006**;** Holden, 2009).

2.3 Food Habits

Food habit refers to why and how people eat which foods they eat, and with whom they eat, as well as the ways people obtain, store, use, and discard food. Individual, social, cultural, religious, economic, environmental, and political factors all influence people's eating habits (Mandala, 2006; Popkin, 2006; Timmons, 2008).

2.3.1 Consumption of local foods

An increasing number of individuals are rejecting imported food items in favor of more locally grown and produced ones (Raschke *et al.*, 2008). That have been grown and/or raised within 100 miles of their homes (Timmons, 2008; Harding, 2009). People have different reasons for wanting to put locally grown food on their tables (Vahatalo, 2005; Popkin, 2006; Kirby *et al.*, 2007). Pleasure of eating freshly harvested food, the availability of varieties of food that are not normally stocked in grocery stores, and getting back in touch with the seasonality of their foods are among the reasons of preparing locally grown and produced foods (Vahatalo, 2005; Popkin, 2006; Timmons, 2008). For some, it is about food safety and the ability to trace a product back to its producer. Many note that locally grown food does not sit on the shelves for a long time before it is consumed and is more nutritious (Popkin, 2006; Marshall, 2008).

Human culture must adapt to what is available locally. This means that, utilizing innovative and traditional methods to extend the growing season, proper post harvest handling, and live within the limitations of regional resource base (Raschke *et al*., 2007; Harding, 2009).

To better understand and quantify market demand and establish realistic goals for sourcing local food, desired spending on local food depends on specific market segments (Raschke *et al*., 2007; Harding, 2009). Desired spending is a calculation that estimates spending by businesses and organizations with high interest in local food. It also shows climate conditions affecting the seasonality of local food production (Kirby *et al*., 2007; Raschke, 2008). The willingness of consumers to pay more for local food increases the motivation of producers to produce the crop in question (Raschke *et al*., 2007). In other words local food represents a fresher, tastier option to foods produced in more distant regions (Vahatalo, 2005).

2.4 Nutritional Quality of Foods

Quality of food nutritionally means its function or use in the body. It refers to its energy value, or its protein, vitamin and mineral content; or combinations of these (Reynaldo *et al.*, 2010). Since the main nutritional problem is energy-protein deficiency, the special food values of interest are the energy concentration and the protein-calorie percentage. The energy concentration refers to the amount of energy in a given volume of food. Some foods are very bulky and contain a lot of water (Gibson *et al.,* 2006). For example, cooked starch foods such as rice absorb water and swell, this means to get the amount of calories that are contained in the dry weight need to eat much more of the cooked food. In other foods for example fats and oils, the energy is very concentrated little is needed to get the amount of calories (Lukmanji *et al*., 2008).

2.5 Types, Sources and Importance of Food Nutrients in Human Body

These are divided into six food categories namely: carbohydrates, proteins, fats/lipids, vitamins, minerals and water. All these are further divided namely macro nutrients which include: carbohydrates, proteins and fats/lipids. They are called macro because they are needed in large amounts in the body. The second group is micronutrients; these are important nutrients but needed in the body in small amounts. The third group is macro elements, these include calcium, phosphorus, iron, iodine and magnesium these are important elements needed in large amounts. The fourth group is micro elements which include selenium, manganese, chromium, vanadium, molybdenum, copper and zinc; these are needed by the body in trace amount but are very important in the normal physiological functions of the body (Bowman and Russell, 2001; Church, 2006).

2.5.1 Carbohydrates

The main nutritional value of this nutrient is to provide dietary energy. It is a part of the structural component of the body (cell membrane); it is also optimal for gastro-intestinal function and health (fibre) (Englyst *et al*., 2007; Venn and Green, 2007).

The food sources of carbohydrates are: - cereals (maize, rice, wheat, millets, and sorghum), tubers (potatoes, cassava, and yam), legumes (pulses), sugarcane, sugar beets and fruits. Carbohydrate is starch together with some sugars (Shils *et al*., 1994; Hu, 2008). The physical properties of starch grain influence the digestibility and processing qualities of the food crops (Mann, 2004). The starch granules of some varieties of food are very small, which improves the starch digestibility (Elia and Cummings 2007; Cummings and Stephen, 2009). In addition to starch and sugar, food crops also contain some non-starch polysaccharides; including cellulose, pectins and hemicelluloses, as well as other associated structural proteins and lignins which are collectively referred to as dietary fibre (Church, 2006; Cummings and Stephen, 2009).

The role of dietary fibre in nutrition has aroused a lot of interest in recent years. Some epidemiological evidence suggests that increased fibre consumption may contribute to a reduction in the incidence of certain chronic diseases, including diabetes, coronary heart disease, colon cancer and various digestive disorders. The fibre appears to act as a molecular sieve, trapping carcinogens which would otherwise have been reticulated into the body; it also absorbs water thus producing soft and bulky stool (Englyst *et al*., 2007; Elia and Cummings, 2007; Venn and Green, 2007; Cummings and Stephen, 2009). The deficiency symptoms of dietary fiber could lead someone to have general weakness due to lack of energy and marasmus (Bowman and Russell, 2001; Wardlaw and Smith, 2008).

White maize is the major food staple in Tanzania (ESRF, 2006). Maize is consumed in both urban and rural areas; it is grown in almost every region of the country. The popular varieties in the Morogoro Municipality include; stuka, staha, katumani, kito, TMV1 and local varieties. About half of Tanzanian small farmers produce maize. Maize production has increased from about 630 000 tons in 1964/65 to over 3 300 000 tons in 2004/05 (ESRF, 2006).

2.5.2 Protein

This nutrient is important in the synthesis of new tissues, repair of worn out tissues, synthesis of enzymes and hormones, which are important for homeostatic functions and formation of the cell membrane. The structural component of the body is the source of energy and the sparing effect of carbohydrate on the body proteins. The food sources rich in this nutrient are: - beans (all types), peas (all types), meat (all types), egg, milk, nuts (all types), (Shils *et al*, 1994; Kinabo *et al.*, 2006).

A protein which does not contain sufficient amounts of one or several of the essential amino acids is called partially complete protein and has lower biological value (Shils *et al*., 1994; Wardlaw and Smith, 2008). These are mostly of plant origin acquired from certain plants like legumes, cereals, nuts and vegetables (Shils *et al*., 1994; Bowman and Russell, 2001; Wardlaw and Smith, 2008). However, in a mixed diet proteins of animal origin are complete proteins, therefore complementation is normally done, for proteins of plant origin example maize and beans (Shils *et al*., 1994; Wardlaw and Smith, 2008). Similarly, adults under no physiological stress can maintain satisfactory nutrition for indefinite periods when consuming sufficient amounts of protein obtained from mixture of plant derived proteins alone (Shils *et al*., 1994; Bowman and Russell, 2001; Wardlaw and Smith, 2008). This is possible because different sources normally have essential amino acids patterns that compensate for each other's deficiencies (Shils *et al*., 1994; Bowman and Russell, 2001; Wardlaw and Smith, 2008). Symptoms of proteins deficiency results in poor growth and development in children, kwashiorkor, tissue degeneration, and poor coordination of metabolic activities in the body (Bowman and Russell, 2001; Kinabo *et al.*, 2006; FAO, 2007).

2.5.3 Lipids/fats

Fats are rich sources of energy (Shils *et al*., 1994; Bowman and Russell, 2001; Wardlaw and Smith, 2008). Fat provides essential fatty acids and acts as a carrier of fat soluble vitamins (A, D, E, and K) (Shils *et al*., 1994; Bowman and Russell, 2001; Wardlaw and Smith, 2008). Fats are mainly structural lipids of the cell membrane which enhance cellular integrity, offer resistance to bruising hence important for cell survival. It insulates the body and protects delicate organs of the body against mechanical injury by providing a cushion around the organs (Shils *et al*., 1994; Bowman and Russell, 2001; FAO, 2007).

The lipid may probably contribute to the palatability of the food (Wardlaw and Smith, 2008). Most of the lipid consists of equal amounts of unsaturated fatty acids, linoleic and linolenic acids, the saturated fatty acids, stearic acid and palmitic acid (Shils *et al*., 1994). In dehydrated products such as dehydrated potato or instant potato, the high percentage of unsaturated fatty acids in the lipid fraction may accelerate rancidity and auto-oxidation, thereby producing off-flavors and odor (FAO, 2007). Sources of foods are: - animal source: meat lard, butter, egg yolk, milk, cream. Plant source: -nuts (ground nut) and nut oils, vegetable oil such as sunflower oil, sesame oil, and cotton seed oil, cereal oil, pumpkin seed oil, palm oil, coconut milk, and the like (Shils *et al*., 1994; FAO, 2007). Deficiency symptoms of fats in the body are related to deficiency of fat soluble vitamins, rough and scaly skin, degeneration of the cell membrane and body weakness (Shils *et al*., 1994; FAO, 2004; FAO, 2007; Wardlaw and Smith, 2008).

2.5.4 Vitamins

Vitamins are complex organic substances that are needed in very small amounts for many of the processes carried out in the body (Shils *et al.,* 1994). Usually only a few milligrams (mg) or micrograms (μg) are needed per day, but these amounts are essential for health. The body cannot make most vitamins, and so they have to be provided by diet. Some vitamins can be made in the body but to a small extent; for example Vitamin D can be obtained by the action of sunlight on the skin, and small amounts of a B vitamin, niacin can be made from the amino acid, tryptophan.

Vitamins have been traditionally grouped into two categories, the water-soluble vitamins (B complex, and C) (Shils *et al.,* 1994; Greene, 2005) and the fat-soluble vitamins (A, D, E and K). Water soluble vitamins are bound to be deficient in the body since they are not stored in appreciable amounts and therefore, provision of these vitamins is essential in the diets and supplementation in cases when diets do not meet the recommended daily needs (Bowman and Russell, 2001).

The vitamins for public health importance are vitamin A and C of which Tanzania government have a special progrmme for vitamin A intervention to children less than five years old after every six month.

2.5.5 Minerals

The body needs minerals in small amounts (Shils *et al.,* 1994; FAO, 2004; Mohammed and Spyrou, 2009). This helps, chemical processes and to build tissues and fluids such as: - Iron for blood making combines with protein and copper to form hemoglobin, a blood component (FAO, 2004; Kinabo *et al.,* 2006). Hemoglobin transports oxygen in the blood from the lungs to the tissues which need oxygen to produce energy and maintain basic life functions (Bowman and Russell, 2001). Iron builds up the quality of the blood and increases resistance to stress and diseases (FAO, 2004; Msuya and Mamiro, 2009). Iron is also necessary for the formation of myoglobin, which is found mainly in muscle tissue (FAO, 2004; Msuya and Mamiro, 2009).

Myoglobin supplies oxygen to muscle cells for use in the production of energy for muscle contraction (Christensen *et al*., 2006), prevents fatigue and also promotes good skin tone. The main advantages of negative ions for the human body include cleansing of the blood, activation of cells, enhancement of the immune system, and adjustment of the autonomous nervous system, (Shils *et al*., 1994**;** Bowman and Russell, 2001; Christensen *et al*., 2006). The good food sources include; green leaf vegetables, cereals, rosella flower, liver, kidney and beans.

Calcium is essential for bones and teeth formation (Shils *et al*., 1994; Christensen *et al*., 2006), regulates heart rhythm; eases sleeplessness; helps regulate the passage of nutrients in and out of the cell wall; assists in normal blood clotting; helps maintain proper nerve and muscle function; lowers blood pressure; important for normal kidney function; reduces blood cholesterol level (Bowman and Russell, 2001;

Christensen *et al*., 2006). The good food sources include; green leaf vegetables, milk, fish and meat.

Phosphorus plays an important role in the regulation of neuromuscular activity of the heart; maintains normal heart rhythm; necessary for proper calcium and vitamin metabolism; and converts blood sugar into energy (Bowman and Russell, 2001; Christensen *et al*., 2006). The good food sources include; sea foods, cashew nuts, dates, green leaf vegetables, honey, peanuts, whole grains. Potassium is the major mineral in most root crops while sodium tends to be low in most of root crops. This makes some root crops particularly valuable in the diet of patients with high blood pressure, who have to restrict their sodium intake marginal like in the southern highlands of Tanzania specifically in Makete District. Potassium helps to maintain fluid and electrolyte balance in the body cells, as well as normal nerve and heart function and blood pressure (FAO, 2007). The good food sources include; green leaf vegetables.

Zinc is a component of more than 200 mammalian metallo-enzymes. Some foods that contain high levels of zinc are; green leaf vegetables , mushroom, onions, nuts, wheat and maize germ, milk, eggs, liver, pumpkin seeds (Shils *et al*.,1994), chickpeas, peanut butter, peanuts, cheddar cheese as well as raisins and oranges (Christensen *et al*., 2006).

In humans, zinc is important for protein synthesis; as an antioxidant; wound healing; vital for development of the reproductive organs; prostate functions and male organ activity; it governs the contractility of muscles; important for blood stability; maintains the alkaline-base balance of the body; helps in digestion and metabolism of phosphorous and helps in normal tissue function (Bowman and Russell, 2001).

Zinc deficiency can manifest as T-cell lymphopenia, decreased lymphocyte response to mitogens, depressed thymic hormone activity, a specific CD4+ T-cell population depression, decreased natural killer cell activity and depressed serum concentrations of albumin, prealbumin, and transferring (Bowman and Russell, 2001; Christensen *et al*., 2006). Zinc has a modulating role in blood sugar regulation, thyroid and gonadal function, adrenal hormone and prolactin production, and calcium/phosphorus metabolism, all of which are disturbed in a state of zinc deficiency (Bowman and Russell, 2001; Msuya and Mamiro, 2009). Other deficient symptoms include; delayed sexual maturity, prolong healing of wounds, white sports on finger nails, retarded growth in children, decreased alertness, fatigue, susceptibility to infection, enlarged prostate gland, skin ulceration, alopecia hair loss on the forehead, infertility/sterility (Bowman and Russell, 2001; Msuya and Mamiro, 2009).

Magnesium helps in the production of energy, nervous system and muscles as well as heart and the formation of bones and teeth. Magnesium is indispensable as a supplement in metabolism of calcium and vitamin C as well as Phosphorus, sodium and potassium. It is essential for proper nerve and muscle function, effectively helping against stress and depression (Bowman and Russell, 2001). Magnesium is vital in the metabolic process to convert blood sugar into energy, and helps for heart attacks, and also necessary in digestive process and functioning of the nervous system. It also helps to eliminate fatigue, improve memory and reduce memory irritability in people (Bowman and Russell, 2001). The good food sources include; green leafy vegetables, cereals (whole grains). Copper is necessary to convert iron into hemoglobin. It also helps to prevent anemia and to promote mental and emotional stability (Shils *et al.*, 1994; Wardlaw and Smith, 2008). The good food sources include; green leafy vegetables.

2.6 Effect of Processing on Nutritional Qualities

Many foods are rarely eaten raw. They normally undergo some form of processing and cooking before consumption, to improve the diet by making healthier eating easier (Hotz and Gibson, 2007; Levy, 2009). Processing results into a number of reactions including changes in lipids, carbohydrate and protein, with heat breakdown of peptides and amino acids and reactions between proteins and carbohydrates. On top of that it has been reported (Mosha *et al*., 1995; Hotz and Gibson, 2007; Nithya *et al.,* 2007) that different processing treatments would reduce the amount of anti-nutritional factors in the food grains. The methods of processing and cooking vary from simple boiling to elaborate fermentation, drying, slicing and field sun drying of some foods as practiced in some developed countries on a large scale, multi-stage production of frozen, canned or flaked products (FAO, 2007; Hotz and Gibson, 2007; Henry and Chapman, 2008).

Processing is a prerequisite for consumption of food which must first be turned into a suitable form and give it good sensory properties (Gibson *et al*, 2006; Hotz and Gibson, 2007). Processing is also important in terms of both the content and bioavailability of nutrients and non-nutrients. Whereas processing may increase the bioavailability of bioactive compounds in foods, a reduction in processing increases their levels, (Hotz and Gibson, 2007; Bethke and Jansky, 2009). Processing may also be used to modify the bioavailability of carbohydrates, such as delaying the glycaemic responses or enhancing the solubility and fermentability of dietary fibre components (Hotz and Gibson, 2007).

Thermal processing has a huge impact on the textural attributes of the final food product, and texture is a major factor contributing to the overall quality of fruits and vegetables (Bethke and Jansky, 2009). Hotz and Gibson (2007) found that there was a significant decrease in thermodynamic energy content in fruits and vegetables upon processing that is independent of water content. The vitamin content of most foods is dramatically decreased by canning while smaller effects are observed upon blanching and freezing. Some forms of processing or over-processing may also adversely affect the nutritional qualities of the food (Gibson *et al*., 2006; FAO, 2007).

Some food processing techniques destroy enzymes and proteins that are present in all raw foods, which are responsible for the chemical and physical changes that naturally occur after harvesting. Food processing techniques also help eliminate the moisture or temperature conditions that are favorable for the growth of microorganisms (Gibson *et al*., 2006; Hotz and Gibson, 2007; Bethke and Jansky, 2009).

Micronutrients, especially vitamins, may be sensitive to any food processing method, including irradiation (e.g. vitamin E levels can be reduced by 25 percent after irradiation and vitamin C by 5-10%). Processing and cooking conditions cause variable losses of vitamins. Losses vary widely according to cooking method and type of food. Degradation of vitamins depends on specific conditions during the culinary process, e.g., temperature, presence of oxygen, light, moisture, pH, and, of course, duration of heat treatment. The most labile vitamins during culinary processes are retinol (vegetable boiling, 33% retention) (Lešková *et al*., 2006).

2.6.1 Effects of heat application plus water on nutritional qualities

2.6.1.1 Carbohydrates

The nutritional quality of the carbohydrates and the effects of processing on that quality is a concern because both the content and the nutritional quality of food carbohydrates can be altered by processing in a number of ways. During wet heat treatment, as in blanching, boiling and canning of vegetables and fruits, there is a considerable loss of low molecular weight carbohydrates (i.e. mono- and disaccharides) as well as micronutrients, into the processing water (Gibson *et al*., 2006; Hotz and Gibson, 2007). In Tanzania potato and cassava crisps are prepared in different regions at different seasons according to availability of harvests but losses obtained during these food processing is unknown, therefore a study is needed to establish the nutritional value of different crisps prepared in the country.

2.6.1.2 Proteins

Proteins are denatured by heat. In this form they are more easily digested by proteolytict enzymes. The major change in amino-acids that occurs on cooking is the maillard reaction that makes lysine unavailable; thereby reducing the nutritive value of the food; loss of free amino-acids also takes place through leaching (Mosha *et al.*, 1995; Gibson *et al.*, 2006; Nithya *et al.*, 2007). The completion of the cooking process is generally indicated by a change of color (Mosha *et al.*, 1995; Mosha *et al*., 1997). For example in meat from red to brown (red to pink in cured products) and flavors are developed (USDA, 2009).

Furthermore, the excessive cooking that is often applied to soften the grain decreases protein quality. The loss in protein energy ratio (PER) and weight is the result of lower protein availability as well as a loss of lysine, which becomes inactivated through the well-known Maillard reaction (Gibson *et al*., 2006). A Maillard reaction is a non enzymatic browning reaction that occurs between reducing sugars and amino groups in foods at processing and in storage. These reactions are temperature dependent and most extensive at intermediate water activities. They are important nutritionally as they may diminish the bioavailability of amino acids, especially lysine, thus diminishing the protein nutritional value (Gibson *et al.*, 2006; Nithya ***et al.*, 2007**).

Roasting is an interesting processing technique because it has the capacity to develop attractive flavors in foods so treated. It also induces important functional properties, attributes that should be compatible with nutritional value. Chemical analysis for available lysine showed the expected decrease in this amino acid, which explains the lower protein quality as roasting time increased (Gibson *et al.*, 2006). In some traditional processing an appreciable amount of protein could be lost. For example in the preparation of crisp (a process of dip frying and dehydrating potato and cassava) the protein content of the potato may be lost (FAO, 2007). Therefore there is a need of a study to establish actual loss which may occur. Some of the loss is due to removal in the exudates, but most losses take place during the soaking in water, (about 50 percent).

2.6.1.3 Vitamins

Vitamin A and C are of public health importance in Tanzania. Vitamins can be lost during cooking in two ways. First, by degradation, this can occur by destruction or by other chemical changes such as oxidation, and secondly by leaching into cooking medium (Mosha *et al*., 1995; Mosha et al., 1997; Gibson et al, 2006). The percentage losses partly depend on the cooking temperature and method of cooking. Vitamin C is the most thermal labile vitamin and is also easily leached into cooking water (Eduardo *et al.*, 2005). Air drying of thin slices of sweet potato leads to only slight losses of vitamin C (Gibson *et al.*, 2006). Boiling may result in a 20 to 30 percent loss of vitamin C from unpeeled roots and tubers. If peeled before boiling the loss may be much higher, up to 40 percent (FAO, 2007). Study on nutrient content of slices of sweet potato, cassava and round potatoes which are practiced in most places of Tanzania is needed to establish losses obtained during food preparation, for the benefit of the users/consumers.

Carotenoids are naturally protected in plant tissues, cutting, shredding, chipping and pulping of fruits and vegetables increase exposure to oxygen and bring together carotenoids and enzymes that catalyze oxidation. Alteration or loss of carotenoids during processing and storage of foods occurs through physical removal (e.g. peeling), geometric isomerization, and enzymatic or non-enzymatic oxidation (Nithya ***et al.*, 2007**). The major cause of carotenoids destruction during food processing and storage is enzymatic and non-enzymatic oxidation. Isomerization of *trans*-carotenoids to *cis*-isomers, particularly during heat treatment, alters their biological activity and discolors the food, but not to the same extent as oxidation (Mosha *et al*., 1997). In many foods, enzymatic degradation of carotenoids may be a more serious problem than thermal decomposition. In home preparation, losses of carotenoids generally increase in the following order: microwaving, steaming, boiling and sautéing. Deep-frying, prolonged cooking, combination of several preparation and cooking methods, baking and pickling all result in substantial losses of carotenoids (Mosha *et al*., 1997; Gibson *et al.*, 2006).

Whatever the processing method, carotenoid retention decreases with longer processing time, higher processing temperature, and cutting or pureeing of the food. Blanching may provoke some losses of carotenoids, but the inactivation of oxidative enzymes that occurs in this type of heat treatment prevents further and greater losses during holding before thermal processing, slow processing and storage. Freezing (especially quick-freezing) and frozen storage generally preserve carotenoids, but slow thawing can be detrimental, particularly when the product has not been properly blanched. Peeling and juicing results in substantial losses of carotenoids often surpassing those of heat treatment. Traditional sun-drying, although the cheapest and most accessible means of food preservation in poor regions, causes considerable carotenoid destruction (Mosha *et al*., 1997). Drying in solar dryer can appreciably reduce losses which is even simple and inexpensive design. For this case, protecting the food from direct sunlight also has a positive effect (Gibson *et al*., 2006). The bases of excluding other vitamins in this discussion were the reasons of looking forward on public health importance in the country.

2.6.1.4 Minerals

Minerals are usually lost through leaching into syrup during canning, especially with potassium, calcium and magnesium (Gibson *et al*., 2006; Bethke and Jansky, 2009). Generally, when mineral is heated, they get less dense. Most minerals expand when heated, but still contain the same mass, so they would get less dense. Some will loose components (specifically the CO2) and take on a lower mass. All these depend on the properties of each individual mineral.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

The study was conducted in Morogoro Municipality, Morogoro District which is one of the six districts in Morogoro region Tanzania. Morogoro Municipal is about 195 kilometers to the west of Dar es Salaam and is situated on the lower slopes of Uluguru Mountains whose peak is about 487.68 meters above sea level (URT, 1997). It lies on longitudes 37 degrees East of the Greenwich Meridian and latitude 4.49 degrees South of equator. It is divided into 2 divisions: namely Morogoro urban and Kingolwira. These divisions are sub divided into 19 wards and only eight wards namely Bigwa, Mzinga, Kichangani, Kihonda, Kingolwira, Mazimbu, Mjimpya and Mafiga were included in the study. Furthermore wards are subdivided into 275 administrative streets (URT, 2005) in population census 2002.

3.1.1 Population

The current population of Morogoro Municipality stands at 228 863 people having the ratio of 114 839 women and 113 082 men. This Municipal has a population growth rate of 4.7% per annum and the average income per person per year is Tshs: 185 000/= (Population Census, 2002).

3.2 Study Design and Sample Selection

3.2.1 Study Design

A longitudinal study design was used to collect data in two seasons which was in July to September for dry season and January to March in wet season.

3.3 Inclusion and Exclusion Criteria

The inclusion criteria in this study were: an individual who owns farms, grow crops, representative levels of income status (high, medium and low), diversity of crops grown in the wards and population size of the households. Individuals who did not own farms, not growing crops nor representing levels of income status were excluded from the study.

3.4 Sampling Procedure and Sample Size

A total of 144 respondents were involved in this study from 8 wards. The sampling procedure was through simple random technique to obtain respondents from whom information related to food crops that were widely grown and consumed, food recipes and the employed cooking methods in Morogoro Municipality was gathered (Table 1). Sample size calculation was done as indicated below:-

The simple formula used:

$$N = \frac{Z^2 * p * q}{d^2}$$

Where n = sample size when population is greater than 10 000

Z = standard normal deviate, was set at 1.96 (in simple at 2.0) corresponding to 95% confidence level,

p = proportion in the target population estimate to have a particular characteristic; if not known use 50%. For this case p = 0.1

q =1.0 - 0.1= 0.9

d = degree of accuracy desired, set at .05 or .02.

Therefore sample size were

$$N = \frac{Z^2 * p * q}{d^2} = (2)^2 (0.10) \text{ x } (0.90)/ (0.05)^2 = 4\text{x}0.09 = 0.36$$

= 144 households were included in the study.

Table 1: Wards, Division and number of farmers included in the study

Ward selected description	Division	Number of Farmers
Bigwa	Kingolwira	18
Kichangani	Kingolwira	18
Kihonda	Kingolwira	18
Kingolwira	Kingolwira	18
Mafiga	Morogoro Urban	18
Mazimbu	Morogoro Urban	18
Mji Mpya	Morogoro Urban	18
Mzinga	Morogoro Urban	18
Total		**144**

3.5 Data collection

3.5.1 Primary data

Data were collected from the field and laboratory. Fieldwork involved a survey, which used structured questionnaires, containing both closed and open ended questions.

3.5.1.1 Field survey

A survey in eight wards was carried out by using a pre-tested questionnaire (Appendix 1) in interviewing potential farmers growing diversity of crops on different varieties. The questionnaire was pre-tested by interviewing progressive farmers and consumers as guided by agriculturalist, from Municipal head quarters. These officers helped to show the wards based on the areas where most potential farmers were found with diversity of crop production and of different varieties. Agricultural extension officers working in each ward participated during survey to collect valuable information for this study. The questionnaires were designed to capture the demographic characteristics, income (house holdings), types of foods commonly grown and consumed (raw and cooked), methods and recipes used in food preparation. The number of farmers interviewed is indicated in Table 1.

3.5.1.2 Laboratory work

Nutrient composition of the 10 fresh raw food samples and 10 cooked food sample varieties from farmers were determined. The proximate analysis (carbohydrate, moisture content, crude protein, crude fat and ash) was done according to the standard method of Association of Official Analytical Chemists (AOAC, 2000). The mineral content (calcium, copper, iron, manganese, zinc, magnesium and phosphorus) was determined using UNICAM atomic absorption spectrophotometer, and dietary fiber was analyzed using enzymic hydrolysis with alpha-amylase and amyloglucosidase.

3.5.2 Food sample collection

Ten samples of raw foods and 10 samples of cooked food for maize flour, rice, beans, green bananas, sweet potatoes, sweet potato leaves, cassava leaves, amaranthus, pumpkin leaves and cowpea leaves were collected from different households in Morogoro Municipality (Table 2). Samples of food were collected based on the information given by the progressive farmers selected by agriculturists in collaboration with the stakeholders at ward level.

3.5.2.1 Collection procedure

Foods were weighed using TANITA cooking scales (Model: 1150, Japan). The scale was placed on a hard background surface and was calibrated at the beginning and end of each reading before starting to weigh another food item. Kitchen bowl was placed on the center of the scale and calibrated to zero. Then the food item was put on the plate and weight was recorded to the nearest grammes. Volume of foods was measured using plastic measuring jars of different volumes, standard measuring cups and spoons of different sizes. Measuring jars and cups were placed on flat hard surfaces when measuring the food. Then a magnet liquid measure s/s, 3162210887001 was used to identify liquid measure equivalents used during the study.

3.5.2.2 Collection of raw foods

Clean and tight plastic containers were used to put samples of different foods collected in the household after measuring and recording the weights/volume of the food items in grammes/milimeters.

Table 2: Selected food samples in the study area

Food Sample (Common name) description (Type/variety on brackets)	scientific name	Local (Swahili) name	Ward of origin (farmer from)	State of samples description
Maize (staha)	*Zea may*s	mahindi	Bigwa	Raw and cooked samples
Rice (saro)	*Oryza sativa*	mchele	Mazimbu	Raw and cooked samples
Beans (red)	*Phaseolus spp*	maharage	Mzinga	Raw and cooked samples
Green bananas (mtwike)	*Musa spp*	ndizi	Bigwa	Raw and cooked samples
Sweet potatoes	*Ipomea batatas*	viazi vitamu	Mafiga	Raw and cooked samples
Sweet potato leaves (tembele bangi)	*Ipomea spp*	(tembele)	Mazimbu	Raw and cooked samples
Cassava leaves (mpira)	*Manihot spp*	kisamvu	Mji mpya	Raw and cooked samples
Local spinach	*Amaranthus spp*	mchicha	Kisangani	Raw and cooked samples
Pumpkin leaves (local)	*Cucurbita pepo*	majani ya maboga	Kingolwira	Raw and cooked samples
Cowpea leaves (local)	*Vigna unguiculata*	majani ya kunde	Kihonda	Raw and cooked samples

3.5.2.3 Collection of cooked foods

Before cooking, the food items were weighed and weights/volume was recorded. The food in question was cooked following individual procedure while observing and recording the procedures. After cooking food was left to cool before it was weighed and placed in clean tight plastic food containers and stored in a cool box with iced water tightened in transparent plastic bag at -5ºC for maximum time of two days before analysis. Analysis of nutrient content was undertaken at the laboratory of the department of animal science and production of the SUA. In the laboratory, fresh samples were kept at room temperature (28 ± 1˚C) for 2 hours before processing while cooked samples were stored in the freezer at –21 ± 0.5˚C.

3.5.3 Sample preparation

The treated samples were homogenized to avoid inter and intra unit variations for a better representative of laboratory sample from sample.

3.6 Nutrient Composition Analysis

Nutrient composition analysis was done in duplicate.

3.6.1 Determination of moisture content

Moisture and dry matter content were determined by drying approximately 100 g of the feed in a porcelain crucible at 105°C for four hours in a temperature controlled oven until there was no further loss in weight, and calculated as:

$$\text{Percent moisture} = \frac{(W_2 - W_1) - (W_3 - W_1)}{(W_2 - W_1)} \times 100$$

Where:

W_2 = Weight of sample and crucible before drying

W_1 = Weight of crucible

W_3 = Weight of sample and crucible after drying

3.6.2 Dry Matter (%)

Dry matter was calculated based on moisture content according to Egan *et al.* (1981), that is; Percent dry matter = 100 % - percent moisture

3.6.3 Crude protein determination

Crude protein of food samples was determined using the semi micro Kjeldahl method as described in the AOAC (2000) method No.920.152. About 0.5 g of each food samples were weighed in duplicate and digested.

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

$$\text{Percent N} = \frac{(14 \times 0.1) \times A}{W} \times 100$$

Where:

A = the titre of acid used in milliliters

W = original weight of the digested sample

N = Total Nitrogen

Percent crude protein = Percent N x Factor (6.25)

3.6.4 Crude fat determination (Ether Extract)

Crude fat content of food samples was determined by the soxhlet method as described in AOAC (2000) methods No. 960.39. Food samples were ground in a motor and pestle in order to increase the surface area for the extraction. About 5 g of the sample were subjected to the soxhlet continuous ether extract for 5 hours.

The percent crude fat (% Ether Extract, %EE) was calculated as follows:

$$\%EE = \frac{(W_3 - W_1)}{W_2} \times 100$$

Where:

%EE = Percent ether extract

W_1 = Weight of sample

W_2 = Weight of flask

W_3 = Weight of flask and sample

3.6.5 Ash content determination

Ash content of the tested samples was determined by AOAC official method No. 940.26 (AOAC, 2000). About 5 g of the test sample was weighed in pre-weighed crucibles. The samples were then ignited in carbolated muffle furnace (530 2RR, England) at 550° C for six hours.

The ash content was calculated as:

$$\%AC = \frac{(W_3 - W_1)}{W_2} \times 100$$

Where:

% AC = Percent ash

W_1 = Weight of crucible

W_2 = Weight of sample

W_3 = Weight of sample in a crucible

3.6.6 Carbohydrate

The total carbohydrate content was determined by difference, according to AOAC (2000) that is, 100% - other proximate chemical compositions, using the following formula; Total carbohydrate = 100 – (% CP + % EE + % CF + % Ash content + % MC)

Where:

CP = Crude protein

EE = Ether extract

CF = Crude Fibre

MC = Moisture content

AC = Ash content

3.6.7 Energy values

Energy value was calculated using the Atwater's convention factors that is, energy values for the collected samples was calculated by multiplying percentage fat, percentage protein, percentage carbohydrates by the Atwater factors of 9, 4, and 4 respectively (AOAC, 2000). Thus, Energy = the sum of [(Carbohydrate x 4) + (Fat x 9) + (protein x 4)].

3.6.8 Mineral analysis

The minerals content of fresh and processed/cooked samples were carried out by AOAC (2000) method No. 968.08. Mineral contents (Ca, Fe, P, Mg, Mn, Cu and Zn) for food samples were determined by using Atomic Absorption/Flame Emission

Spectrophotometer (AA S UNICAM 919). Absorbencies of various cations were read and the mineral contents (mg/100g) were calculated as follows:

$$\text{Mineral content mg/100g} = \frac{R \times 100 \text{ ml D.F}}{S \times 1000} \times 100$$

Where:

R = Reading in parts per million

100 = Volume of sample made (ml)

D.F = Dilution factor

1000 = Conversion factor to mg/100g

S = Sample weight

3.7 Secondary Data

Secondary data were obtained from existing information published from various institutions (Sokoine University of Agriculture, University of Manitoba), internet, international organizations (United States Department of Agriculture, East Africa Food composition table), agricultural officers, and from recognized companies (McGraw-Hill Companies) and non governmental organization (Tanzania Food Nutrition Centre) dealing with chemical composition of foods. There were important literature reviews in comparing study results.

3.8 Data Analysis

Collected data was coded, summarized, analyzed and evaluated using Statistical Package for Social science (SPSS version 11.5) software in order to make realistic inferences based on the study sample. Analysis based on descriptive statistics such as frequency, percentages and means was used to obtain the variability and central tendency of the variables. The format for determining nutrient content of some selected 10 food samples. Raw and cooked was designed (Appendix 2).

Experimental data was taken in duplicate with respect of each aspect. There after was added and its total was averaged and these averages was used to get the data value in calculating nutrients of food samples selected. Results were summarized in tables shown in Appendix 6 titled established data base for nutrient content of food selected found widely grown and consumed in the Municipality.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

This Chapter summarizes the findings of this study on foods widely grown and consumed in Morogoro Municipality. It covers available foods in the study area, recipes of dishes, the main cooking methods of foods and recipes of widely grown and consumed crops/foods in the study area. Results presented in this Chapter include nutrient content by category of some selected raw and cooked foods commonly consumed during wet and dry seasons in the study area. The noted differences of nutrient content between the two seasons include nutritional qualities and effect of processing on nutritional qualities. The study also established data base of food dishes grown in Morogoro Municipality.

4.2 Foods Widely Grown and Consumed in Morogoro Municipality

4.2.1 Food crops widely grown in the study area

The results of the food crops widely grown in Morogoro Municipality are presented in Table 3. Results from this study observed that the majority (93.06%) of the surveyed households grow maize, followed by pumpkin leaves (90.28%), Cowpea leaves (88.89%) and Sweet potato leaves (78.47%). The least food crop was yams (4.17%).

Morogoro municipality has climatic and soil conditions which allow production of many crops. Some of these crops are grown as cash crops and as food crops MALDO’s office (personal communication on 22 October, 2008). In terms of cereal crops, maize is the most widely grown crop in Morogoro Municipality while rice is the least grown. Sweet potato and bananas are the most grown roots, tubers and bananas group. Beans were found to be the only protein source widely grown in the category of legumes.

Table 3: Food crops widely grown in Morogoro municipality (N= 144)

Food description	n	Percent
Cereals		
Maize	134	93.06
Rice	49	34.03
Roots, tubers and banana crops		
Bananas	69	47.92
Cassava	49	34.03
Sweet potatoes	52	36.11
Yams	6	4.17
Legumes		
Beans	48	33.33
Cowpeas	31	21.52
Pigeon peas	25	17.36
Oil crops		
Coconuts	11	7.64
Sunflower	32	22.22
Vegetables		
Amaranthus	84	58.33
Pumpkin leaves	130	90.28
Cassava leaves	52	36.11
Cowpea leaves	128	88.89
Sweet potato leaves	113	78.47

Pumpkins were found to be the most grown vegetable compared to others. The vegetables that followed closely were cowpea, sweet potato and amaranthus. Other crops grown by some of the respondents include yams, pigeon peas, coconuts, and sunflower (Table 3).

4.2.2 Foods widely consumed in Morogoro municipality

Foods that are widely consumed in Morogoro municipality are presented in Appendix 3. Maize was found to be the most popular staple food as majority consumed it daily in the form of stiff porridge popularly known as *ugali* in Kiswahili language. *Ugali* is a staple dish that is widely consumed in many other parts of Tanzania (ESRF, 2006). It is commonly prepared using maize flour. In some parts of the country, *ugali* made from cassava, millet or sorghum flours are preferred to maize flour (ESRF, 2006).

In Morogoro, cassava flour is used only during severe shortage of cereals such as maize and rice. Maize of the variety *staha* is the most accepted and grown by farmers hence widely available in the market. The qualities of *staha* which made it prominent include its high yielding potential and resistant to adverse condition of weather compared to other variety like *katumani*, *kito* and local ones (ESRF, 2006) and MALDO's office (personal communication on 22 October, 2008).

The refined maize flour (flour from dehulled maize) is popular than whole maize flour. The habit of dehulling maize leads to loss of some important nutrients especially the B vitamins. Whole maize meal contain 0.30 mg vitamin B1, 0.08 mg vitamin B2 and 0.20 mg vitamin B6 per 100 g edible portion while dehulled maize meal (60 to 80% extraction) contained 0.14 mg vitamin B1, 0.05 mg vitamin B2 and 0.12 mg vitamin B6 per 100 g edible portion (West *et al*., 1988).

However, symptoms of vitamins B deficiency among children under five years of age in Morogoro Municipality was reported to be very low (4.28%) (MMOH, 2009)**.** This could be due to availability of vitamin B sources other than maize. In addition, whole maize flour is usually and often times recommended by nutritionist for preparation of babies' maize based porridge (FAO, 2004; FAO, 2006).

Sweet potatoes and green bananas (plantains) are in most cases consumed during breakfast and during the holy month of "Ramadhan". This is a fasting period for Moslems, according to their beliefs and it is done for a whole month. Beans are also among the foods that are consumed almost every day throughout the year. When the stored beans are depleted, farmers buy other types of beans from the markets. The consumption of milk is limited to livestock keepers and mainly given to younger children especially under two years of age. Sardines are consumed throughout the year, the frequency of consumption increases in the dry season because of limited availability of vegetables. Consumption of beef, chicken and eggs is very low similar to the consumption of fruits such as oranges, guava and pawpaw. Low consumption of animal protein may lead to deficient of amino acid which is nutritionally indispensable. These include; tryptophan, leucine, isoleucine, valine, phenylalamine, methionine, lysine, threonine and histidine because some of it especially lysine, threonine and histidine can not be transaminated and so must be supplied in the diet as such (Bowman and Russell, 2001.).

Low dietary intake of fruits may cause micronutrient malnutrition (FAO, 2004) because fruits are the major source of vitamin and minerals (Hanumantharaya, 2009). But residents in the study area were found consuming vegetables almost daily, therefore micronutrient malnutrition could not be a problem to them, as said by FAO (2004) vegetables are good sources of micronutrient. Source of fats and oils is mainly coconut which is used in the cooking of various dishes because of availability and its different consistence which gives satisfaction to food consumers.

Different types of vegetables are used throughout the year without additional side dishes as recommended for balanced meals in terms of nutrients. Consumption of fruits is very low compared to vegetables. Most families consume vegetables daily (95.14%) while only 27.08% consume fruits on daily basis. Eduardo *et al*. (2005); Kinabo *et al*. (2006) and Ann *et al.* (2008) state that fruits and vegetables are best sources of vitamins and some essential minerals. These foods may supplement micronutrient also to children less than 2 years and may reduce prevalence of nutrient deficiencies, which in turn reduces incidence of diseases and growth faltering. Hence poor consumption of these nutritious foods may lead to multiple sicknesses especially in children under five years of age (Kinabo *et al*. 2006, Dewey and Adu-Afarwuah, 2008). Report by Morogoro Municipal Health Office, 2009 shows that the rate of stunting, under weight and anemia in children under five years is 3.5%, 4.1% and 4.03% respectively. There might be many causes for these; poor consumption of fruits and vegetables is among them.

4.2.3 Available foods in the study area

Available foods in the study area are presented in Table 4. In most cases these foods are available throughout the year; the highest quantity is during the harvesting time, which is June, July and August for maize, sorghum and rice. Many fruits are abundantly available in the month of July to December, but bananas are available throughout the year. However during cold months the quality of banana fruits is somehow poor. Ripening of bananas depend on the hormone ethylene which works better under warm conditions (Perkins, 2005; FAO, 2007). Oranges, tangerines and lemon were abundant from May to August while mangoes and pineapples around November to February. Although pawpaw can be found throughout the year, they were abundant in the month of June to August and passion fruits were abundant from March to July. Lack of appropriate storage facilities and knowledge on food preservation; traditional festivals, drought conditions led to shortage of foods in six months of the year especially between October and March, as reported by Municipal Agriculture and Livestock Development Officer (MALDO, 2010 personal communication on 22 October, 2008). The semi dry/dry season comes right after harvest and therefore food is available and the number of meals per day increases from two to three (Table 5).

Table 4: Type of foods available in the study area by category

Food group (category)	Name of foods available in the study area
Cereals	maize, sorghum and rice
Tubers	cassava, sweet potatoes, taro (highland/wet areas), yams, onions and garlic
Legume	beans, cowpeas, groundnuts and pigeon peas
Vegetables	amaranthus, pumpkin leaves, cowpea leaves, sweet potato leaves, taro leaves *Lactuca carpensis*, local spinach, *Solanum nigram* and different kinds of wild mushrooms for example (*Termitomyce letestui*,Termitomyces microcarpus friting,and Termitomyces tyleranus); and cultivated example (*Pleurotus sajor-caju*,*Pleurotus ostreatus* and *Pleorotus citrinopilentus*), Chinese cabbage, swisschard and spinach.
Fruits	oranges, mangoes, pineapples, guavas, lemons, pawpaw, passion, bananas, tangerines, jack fruit, sour soap (A*nnonas muricata*), bread fruit, lime, Sweet soap (A*nnonas squamosa*), black pum, grape fruit and tomatoes
Animal food	chicken, fish from Mindu basin and Ruvu river, (sardines, nguruka, lung fish) beef, eggs, pork, goat meat and milk.
Oil crops	coconut, sunflower, simsim and groundnuts
Sugar sources	honey, sugarcane
Spices	turmeric, black pepper, cinnamon, cardamom, black pepper, ginger, garlic, cucumber seeds

Table 5: Number of meals per day in dry and wet seasons (N=144)

Season of the year	**Wet season**		**Dry season**	
Number of meals per day	**Frequency**	**Percent**	**Frequency**	**Percent**
Three times a day	24	17	128	89
Two times a day	120	83	16	11
Total	**144**	**100**	**144**	**100**

Source of food during the dry season for most households is from their own production and during the rainy season food is obtained from markets or shops except for vegetables, which are obtained from own farms. Crops like maize, rice, sweet potato, cassava and beans serve both as food as well as cash crops. The habit of selling food crops for other uses sometimes contribute to household's food insecurity hence contributing to increased incidences of malnutrition (MAFC, 2007). The situation is particularly critical during the wet season (Table 5) when calories are needed to do agricultural work and market prices are high due to shortage in supply especially in urban areas. Other factors contributing to seasonal food insecurity include, overselling due to competing needs for cash including healthy, education and clothing. In addition inadequate post harvest management knowledge contributes to food insecurity (MAFC, 2007).

4.3 Recipes of Dishes Widely Consumed in Morogoro Municipality

4.3.1 The main cooking methods of foods and recipes in widely grown and consumed in the study area

Boiling and stewing are the major cooking methods commonly used by respondents in the preparation of various dishes as shown in Table 6. Gibson *et al.*, (2006) and FAO, (2007) reported great loss of nutrients in vegetables prepared using the boiling and stewing methods for long time. Vitamins are susceptible to both processes; the percentage of loss will depend partly on the cooking temperature. Vitamin C is the most thermal labile vitamin and it also leaches easily into cooking water **(**Eduardo *et al*., 2005). Green vegetables may lose more than 50% of the vitamin in this way if they are boiled for prolonged periods (Eduardo *et al.*, 2005).

Other loss was between 23 to 67, 26 to 76 and 20 to 56 percent in carbohydrates of maize flour, rice and beans respectively. These findings were supported by Gibson *et al*. (2006), Hotz and Gibson (2007) who reported that carbohydrates can be altered by food processing methods where a considerable loss of low molecular weight carbohydrates (i.e. mono- and disaccharides) as well as micronutrients, into the processing water. Frying and roasting are rarely used; this could be due to the fact that the types of foods commonly consumed do not require frying and roasting during preparation, however they are used occasionally especially during the holidays. The common staple foods are maize stiff porridge (*ugali)*, rice, green banana, sweet potato. Vegetables widely consumed are pumpkin leaves, cowpea leaves, cassava leaves and sweet potato leaves (Table 6).

Unfortunately, people living in the study area majority are poor and lack knowledge on the utilization of available food sources to balance meals. For those who have the ability to get the balanced meals, of which income level was high to purchase food do not have enough knowledge on proper food preparation for maximum retention of nutrients as presented in Table 7.

Table 6: Main cooking methods of foods and recipes widely used in the Morogoro Municipality

Type of Dish common consumed	Ingredients	Method of cooking
Maize Stiff porridge: (dehulled maize flour)	1500 ml water; 750 g maize flour	Boiling
Stewed beans	250 g red beans; 59 ml cooking oil; 10 g salt	Boiling
Rice	500 g rice; 750 ml water; 118 ml cooking oil20 g salt	Boiling
Boiled bananas	500 g green bananas *(mtwike);* 125 ml water; 19 g onion; 200 g tomatoes; 125 ml boiling; 19 g onion; 200 g tomatoes; 200 g carrot; 250 g beef; 59 ml cooking oil; 10gm salt	Boiling and stewing
Sweet potatoes	500 g Sweet potatoes; water; 1gm salt	boiling
Pumpkin leaves	216 g Pumpkin leaves; 119 ml water; 5 g salt; 20 g onion; 59ml cooking oil	boiling and stewing
Cowpea leaves	500 g cowpea leaves; 119 ml water; 5g salt; 20 g onion; 59 ml cooking oil	boiling and stewing
Amaranthus	1500 g amaranthus; 7.5 salt g; 59 ml cooking oil; 50 g onion; 59 ml cooking oil	boiling and stewing
Cassava leaves	500 g Cassava leaves; 750 ml water; 20 g onion; 59 ml cooking oil; 1 medium size coconut; 10 g salt	boiling and stewing
Sweet potato leaves	500 g Sweet potato leaves; 40 g onion; 50 g tomatoes; 59 ml cooking oil; 10 g salt	boiling and stewing

Table 7: Income level and utilization of food sources in the study area

Average income per month	Frequency (n)	Percentage (%)	Main food sources per meal	Main cooking methods
More than 100,000 shillings and above	25	17.36	maize flour in form of stiff porridge, rice, bananas, sweet potatoes, legumes, meat, milk, eggs, fish/sardines, vegetables, fruits	Boiling, stewing, roasting, frying
40,000 to 100,000	96	66.67	maize flour in form of stiff porridge, rice, bananas, sweet potatoes, legumes, meat, fish/sardines or vegetables	Boiling, stewing,
Below 35,000 shillings	23	15.97	maize flour in form of stiff porridge, bananas, sweet potatoes, legumes, fish/sardines, vegetables	Boiling, stewing,

Table 8: Income level and utilization of food sources in the study area

Average income per month	**Frequency (n)**	**Percentage (%)**	**Main food sources per meal**	**Main cooking methods**
More than 100,000 shillings and above	25	17.36	maize flour in form of stiff porridge, rice, bananas, sweet potatoes, legumes, meat, milk, eggs, fish/sardines, vegetables, fruits	Boiling, stewing, roasting, frying
40,000 to 100,000	96	66.67	maize flour in form of stiff porridge, rice, bananas, sweet potatoes, legumes, meat, fish/sardines or vegetables	Boiling, stewing,
Below 35,000 shillings	23	15.97	maize flour in form of stiff porridge, bananas, sweet potatoes, legumes, fish/sardines, vegetables	Boiling, stewing,

4.3.2 Recipes for the dishes widely consumed in the study area

Recipes for widely consumed foods are shown in Appendix 4. The ingredients are averages found used by the majority. Majority used the aluminium saucepans, wooden spoons as the major cooking utensils. Sources of fuel for cooking are charcoal and firewood. It is very difficult to control cooking temperature and time when using such sources of fuel hence incidences of overcooking. Overcooking of the food especially in vegetables results in substantial losses of some vitamins like vitamin C and carotenoids (Mosha *et al*., 1995; Mosha *et al*., 1997; Gibson *et al.*, 2006).

4.3.3 Vegetable cooking procedures

Table 8 presents results on general practices of preparing commonly consumed vegetables. The common practice found in preparation of pumpkin and cowpea leaves is throwing away of cooking water after boiling. This practice has been reported to significantly reduce the amount of nutrients especially the water soluble nutrients like vitamins B group and C (FAO, 2007).

Furthermore the study found out that in some households, fresh vegetables especially amaranthus and sweet potato leaves are put under the sun to wilt before cooking. This is done to improve the taste of fresh amaranthus and sweet potato leaves. This practice leads to considerable vitamin C destruction (FAO, 2004; FAO, 2007).

According to Mosha *et al*, (1995 and 1997) blanching (partial cooking before actual cooking) and/or cooking are/is important for developing the desirable flavour and texture and fixing the more appearing deep green color. Losses of various nutrients have been reported in traditional processing by various researchers example Lyimo *et al* (1991), cited by Mosha *et al* (1995). In this study some respondents (66.67%) threw away water used in boiling vegetables. This was found in the preparation of pumpkin, cassava and cowpea leaves. This affects loss of thermal labile vitamins such as Ascorbic acid, thiamine and carotenoids. The loss of ascorbic acid during blanching and cooking was attributed to leaching and oxidation to diketogulonic acid; the reaction enhanced by light, oxygen, metal iron, moisture and neutral or alkaline conditions levels (Mosha *et al.,* 1995). The degradation of thiamine during thermal processing was associated with heat effect which causes thiamine cleavage to its pyrimidine and thiazole moieties (Mosha *et al.,* 1995). Thiamine degradation is enhanced by oxygen, metal iron and neutral or alkaline conditions (Mosha *et al.,* 1995). Riboflavin losses occur during blanching associated with leaching associated with leaching (Eduardo *et al.,* 2005; Mosha *et al.,* 1995). Photo degradation occurs especially when vegetables were cooked in uncovered containers (Mosha *et al.*, 1995).

The study also found that some respondents (33.33%) put under the sun amaranthus and sweet potato leaves to wilt before cooking. This was also reported by other researchers for example Lyimo *et al.* (1991). This sun-drying and shade drying have significant losses of vitamin particularly photo labile vitamin such as Ascorbic acid riboflavin and thiamine (Mosha *et al.*, 1995; Donati, 2006). The loss of Ascorbic acid during drying was attributed to oxidation (Mosha *et al.*, 1995; Eduardo *et al.*, 2005). Ascorbic acid is oxidized to a nutritionally inactive diketogulonic acid when vegetables are dried in open light-air system (Mosha *et al.*, 1995).

Loss of thiamine during drying usually becomes attributed to heat degradation and oxidation on exposure to air. Thiamine is stable in light; however extended exposure to U.V and gamma radiations leads to degradation. Also, the action of thiamine enzyme on thiamine, particularly in unbalanced vegetables results in the formation of β-hydroxyethyl thiazole, and 2-methyl-4amino-5-hydroxymethyl purimidine which are nutritionally inactive (Mosha *et al.*, 1995). Losses of Riboflavin during drying and storage are mainly associated with photo sensitive in which Riboflavin cleaves to nutritionally inactive lumiflavin (Mosha *et al.*, 1995). Riboflavin is heat stable particularly in low moisture and acidic conditions. Various studies have shown considerable loss of carotonoids during conventional blanching (Mosha *et al.*, 1997). Carotenoids losses are attributed to wilting, damage of the leaf tissue and isomerization which occur during heat processing (Mosha *et al.*, 1997).

Since vegetables are rich sources of micronutrients they are therefore have a potential for reducing micronutrient hunger if proper cooking practices are used during food preparations in the Morogoro Municipality. Protecting green vegetables from light and excessive heat by drying them under shade, blanch in steam for at least five minutes prior to drying, cook them in small amounts of water with the least amount of heat for the shortest amount of time possible to avoid over cooking is needed.

Table 9: Common practice of vegetable preparation in the study area (N=144)

Vegetable description	Common practice found in food preparation	Frequency (n)	Percentage (%)
Amaranthus	put under the sun to wilt before cooking	17	11.8
Pumpkin leaves	throwing away of cooking water after boiling	41	28.47
Sweet potato leaves	put under the sun to wilt before cooking	31	21.53
Cassava leaves	throwing away of cooking water after boiling	16	11.1
Cowpea leaves	throwing away of cooking water after boiling	39	27.1

4.4 Nutrient Content of Some Selected Raw and Cooked Foods, Widely Used in Morogoro Municipality

The nutrient content of each food is reported per 100 g edible portion. The data are reported as means (averages) and the range of dry and wet seasons are indicated in brackets (Appendix 5).

a) Protein food group

The food sources rich in protein commonly grown and consumed are beans (red colored type). The residents of Morogoro Municipality use this crop as their main source of plant protein. This type of protein does not contain lysine and methionine as essential amino acids therefore regarded as partially complete proteins. It is also known to have lower biological value (Seiquer, 2006) unless it is mixed with other sources of protein. Adults under no physiological stress can maintain satisfactory nutrition for indefinite periods when consuming sufficient amounts of protein obtained from mixture of plant derived from proteins alone (Wardlaw, 2008). This is possible because different sources normally have essential amino acids patterns that compensate for each others deficiencies (FAO, 2004). Symptoms of proteins deficiency result in poor growth and development in children, kwashiorkor, tissue degeneration, and poor coordination of metabolic activities in the body (FAO, 2007).

The major sources of protein in the country are beans (all types), peas (all types), meat (all types), eggs, milk, nuts (all types) and fish (all types) (Shils *et al.*, 1994). However, majority of people afford the plant source of protein as animal sources of protein are very expensive and not widely available (FAO, 2004; Mohammed and Spyrou, 2009). Fish especially sardines are consumed throughout of the year but especially so in the dry season. Consumption of meat is occasional for the majority of the Municipal residents. Milk is mainly given to young children. In non pastoralist communities, milk is mostly given to young children (8 years and below). Other sources of plant proteins that may be of importance in Morogoro are soya beans, pigeon peas, groundnut, bambaranuts and cow peas. Keeping of small animals is not common, if promoted could supplement the red beans protein.

b) Carbohydrates food group

The food rich sources of carbohydrates grown and consumed in the study area are: cereals (maize, rice), roots, tubers and bananas (sweet potatoes, cassava and bananas) other sources include legumes (beans, cow peas and pigeon peas), sugar sources are sugarcane, sugar and some fruits (oranges, ripe bananas and pawpaw) (Appendix 4).

White maize is the major food staple found widely grown and consumed in both urban and peri urban areas of the municipality. About 93.06 percent of the respondents produce maize, followed by banana (47.18%), sweet potatoes (36.11%) and rice 34.03%). Maize production in Tanzania has increased from about 630 000 tons in 1964/65 to over 3 300 000 tons in 2004/05 (ESRF, 2006). Rice ranked number two in the group of staples. These results compare well with those reported by ESRF, (2006) and MAFC (2007). The prevailing climatic changes cause the drop of the harvest due to drought condition which contributes to poor harvest of commonly grown crops.

c) Fats food group

Food crops rich in oils grown and consumed in the study area were found to be coconuts and sunflower. These crops are grown at minimal rates compared to the consumption of cooking oil the resident use during food preparations. Vegetable oil such as sunflower oil, sesame oil, and cotton seed oil, cereal oil, pumpkin seed oil, palm oil, coconut cream and groundnuts are used during different food preparation procedures (Table 9). However, majority (77.78 %) of the respondents used cooking oil from unknown sources (cooking oils from the shop(s)/ retails depend on availability and the capacity of respondents to buy, they never ask for particular brand.

Table 10: Consumption of cooking oil in the study area

Type of cooking oil commonly used	Frequency	Percentage
coconut milk	5	3.5
sunflower oil	10	6.9
sesame oil	3	2.1
cotton seed oil	2	1.4
cereal oil	2	1.4
pumpkin seed oil	4	2.8
palm oil	2	1.4
groundnuts	4	2.8
Unknown type (according to availability)	112	77.7
Total	**144**	**100**

d) Minerals content of foods commonly consumed

Mineral content of foods commonly consumed are presented in Appendix 6.The foods grown and widely consumed in the study area were found to be rich in minerals; calcium 0.74% (raw amaranthus), iron 0.012 % (raw cassava leaves), zinc 0.0025% (raw cowpea leaves), magnesium 0.92 % (raw green banana), phosphorus 0.143 % (raw beans), manganese 0.01 % (raw sweet potato leaves) and copper 0.0011% (raw cowpea leaves). The lower value were found in minerals; calcium 0.0071% (raw pumpkin leaves), iron 0.0001% (cooked rice), zinc 0.0002% (raw sweet potato), magnesium 0.0018% (raw pumpkin leaves), phosphorus 0.0042 % (raw sweet potato leaves) and copper 0.00001% (raw sweet potato and cooked rice).

e) Major differences between nutrients contents obtained and the reported values

- Proteins

The only protein rich food analyzed in this study was raw red beans. The protein content was 18%. This value is slightly higher to (Mateljan, 2010) who had the value of 15.35% and slower to (Enujiugha and Akanbi, 2005) who reported the value of 22%. The differences could be due to variety in question, climatic condition, and soil type where the crop was been grown before nutrient content of the foods determination.

- Carbohydrates

The staples analyzed in this study were raw maize flour and stiff porridge from maize flour (*ugali)*, raw and cooked rice. Total carbohydrate content was 67% (raw maize flour) the value was lower than that reported by Lukmanji *et al.* (2008) who reported the value of 76.9%. The differences could be due to variety in question, climatic condition and soil type where the crop was been grown before nutrient content of the foods determination. Cooked green banana contained total carbohydrates of 18% lower than Lukmanji *et al.* (2008) who reported a value of 31.2%. These differences could be due to banana type, variety, cooking water used, maturity condition of the crop before proximate analysis, soil type and climatic condition of the area where the crop was grown before analysis.

- Fats

The fat richest food found was cooked sweet potato leaves (19%), different to Lukmanji *et al., 2008* who reported the value of 8.1%. The lowest fat content was found in pumpkin leaves raw 0.1% lower than that reported by West *et al.* (1988)

(0.2%). The difference could be due to the different amount of cooking oil used in the preparation of food in individual research undertaken.

- Minerals

i) Calcium

The foods grown and widely consumed in the study area were found to be rich in minerals; calcium 0.74% (amaranthus raw) different to Ciência (2010) who reported the value of 0.011%. The difference of Calcium and iron contents varies among cultivars of this crop from 1300 to 2136 ppm in dry basis (Singh *et al.*, 2009 and Ciência, 2010).

ii) Iron

Among foods grown and widely consumed in the study area determined, iron was found higher in raw cassava leaves (0.012%, the value was higher than that reported by Msuya and Mamiro (2009) 0.0037%. The difference could be due to composition of the soil and variety of the crop analyzed in question (Zeblena *et al*., 2010).

iii) Zinc

Zinc was found high in raw cowpea leaves (0.0025%) higher than the reported value by Msuya and Mamiro (2009) (0.0004%). The difference could be due to of the soil type and variety of the crop analyzed in question (Zeblena *et al*., 2010).

iv) Copper

The foods grown and widely consumed in the study area determined, raw cowpea leaves was found high in copper (0.0011%). Unfortunately the study failed to get the copper element in nutrient content of raw cowpea leaves from other sources to compare with.

v) Magnesium

In proximate analysis done to foods grown and widely consumed in the study area, magnesium was found highly in raw green banana variety *mtwike* (0.919%). This was different to that reported by FAO (2007) (34.22%), in the borrowed data base of USDA (1998). The differences could be due to variety in question, climatic condition and soil type (Zeblena *et al.*, 2010) where the crop was been grown before nutrient content of the foods determination.

vi) Manganese

The rich source of manganese was raw sweet potato leaves (0.01%). Unfortunately the study failed to get the manganese element in nutrient content of raw sweet potato leaves from other sources to compare with.

vii) Phosphorus

During this study, phosphorus nutrient was found high in raw beans (0.398%, higher than Enujiugha and Akanbi (2005) who reported the value of (0.0352%) and different to Mateljan (2010) who had the value of (0.0251%). These differences could be due to beans type, variety, maturity condition of the crop, soil type and climatic condition of the area where the crop was grown before analysis.

4.5 Established data base of selected widely grown and consumed food in Morogoro Municipality during study

Nutrient content of selected foods that are widely grown and consumed are presented in Appendix 6. This established data base may be useful in prescribing diets for different individual's needs and for developing nutritional guidelines. Most values for different nutrient content compare well, or within range of the one established by the TFNC and HAVARD (Lukmanji *et al.,* 2008).

Lukmanji *et al.* (2008) food data base was established using various methods: proximate analysis and borrowed information from other publications. The food sources were mainly from Dar-es salaam and Kisarawe. In this study the source of foods was only the crops grown in Morogoro Municipality. The differences could be due to climatic condition, soil type, maturity of the crop in question, variety, soil fertility (good agriculture practices imposed on improvement of the soil) where the food samples were harvested (FAO, 2004). Furthermore, for the cooking samples obtained the difference in nutrient content could be due to destruction or by other chemical changes such as oxidation, and secondly by leaching into cooking medium (Mosha *et al*., 1995; Mosha *et al*., 1997; Gibson *et al*., 2006), amount of water used in cooking, when cooking water is thrown away before final steps of cooking could cause loss of some minerals (FAO, 2004).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

The study found that food crops widely grown and consumed in Morogoro municipality were maize and rice on the side of cereal crops; sweet potatoes and bananas in roots, tubers and banana group. Pumpkin leaves ranked highly in the category of widely grown green leafy vegetables followed by cowpea leaves, sweet potato leaves, amaranthus and cassava leaves. The study revealed that the major staple that was consumed daily was stiff porridge (*Ugali*) made from refined maize flour. Majority consumed green leafy vegetables almost every day and beans was the major source of protein in the area. Consumption of fruits was very low as less than third managed to consume fruits on daily basis. Selected nutrient contents in analyzed foods compare well with those reported elsewhere, however, major differences were found in carbohydrate contents in raw maize flour (67%), and cooked green banana variety *mtwike* (18%), these values were lower than reported values. Calcium and iron contents were higher in raw amaranthus (0.74%) and raw cassava leaves (0.012%) than recently reported values of 0.011% and 0.003%, respectively. The disparity could be due to differences in crop varieties and cultivars, type of soil and climate condition. In some cases content of nutrients differed between raw and cooked food. This was so apparent in leafy green vegetables, whereby difference was found between raw amaranthus (739 mg/100g calcium) and cooked amaranthus (292 mg/100 g calcium). The loss could be due to the practice of throwing away cooking water before the final steps of cooking.

Based on these findings, it is therefore recommended that

- Further studies on determination of nutrient content of foods produced in different zones of the country need to be conducted to enable people to choose foods appropriately based on their nutrients and energy needs.
- Nutritionists and health workers in every setting should educate the community on the importance of different nutrients found in variety of foods for optimal health. Also need to advice people on the appropriate methods of food preparation for maximum retention of nutrients.
- Sensitization to increase production and consumption of other crops found in the area such as pigeon peas, soy beans and bambara nuts is recommended to increase variations of foods consumption hence provision of variety of nutrients at different qualities and quantity.
- Establishment of nutrient data documentation so that people in their locality can opt to choose healthy foods as per regional food composition tables and their economic abilities (income).

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APPENDICES

Appendix 1: Questionnaire

i). Sokoine University of Agriculture
Faculty of Agriculture
Department of Food Science and Technology
Title: To Assess the Nutrient Content of Foods Widely grown and consumed In Morogoro municipality.

A QUESTIONNAIRE AT HOUSEHOLD LEVEL

Dear Respondents

Good morning/afternoon. I am a student from Sokoine University of Agriculture.

I would like to thank you for agreeing to meet with me today.

All the questions I shall be asking relate to my research MSc. Human Nutrition degree course and any answer or replies made will be kept confidential. No names will be revealed and on the interview form itself, a number known only to me will identify you. My research attempts to;

i.) Identify food widely used in Morogoro Municipality

ii).Establish data base of food dishes within Morogoro Municipality.

iii).Determine the main cooking methods foods widely used in Morogoro Municipality.

iv) Determine nutrient content of some selected raw and cooked food widely used in Morogoro Municipality.

Appendix 1. A : Questionnaire continue

Full name of family member	**Relation with head of household**	**sex**	**Age(years)education level**	**Marital status**	**occupation**
	1= head of house 2=wife/husband 3=girl/boy 4=mother/father 5=grand father/mother 6=grand child 7=cousin 8=mother/father in law 9=aunt/uncle 10=brother/sister in law 11=house boy/girl 12=other	1=male 2=female	1=not gone to school 2=adult education 3=std.1-4 4=std.5-8 5=s/school 6=form iv 7=form iv + training 8=form vi 9=form vi + training 10=university 11=in school/preschool 12=retired officer	1=adult single 2=monogamy 3=polygamy 4=divorced 5=separation 6=widowed 7=student (unmarried)	1=civil servant employed 2=self employed 3=nongovernmental employed 4=business man 5=farmer/live stock keeper

ii). Respondent number…………Division--------------Ward………….Date……………….

1 A: Household characteristics**;**

(Tick appropriate)

1. B: Household social economic status

asset	**When bought**	**Who bought**	**cost**
House of brick and thatched with corrugated sheet			
House of posts and thatched with corrugated sheet			
Poor house			
Radio (mkulima)			
Radio (other type)			
A shamba (don't have)			
A shamba(50-150) m^2			
A shamba(200-300) $m^2$and more			
meals			
Times of meals per day	Tick as required 1,2,3,not sure		
Children school uniform			

1. C: Farm and crop management

crop	var	Production system: 1=rain fed 2=dry season(irrigation) 3=wet season(irrigation)	If irrigation type: 1=bucket/can 2=sprinkler 3=surface 4=drip 5=others	Management level: 1=traditional/smallholder 2=large scale private 3=large scale government	Cropping system 1=mono crop 2=mixed 3=intercrop/relay	Conservation methods 1=rotation 2=mulching 3=terraces 4=fertilizers/manure 5=other
Food crops						
1) maize						
2) Paddy rice						
3) sorghum						
4) cassava						
5) Sweet potatoes						
6) plantains						
7) beans						
8) cowpeas						
9) pigeon peas						
10) lima beans						
11) Coconut.						
12) others						
Cash crops						
1) simsim						
2) sunflower						
3) onion						
4) sugarcane						
5) coconut						
6) others						

Use a separate sheet to describe the cropping calendar and sequence for each crop grown Additional notes on farm and crop management, cropping calendar and sequence:

1. D_1: Type of food commonly used (nutrition)

Please let me know the type of commonly consumed foods at household level. The listed foods are as follows:-

List of foods consumed	**Frequency of consumption**				
	Daily	**Five times a week**	**Three times a week**	**Once a month**	**Occasionally**
Ugali					
Rice					
Cassava					
Sweet Potatoes					
Plantain Banana					
Beef					
Chicken					
Eggs					
Milk					
Beans					
Sardines/Fish					
Amaranthus					
Pumpkins leaves					
S/potato leaves					
Garden egg					
Oranges					
Guava					
Ripe banana					
Pawpaw					
Animal fats					
Honey					
Sugarcane					
Sugar					
Coconut					

Use a separate sheet to describe the commonly food consumed at household

Additional notes on commonly food consumed at household

1. D2: Please let me know how you prepare the type of commonly used foods which are commonly used as per 1: D1 above.

Use separate sheet to describe the methods of cooking/prepare foods. Additional notes on methods of cooking/prepare foods (mention recipes and quantity if possible)

List of foods consumed	**method of cooking/prepare food**				
	boiling	**stewing**	**roasting**	**Steam cooking**	**Other explain; mention recipes and quantity if possible**
Ugali(maize, dehulled, soaked, milled) flour=1					
Ugali (maize, dehulled, milled) flour=2					
Ugali(sorghum, dehulled, soaked, milled)flour=3					
Ugali (sorghum, dehulled, milled) flour=4					
Ugali (cassava, soaked, milled) flour=5					
Ugali (cassava, chipped, dried, milled)flour=6					
Rice=7					
Cassava					
Sweet Potatoes					
Plantain Banana					
Beef					
Chicken					
Eggs					
Milk					
Beans					
Sardines/Fish					
Amaranthus					
Pumpkins leaves					
S/potato leaves					
Animal fats					
Coconut					
(Other)					

Use a separate sheet to describe the methods of cooking/prepare foods
Additional notes on methods of cooking/prepare foods (mention recipes and quantity if possible)

1. :E Let me know your eating pattern

no	Time of the day	Commonly food consumed for household	comments
1	Break fast		
2	Snacks before lunch		
3	Lunch		
4	Snacks (mid afternoon)		
5	Dinner		

THANKS

Appendix 2: Format when determining nutrient content of some selected 10 food samples. Raw and cooked (for establishing data base) foods, of widely grown in Morogoro municipality amount in g /100grammes edible portion of food.

i) macronutrient plus water, dietary fiber ,ash and energy value of food

Raw and cooked food	% EP	**Water (g)**	**Energy (kcal)**	**Protein (g)**	**Fat (g)**	**Starch (g)**	**Dietary Fiber (g)**	**Ash (g)**

ii) micronutrient: minerals

Raw and cooked food	**Ca (mg)**	**Cu (mg)**	**Iron (mg)**	**Mn (mg)**	**Zn (mg)**	**p (mg)**

Appendix 3: Food varieties and the frequency of consumption in study area

	Frequency of consumption									
Foods	**Daily**		**Five times a week**		**Three times a week**		**Once a month**		**Once after two month**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Cereals										
Maize meal	134	93	5	3.5	5	3.5	-	-	-	-
Rice	8	5.6	16	11	88	61	16	11	16	11
Roots, tubers and banana										
Cassava	19	13.19	39	27.08	38	26.28	-	-	48	33.33
Sweet Potatoes	22	15.3	6	4.17	14	9.72	11	7.64	61	42.36
Banana	41	28.47	10	6.94	31	21.53	31	21.53	31	21.53
Proteins										
Beef	9	6.25	33	22.92	9	6.25	19	13.19	74	51.39
Chicken	-	-	25	17.36	5	3.5	15	10.42	99	68.75
Eggs	4	2.8	13	9.03	8	5.56	85	59.03	34	23.61
Milk	46	31.9	10	6.94	14	9.72	60	41.67	14	9.72
Fish	39	27.1	27	18.75	50	34.72	7	4.86	20	13.89
eans	41	28.47	31	21.53	62	43.06	10	6.94	-	-
Vegetables										
Amaranth	46	31.94	26	18.06	41	28.47	10	6.94	21	14.58
Pumpkin leaves	19	13.19	42	29.17	56	38.89	27	18.75	-	-
Sweet potato leaves	25	17.36	37	25.69	41	28.47	25	17.36	16	11.11
Cassava leaves	40	27.78	20	13.89	49	34.03	20	13.89	15	10.42
Cowpea leaves	7	4.86	77	53.47	14	9.72	46	31.94	-	-
fruits										
Orange	10	6.94	75	52	14	9.72	45	31.25	-	-
Ripe Banana	7	4.86	7	4.86	40	27.78	7	4.86	83	57.64
Pawpaw	22	15.28	-	-	44	30.56	39	27.08	39	27.08
Sugar sources										
Honey	8	5.56	8	5.56	30	20.83	53	36.81	45	31.25
Sugarcane	53	36.81	21	14.58	11	7.64	28	19.44	31	21.53
Sugar	93	64.58	17	11.81	9	6.25	25	17.36	-	-
Oil										
Coconut	5	3.47	97	67.36	35	24.31	9	6.25	-	-
Total	698	484.71	642	445.57	708	454.67	588	439.69	647	449.19

Appendix 4: Recipes for the dishes found widely consumed in the study area

The recipes found used in the study under food groups based local dishes. The ingredients shown were presented as averages of the data from found used by the majority.

1. **Cereal based local dishes**

i).Maize meal in form of stiff porridge :(ugali) in Kiswahili.

Ingredients:

300 g of Maize flour

1500 ml of water boiling in a cooking saucepan

300 ml of cold water (room temperature)

Utensil

Saucepan

Wooden spoon

Bowl (medium size)

Saving plate

Cooking methods

a). 75 g of flour was placed into the bowl of cold water (300ml). Stir the mixture with the wooden spoon until is well mixed in to avoid lumps.

b). put water in a cooking saucepan and bring it to boil, then pour the mixture into the pan of boiling water, let it boil over a high heat while stirring and at this time the porridge starts to stiffen.

c). after the ugali reach the consistency of porridge, add the remaining amount of flour and mix (work hard to avoid lumps) until the ugali is thick, then reduce heat let it to simmer ,cover it and cook for 10 minutes while mixing frequently to prevent burning and stickling. Ugali will be ready when it pulls from the sides of the cooking pan easily and does not stick.

d). cover the pot with a plate and invert the pan so that ugali drops on the plate

e). ugali is ready to eat. It can be eaten with any relish of choice example Tanzanian mushroom stew, amaranthus relish, beans stew, meat stew or a combination of vegetable relish with protein base stew.

ii). Rice: (wali) in Kiswahili.

Ingredients:

500 g of rice

750 ml of water (room temperature)

118 ml of cooking oil

20 g of salt

Utensil

Saucepans

Wooden spoon

Cooking methods

a). Sort rice, separate it from debris and small stones if any.

b). put enough water in the cooking pot (saucepan) and bring it on the fire.

c). When water starts to boil add cooking oil and salt, and rice cover the cooking pot, wait until water decreases.

d). By means of wooden cooking spoon, turn rice up side down and then cover the cooking port with the lid while on top of the lid spread enough hot charcoal, wait for 45 minutes. People who opt to use coconut may use coconut milk instead of cooking oil. The dish may be eaten with a variety of relish for example beans stew, meat stew, and or with variety of prepared vegetables of a day.

2. Legume based local dishes

i). Beans: (maharage) in Kiswahili.

Ingredients:

250 g of beans

59 ml of cooking oil

10 g of Salt

Utensil

Saucepans

Wooden spoon

Cooking methods

a). Take beans and sort them to get sound ones for cooking wash it.

b). put enough water in the cooking pot, add some beans in it bring to boil until it is soft, depends on the utensil, and source of heat used in cooking it may take a half an hour to one hour. When beans are soft enough add some cooking oil and salt.

c). People who opt to use coconut may use coconut milk instead of cooking oil. Cover the boiling pot for 20 minutes. The dish is then ready to be eaten as such or with rice, ugali, mixed with cooked bananas sweet potatoes

3. Root, tubers and banana based local dishes

i). Green bananas: (ndizi) in Kiswahili; variety mtwike

Ingredients:

500 **g of Green bananas**

125 ml **of water**

19 g of Onion

200 g of tomatoes

200 g of Carrot

250 g of Fresh meat

59 ml of cooking oil

10g of Salt

Utensil

Saucepan

Wooden spoon

The saucepan cover lid

Kitchen knife

Cooking methods

a). Cut the meat, clean it, bring to boil till becomes soft.

b). Peel green bananas, dice it and then clean it, put peeled green bananas in the cooking pot and put it on the fire, cook for 20 minutes.

c). Slice the onion, tomato and carrot add it in the cooking pot with green bananas, add cooked meat in the green banana cooking pot add some cooking oil (other people opt to use coconut milk), salt plus little water depends on the type of banana in question, cover with a lid for 10 minutes.

d). The dish is ready and may be eaten with amaranthus, sweet potato leaves or any vegetable relish prepared of a day.

ii). Sweet potatoes: (viazi vitamu) in Kiswahili

Ingredients:

500 g of sweet potatoes

120 ml of water

1g of Salt

Utensil

Saucepan

Wooden spoon

The saucepan cover lid

Kitchen knife

Cooking methods

a). Peel sweet potatoes and dice it to reasonable size of the will, clean it, put it in the clean cooking pot with water;

bring it to boil for 10 minutes.

b). After the sweet potatoes is half cooked, add some salt then continue cooking for 20 minutes until it is ready. Only minimal amount of water is needed to remain in cooked dish.

c). It may be eaten as bread at morning time, or eaten with any prepared relish of a day.

4. Vegetable based local dishes

i). Pumpkin leaves: (majani ya maboga) in Kiswahili

Ingredients:

216 g of Pumpkin leaves
119 ml of Water
5 g of Salt
20 g of onion
59 ml of cooking oil

Utensil

Saucepan
Wooden spoon
The saucepan cover lid
Kitchen knife

Cooking methods

a). Sort the pumpkin leaves, wash it, slice it according to ones will,

b). Put it in the cooking port then bring it to the fire. Some water drops of vegetables in the pan after the washing is one used for cooking.

c). Still cook until is soft, add some salt then put it out of fire. Fry the onion in cooking oil after become brownish add some drained cooked pumpkin leaves cover the pot for 30 minutes

d). Now is ready and can be eaten as a relish or used as a side relish to protein base food to staple food

ii). Cowpea leaves

Ingredients:

500 g of cowpea leaves
119 ml of Water
5 g of Salt
20 g of Onion
59 ml of cooking oil

Utensil

Saucepan

Wooden spoon

The saucepan cover lid

Kitchen knife

Cooking methods

a). Sort the cowpea leaves and remove un wanted parts, clean it, slice it, put it in the cooking port add some water and then still cook using the wooden cooking spoon till when it become soft.

b). Add some salt then bring out the fire, fry the onion in cooking oil, when the onion becomes brownish, add some cooked cowpea leaves but not too wet, cover the cooking pot for 3 minutes it's ready to be eaten with staple food for example ugali, rice, cooked banana

iii). Amaranthus: (mchicha) in Kiswahili

Ingredients:

1500 g of amaranthus

7.5 g of salt

59 ml of cooking oil

50 g of onion

59 ml of water

Utensil

Saucepan

Wooden spoon

The saucepan cover lid

Kitchen knife

Cooking methods

a). Sort the amaranthus leaves and remove unwanted parts, put it under the sun until show the signs of wilting

b). Remove it from the sun, clean it, put cleaned amaranthus in a clean cooking pot.

c). By using the wooden cooking spoon, does still cooking, add salt, cooking oil and sliced onion.

d). Cook for five minutes. It's ready and can be eaten with a staple food, root and tuber food group as relish or side the protein food at meal time.

iv). Cassava leaves : (kisamvu) in kiswahili

Ingredients:

500 g of cassava leaves

750 ml of water

20 g of onion

59 ml of cooking oil

1coconut medium size

10 g of salt

Utensil

Saucepan

Wooden spoon

The saucepan cover lid

Kitchen knife

Cooking methods

a). Select the tender parts of cassava leaves for cooking then homogenize it by pounding in a wooden motor and paste.

b). After become soft enough put it in a clean cooking pot. Add some water and then put it on the fire to boil cook until comes it takes 30 minutes to soft.

c). Slice the onion and fry it in the cooking oil by using the different pot then add oil cooked cassava leaves and still it then stew it. Cover the pot with the lid. Cook for 20 minutes. It can be eaten with staple food.

v). Sweet potato leaves: (matembele) in Kiswahili

Ingredients:

500 g of sweet potato leaves

40g of onion

50 g of tomatoes

59 ml of cooking oil

10 g of salt

Utensil

Saucepan

Wooden spoon

The saucepan cover lid

Kitchen knife

Cooking methods

a). Select the useful ones for cooking and remove the unwanted skin, wash it and put it on the sun to remove unwanted water then fry the onion in cooking oil.

b). Use the cooking pot, then Add some sweet potato leaves then sliced tomatoes and cover the mixture.

c). After five minutes add salt and cover again for ten minutes. Now its ready can be eaten with staple food.

Appendix 5: Nutrient content of foods found in two seasons (dry and wet) of widely grown and consumed food crops in Morogoro municipality by category. Macro nutrients: - Carbohydrates, proteins and fats/lipids

Cereals amount in g / 100 g of edible portion					
Sel.fd ckd and raw	moisture	energy	protein	fats%	Carbohy
	% av (range)	kcal av (range)	%av (range)	av (range)	% av (range)
maize flour raw	11(9.7-12)	298(230-366)	9.1(8.6-9.6)	1.6(1.2-1.9)	67(56-79)
Maize ml (cooked)	72(70-75)	111(101-121)	3.4(2.8-4)	0.8(0.7-0.8)	23(21-26)
Rice (raw)	9.9	350	10	0.8	76
Rice(ckd)	58	173	4.9	5.4	26
Legumes amount in g /100 g of edible portion					
Bns (raw)	11	311	18	1.8	56
Bns(ckd)	62	154	8	4.6	20
Roots, tubers and bananas amount in g / 100 g of edible portion					
Grn banana (raw)	72(70-74)	89(79-100)	1.6(1.1-2)	0.4(0.3-0.6)	22(21-23)
Grn banana (ckd)	76(76-77)	102(85-119)	0.8(0.7-0.9)	5.4(5.3-5.5)	18(16-20)
Swt ptato (raw)	65(62-68)	133(122-145)	1.7(1.3-2.1)	0.2(0.1-0.2)	32(29-34)
Swt ptato (cooked)	70(70-70)	110(106-115)	1.8(1.6-2.1)	0.5(0.4-0.6)	2.5(23-28)
Vegetables amount in g / 100 g of edible portion					
Swt ptato leaves raw	68(51-85)	161(137-184)	4.4(4.3-4.4)	0.5(0.5-0.6)	6.4(6-6.7)
Swt ptato leaves cooked	66(65-67)	176(131-218)	4.1(3.1-5.2)	19(18-19)	24(21-28)
Cassava leaves (raw)	97(96-97)	76(57-95)	6.8(5.9-7.6)	1.8(1.6-2)	9.4(7.3-12)
Cassava leaves cooked	99(98-99)	198(169-227)	6.4(4.8-8)	9(6.9-11)	23(22-24)
Amaranthus (raw)	61(59-53)	142(133-150)	5.1(4.3-6)	2.5(2.4-2.6)	25(21-29)
Amaranthus (ckd)	72(68-76)	100(71-130)	5.7(4-7.4)	2.9(2.2-3.6)	23(20-26)
Pumpkin leaves (raw)	88(80-96)	50(37-62)	6.1(4.3-7.8)	0.1(0.1-0.1)	6.1(4.7-7.5)
Pumpkin leaves (cooked)	83(65-101)	221(130-313)	3(3-3.2)	1.8(1.4-2.2)	29(29-30)
Cowpea leaves (raw)	67(64-70)	116(114-117)	3.9(2.9-4.9)	1(0.9-1)	24(23-24)
Cowpea leaves (cooked)	64(63-65)	185(156-214)	4.3(2.9-5.8)	13(10.31-12.83)	13(9.97-13.03)

Micronutrients: minerals

Cereals	amount in g / 100 g of edible portion							
Sel.fd ckd and raw	Ash (%)	Ca (mg)	Cu (mg)	Iron (mg)	Mn (mg)	Zn (mg)	Mg (mg)	p (mg)
	av(range)	av(range)	av(range)	av(range)	av(range)	av(range)	av(range)	av(range)
maize flour raw	0.03(0.02-0.03)	123(116-131)	0.8(0.8-0.8)	3.6(3.1-4)	1(0.9-1)	0.9(0.9-1)	104(101-106)	158(135-181)
Maize ml (cooked)	0.01(0.01-0.02)	123(116-131)	0.2(0.2-0.2)	1.4(0.9-1.8)	0.6(0.5-0.6)	0.3(0.2-0.4)	22(17-28)	70(52-87)
Rice (raw)	0.09	23	0.3	1.9	1.9	1.5	64	237
Rice(ckd)	0.08	22	0.1	0.1	1.4	1	23	89
Legumes	amount in g/100g of edible portion							
Bns (raw)	0.33	178	0.7	7.2	2.3	1.9	149	398
Bns(ckd)	0.19	161	0.8	0.5	2.7	1.9	83	397
Roots, tubers and bananas	amount in g/100g of edible portion							
Grn banana (raw)	0.1(0.1-0.11)	55(51-59)	05(0.5-0.5)	1.8(1.5-2)	3.4(3.3-3.5)	0.4(0.3-0.4)	34.49 (40.42-28.56)	143(130-157)
Grn banana (ckd)	0.1(0.09-0.11)	48(44-51)	0.4(0.3-0.4)	1.3(1.1-1.5)	2.9(2.8-3	0.3(0.2-0.3)	85(72-97)	106(94-118)
Swt ptato (raw)	0.09(0.09-0.09)	28(22-34)	0.1(0.1-0.1)	4.3(3.4-5.1)	0.7(0.5-0.9)	0.2(0.1-0.3)	25(24-26)	68(60-76)
Swt ptato (cooked)	0.1(0.09-0.11)	48(34-61)	0.7(0.7-0.7)	3.9(2.7-5.1)	1.1(0.9-1.2)	0.5(0.4-0.6)	77(67-88)	193(185-201)
Vegetables	amount in g/100g of edible portion							
Swt ptato leaves raw	0.17(0.16-0.18)	134(123-139)	0.9(0.9-1)	3.9(3.6-4.2)	10 (9.1-11)	1.9(1.8-2)	67(55-79)	42(41-42)
Swt ptato leaves cooked	0.3(0.02.0.14)	381(320-442)	0.8(0.7-0.9)	4.5(3.9-5.14)	3.5(2.6-4.4)	0.9(0.8-1)	200(160-239)	144(123-164)
Cassava leaves (raw)	0.22(0.18-0.25)	84(65-102)	1(0.9-1)	12(9.7-14)	0.3(0.2-0.4)	0.6(0.4-0.8)	35(24-47)	76(57-95)
Cassava leaves cooked	0.38(0.25-0.5)	74(65-83)	0.1(0.1-0.2)	3.3(2.2-4.3)	1.4(1.2-1.6)	0.4(0.4-0.5)	36(25-47)	76(56-95)
Amaranthus (raw)	0.42(0.29-0.55)	739(698-780)	0.4(0.3-0.4)	6.1(5.1-7.1)	2.3(2-2.6)	0.9(0.7-1.1)	385(286-484)	67(55-79)
Amaranthus (ckd)	0.4(0.29-0.5)	292(284-300)	0.5(0.5-0.5)	9.3(6.8-12)	1.1(0.8-1.5)	2.1(1.9-2.3)	212(199-225)	66(53-79)
Pumpkin leaves (raw)	0.21(0.18-0.23)	7.1(5.5-8.7)	0.5(0.5-0.5)	6(4.5-7.5)	0.9(0.7-1.2)	0.3(0.2-0.4)	18(18-18)	71(64-78)
Pumpkin leaves (cooked)	0.32(0.22-0.41)	7.5(7.4-7.7)	0.4(0.4-0.4)	0.6(0.5-0.7)	0.5(0.4-0.6)	0.8(0.7-0.9)	49(39-59)	55(46-64)
Cowpea leaves (raw)	0.54(0.54-0.54)	243(242-243)	1.1(1-1.1)	5.5(3.9-7)	1.5(1.4-1.5)	2.5(2.4-2.6)	62(52-71)	77(71-82)
Cowpea leaves (cooked)	0.29(0.24-0.34)	243(242-243)	0.5(0.1-1)	5.1(3.1-7)	1.5(1.4-1.5)	1.4(0.2-2.6)	62(52-71)	77(71-82)

Appendix 6: Established data base for nutrient content of food selected found widely grown and consumed in Morogoro municipality during study.

i). Macro nutrients: - Carbohydrates, proteins and fats/lipids

Cereals amount in g / 100 g of edible portion					
Sel.fd ckd and raw	moisture	energy	protein	fats	Carbohy
	%	kcal	%	%	%
maize flour raw	11	298	9.1	1.6	67
Maize ml (cooked)	72	111	3.4	0.8	23
Rice (raw)	9.9	350	10	0.8	76
Rice(ckd)	58	173	8.9	5.4	26
Legumes amount in g /100 g of edible portion					
Bns (raw)	11	311	18	1.8	56
Bns(ckd)	62	154	8	4.6	20
Roots, tubers and bananas amount in g / 100 g of edible portion					
Grn banana (raw)	72	89	1.6	0.4	22
Grn banana (ckd)	76	102	0.8	5.4	18
Swt ptato (raw)	65	133	1.7	0.2	29.48
Swt ptato (cooked)	70	110	1.8	0.5	25
Vegetables amount in g / 100 g of edible portion					
Swt ptato leaves raw	68	161	4.4	0.5	6.4
Swt ptato leaves cooked	66	176	4.1	19	24
Cassava leaves (raw)	97	76	6.8	1.8	9.4
Cassava leaves cooked	99	198	6.4	9	23
Amaranthus (raw)	61	142	5.7	2.5	25
Amaranthus (ckd)	72	100	5.1	2.9	23
Pumpkin leaves (raw)	88	50	6.1	0.1	6.1
Pumpkin leaves (cooked)	83	221	3	1.8	29
Cowpea leaves (raw)	67	116	4.3	1	24
Cowpea leaves (cooked)	64	185	3.9	13	13

Micronutrients: minerals

Cereals	amount in g / 100 g of edible portion							
Sel.fd ckd and raw	Ash (%)	Ca (mg)	Cu (mg)	Iron (mg)	Mn (mg)	Zn (mg)	Mg (mg)	p (mg)
maize flour raw	0.3	123	0.8	3.6	1	0.9	104	158
Maize ml (cooked)	0.1	123	0.2	1.4	0.6	0.3	22	70
Rice (raw)	0.9	23	0.3	1.9	1.9	1.5	64	237
Rice(ckd)	0.8	22	0.1	0.1	1.4	1	23	89
Legumes	amount in g/100g of edible portion							
Bns (raw)	3.3	178	0.7	7.2	2.3	19	149	398
Bns(ckd)	1.9	161	0.8	0.5	2.7	1.9	83	397
Roots, tubers and bananas		amount in g/100g of edible portion						
Grn banana (raw)	1	55	05	1.8	3.4	0.4	919	143
Grn banana (ckd)	1	48	0.4	1.3	2.9	0.3	85	106
Swt ptato (raw)	0.9	28	0.1	4.3	0.7	0.2	25	68
Swt ptato (cooked)	1	48	0.7	3.9	1.1	0.5	77	193
Vegetables	amount in g/100g of edible portion							
Swt ptato leaves raw	1.7	134	0.9	3.9	10	19	67	42
Swt ptato leaves cooked	3	381	0.8	4.5	3.5	0.9	200	144
Cassava leaves (raw)	2.2	84	1	12	0.3	0.6	35	76
Cassava leaves cooked	3.8	74	0.1	3.3	1.4	0.4	36	76
Amaranthus (raw)	4.2	739	0.4	6.1	2.3	0.9	385	67
Amaranthus (ckd)	4	292	0.5	9.3	1.1	2.1	212	66
Pumpkin leaves (raw)	2.1	7.1	0.5	6	0.9	0.3	18	71
Pumpkin leaves (cooked)	3.2	7.5	0.4	0.6	0.5	0.8	49	55
Cowpea leaves (raw)	5.4	243	1.1	5.5	1.5	2.5	62	77
Cowpea leaves (cooked)	2.9	243	0.5	5.1	1.	1.4	62	77