NUTRITIONAL COMPOSITION OF CASSAVA BASED RECIPES AND ITS IMPLICATION ON THE NUTRITION STATUS OF CHILDREN AGED 6-59 MONTHS IN MTWARA DISTRICT

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A THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN SCIENCE, HUMAN NUTRITION OF THE OPEN UNIVERSITY OF TANZANIA

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CERTIFICATION

The undersigned certify that they have read and here by recommend for acceptance by the Open University of Tanzania a thesis titled: **"*Nutritional Composition of Cassava Based Recipes and its Implication on the Nutrition Status of Children Aged 6-59 Months in Mtwara District,*"** in fulfilment of the requirements for the Degree of Doctor of Philosophy in Science, Human Nutrition of the Open University of Tanzania.

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DECLARATION

I, **Diana Nicodemas**, do hereby declare to the Senate of Open University of Tanzania, that this thesis is my own work done within the period of registration and that it has neither been submitted nor being concurrently submitted for degree award to any other university

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Date

DEDICATION

This work is dedicated to my family of Mr. and Mrs. Nicodemus Rwegarulila, whose courage, compassion and love were a source of inspiration for this work and laid the foundation of my education which made me what I am today

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ABSTRACT

The aim of this study was to examine the nutritional composition of cassava based recipes and their implication on nutrition status of children aged 6-59 months. A cross-sectional study was carried in six villages of Mtwara Rural District with a sample of 329 children. Food-frequency-questionnaire was used to identify cassava consumption frequency, 24-hours dietary recall identified common cassava meal based recipes. Anthropometric measurements were also taken and dietary diversity established. Chemical analyses was done to determine the nutrient content of different cassava based recipes. Four commonly used recipes were identified namely Coconut-Cassava-Recipe, Plain-Cassava-Recipe, Groundnuts-Cassava-Recipe and Tomato-Cassava-Recipe. Stunting rate (41%), wasting prevalence (7.3%) and underweight prevalence (18.8%) were recorded. The feeding frequency of 2 days in a week was dominant for children of 6-10 months. Among children aged 11-59 months the dominant cassava consumption frequencies in a week were two days (36.8%), three days (20.1%) and six days (27.7%). Overall 87.33% of all children aged 6-59 months had a feeding frequency of 2 days, 3 days or 6 days in a week. However, no significant association ($p \geq 0.05$) was established between cassava concumption frequency and prevalence of manultrition. Cyanide contents in all the recipes were within acceptable level of 10ppm, but phytate contents were above the tolerable level of 25 mg/100 g, with the lowest being 78.73mg/100g in CCR. The contribution of cassava to the RDAs of the selected nutrients were 19.4% for iron, 21% for zinc, 0.527% for fat and 4.26% for protein among children aged 6-59 months which is extremely low. The average IDDS of 2.5 obtained in this study was far below the target IDDS of 5 implying poor dietary diversity of consumed food groups. Prevelance of malnultrition generally suggests a interacting effect of several factors.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
CCR	Coconut Cassava Recipe
CESHH	Centre of Excellence Science Seafood & Health
Df	Degrees of freedom
EUFIC	Europen Food Information Council
FW	Fresh Weight
GCR	Groundnut Cassava Recipe
HAZ	Height for Age Z-score
HCN	Hydrocyanic Acid
IDDS	Individual Dietary Diversity Score
MAM	Moderate Acute Malnutrition
MUAC	Mid-Upper Arm Circumference
P-value	Probability Value
PCR	Plain Cassava Recipe
SAM	Severe Acute Malnutrition
TCA	Trichloroacetic Acid
TCR	Tomato Cassava Recipe
UV-VS	Ultraviolet Visible Spectrophotometer
WAZ	Weight for Age Z-score
WHZ	Weight for Height Z-score

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Cassava (Manihot Esculenta Crantz) is one of the most widely grown staple crops in Sub-saharan Africa. Currently, about half of the world production of cassava is in Africa. Cassava is cultivated in around 40 African countries, stretching through a wide belt from Madagascar in the South East to Senegal and to Cape Verde in the North West. Around 70 percent of Africa's cassava output is harvested in Nigeria, Congo and Tanzania. Throughout the forest and transition zones of Africa, cassava is either a primary staple or a secondary food staple. Cassava plays important roles in African development like famine reserve, rural food staple; cash crop and urban food staple (Felix, 2004).

Cassava is an increasingly important crop in Tanzania: it is the second most important food crop after maize in terms of production volume and per capita consumption, supporting the livelihood of 37% of farmers in rural areas. The majority of the poorest farmers (59%) are reported to grow the crop for food (Bennett *et al.,* 2012).

Cassava is widely grown in all farming systems in Tanzania due to its adaptability to various soils and agro-ecological conditions. Tanzania is the fourth producer of cassava in Africa; the main producing areas being the coastal strip along the Indian Ocean, around Lake Victoria, Lake Tanganyika and along the shores of Lake Nyasa. According to the Tanzania Ministry of Agriculture, in 2008 cassava planting covered 800,000 hectares and produced 1.72 million tons of cassava (dried), with a yield of 2.1

tons per hectare. Looking at the three top producing zones, the South Zone produces the greatest volume (517,000 tons) or 30.7% of Tanzania's all cassava production. The Lake Zone provides 27.5% of national production and the East Zone follows with 15.1% (Shinichi, 2011). Several initiatives are supporting the development of the cassava value chain in Tanzania. For instance, presently two projects have been implemented in collaboration with TNFC aiming at opening new market opportunities for processed cassava (Bennett *et al.,* 2012). It is important to note that cassava leaves are consumed as green vegetables and the roots as staple food in most of the cassava growing countries like Tanzania (Hahn *et al.,* 1988).

Cassava is extremely important for food security for several reasons: (1) It is tolerant to drought (2) it can be harvested at any time of the year (3) It produces many tubers even without application of fertilizer or pesticide (Shinichi, 2011) and (4) is also a staple food for a significant fraction of the population in Tanzania and Africa at large.

1.2 Problem Statement and Justification of the Study

1.2.1 Problem Statement

More than 80% of the African populations live in rural areas with great dependence on agriculture for their livelihoods. Cassava being one of the most important staple food crops grown in tropical Africa, it plays a major role in efforts to alleviate the African food crisis because of its efficient production of food energy, year-round availability, tolerance to extreme stress conditions, and suitability to present farming and food systems in Africa (Hahn *et al.,* 1988) and hence ensure food security. Cassava roots have high starch content, about 60%, and therefore a cheap and excellent source of dietary carbohydrate. It is also rich in calcium, thiamine, riboflavin and niacin but contain low levels of protein and other essential nutrients which are more available in its leaves.

In view of this cassava meal can only be improved by incooperating other foods to make cassava diet nutritious (Dziedzoave *et al.,* 2006). Thus if not complemented with other types of foods, cassava roots when used as staple food may result into nutritional insecurity and hence malnutrition due to imbalanced and inadequate nutrients intake.

In Tanzania, 34.4% of children below five years are stunted,13.7% are underweight and the country's average stunting p
revalence is 35% but varies between 31.9 to 40.9% in Mtwara region (TFNC, 2014). The data also show that the prevalence of chronic malnutrition stands at 31.65% for Mtwara Rural District (TFNC, 2014), which still calls for attention in nutrition assessment and analysis. Despite the government's and development partners' efforts to address malnutrition, there has been poor progress in improving the nutritional status of children and women in Tanzania.

According to WHO (1997), stunting which is an indicator of under nutrition is regarded as'very high' if is greater than 40% in the population. In other countries malnutrition manifestation has also been observed in areas where cassava is a staple food. For example a study conducted by Nungo *et al.,* (2012) in Western Kenya indicated that children were malnourished due to high cassava consumption with a frequency of up to three times in a day mainly as porridge, boiled cassava and ugali (stiff porridge) prepared from cassava flour. The commonness of cassava as a staple food and the nutritional experience from areas with similar dependance on cassava further calls for evaluation of the assiciation between cassava consumption pattern and the nutrition status of the children aged 6-59 months.

Processing can also affect the nutritional value of cassava through modification and losses in nutrients of high value (Montagnac *et al.,* 2009) depending on the processing method. Although a research has been done regarding cassava production, processing and consumption (Shinichi, 2011), litlle if any has been done to analyse the nutritional value of the formulated cassava recipes and the nutritional status of consumers of the same where cassava is a staple food.

According to Habwe *et al.,* (2009) who evaluated the iron nutrient content of the selected East African indigenious vegetables formulated into different recipes in their remarks concluded that “it is not enough to just develop recipes, what is more important is their nutrient content if the effort is towards improving nutrition security. This study also intended to take the same focus by examining the nutritional contents of the differently formulated cassava recipes and their implications on the nutritional status of children aged 6-59 months.

1.2.2 Justification of Study

The nutritional quality of different cassava recipes is sparingly documented thus making it difficult for the consuming population to understand how it affects their nutritional status. Analysis of nutrients in the identified recipes will enable nutritionists and the entire population to understand the nutritional value of the consumed food. The prevalence of malnutrition in Tanzania is highly documented (TFNC, 2014) which could be linked with wide growth of cassava and its consumption as staple food in various areas of the country (Felix, 2004). Thus an understanding of the nutritional quality of different cassava recipes especially in Mtwara region where stunting prevalence is 31.65% (TFNC, 2014) is of paramount importance and the fact that the region is among those with high cassava production (Shinichi, 2011).

Documentation of the nutritional composition of various cassava recipes will form a base for optimising the nutrient content of the same through various formulations. Proper nutrition will ensure a healthy population, promote social-economic well beings and reduce the burden to health services. Furthermore, the findings of this study will also give a clear picture on the consumption pattern of cassava recipes and provide an opportunity for assessing the daily recommended dietary allowance for the major nutrients required by the body. This will also form a base for judging whether the existing consumption pattern meets the daily recommended dietary allowance of the target population and make the necessarry recommendations. The association between cassava recipes, consumption pattern and the nutritional status of the study population will enable the nutritionist to determine the appropriate intervetions needed to address any nutritional imbalances.

By also establishing the contribution of cassava staple to recommended dietary allowance (RDA) would form a base that is appropriate for dietary diversity intervention and also broaden awareness among the affected population. It is thus important to evaluate how cassava based meals can adequately contribute to RDA for healthy life.The knowledge and experience gained from this study could also provide some considerations to the study population on the eating behavior and food diversity to reduce the risk of exposure to malnutrition.

1.3 Study Objectives

1.3.1 General Objective

The study aimed at bridging the knowledge gap by determining the nutritional composition of different cassava recipes and implications on the nutrition status of the children aged 6-59 months within communities in which cassava is staple.

1.3.2 Specific Objective

(i) To Determine the proximate composition, minerals composition, phytates content and cyanides content of the most common consumed cassava recipes.

(ii) To determine the cassava consumption frequency and dietary diversity score for children

(iii) To identify the contribution of cassava to the recommended dietary allowance of iron, zinc, protein and fat among the children aged 6-59 months.

(iv) To determine the nutrition status of the children aged 6-59 months.

(v) To evaluate the assossiation between individuals cassava consumption pattern and their nutritional status.

1.4 Hypothesis

The null hypothesis: H_0, Cassava consumption pattern within households affects the nutrtition status of the children aged 6-59 months.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Cassava

Cassava is a drought-tolerant can grow in poor soil and can withstand drought, staple food crop grown in tropical and subtropical areas widely in Africa, Asia and Latin America (Montagnac *et al.,* 2009). It is a plant originating from South America and is known under various names: *Manihot esculenta*, manioc, yucca and tapioca. The tubers part of the root system and the leaves are used for food.

It is an important staple in many developing countries of Africa, South and Central America, India and Southeast Asia. It is an important famine reserve crop in countries with unreliable rainfall. Cassava is not grown in other countries like Canada, but it is better known to Canadians as the source of tapioca. Tapioca is obtained by extracting the starch portion of the cassava tuber; tapioca starch is used as a thickening agent and is non-toxic (Olsen and Schaal, 1999).

2.2 Cassava Growing Areas in Tanzania

Cassava in Tanzania is an integral component of most cropping systems and is among the most important staples in many zones. The country realizes the importance of cassava and has given the second priority ranking in its national research. Cassava is cultivated and produced in all regions of Tanzania. The main producing areas are: Mwanza, Mtwara, Lindi, Shinyanga, Tanga, Ruvuma, Mara, Kigoma, coast regions and most regions in Zanzibar (FAO, 2001).

2.3 Cassava Varieties

Farmers in Africa grow several cassava varieties. Cassava varieties are classified according to morphological traits as well as taste, cyanide content, average yield, disease performance and pubescence (Salvador *et al.*, 2014). For example, the COSCA researchers identified over 1000 local cassava varieties in six counties of the study, namely the Congo, Côte d'lvoire, Ghana, Nigeria, Tanzania and Uganda. The farmers group the local cassava varieties into the bitter and the sweet varieties. The sweet varieties are more popular in Côte d'lvoire, Ghana and Uganda while the bitter varieties are more common in the Congo, Nigeria and Tanzania. The COSCA farmers reported that the bitter varieties are more resistant to pests; higher yielding and store better in the ground than the sweet varieties (FAO, 2005).

2.4 Nutrients of Cassava

The nutritional content of cassava depends on specific plant part (roots or leaves), geographic location, variety, age of the plant and environmental conditions (Salvador *et al.*, 2014). Cassava root is an energy-dense food. It is a good and efficient source of carbohydrate production per hectare, which ranks it before maize, rice, sorghum, and wheat. The root is a physiological energy reserve with high starch content 60% making it a good dietary carbohydrate source. The lipid content in cassava roots ranges from 0.1% to 0.3% on a FW basis.

This content is relatively low compared to maize and sorghum, but higher than potato and comparable to rice. About 50% of the crude protein in the roots consists of whole protein and the other 50% is free amino acids. Cassava roots have thiamin, riboflavin, niacin, calcium, iron, potassium, magnesium, copper, zinc, and manganese contents comparable to those of many legumes, with the exception of soybeans (Montagnac *et al.*, 2009).

2.5 Health Benefits of Cassava

Cassava has nearly twice the calories than that of potatoes and perhaps one of the highest value calorie food for any tropical starch rich tubers and roots. One hundred grams root provides 160 calories. Cassava is very low in fats and protein than in cereals and pulses. Nonetheless, it has more protein than that of other tropical food sources like yam, potato, plantains, etc. As in other roots and tubers, cassava too is free from gluten. Gluten-free starch is used in special food preparations for celiac disease patients. Cassava is a moderate source of some of the valuable B-complex group of vitamins such as folates, thiamin, vitamin B-6, riboflavin, and pantothenic acid. Cassava leaves are a good source of dietary proteins and vitamin K. Vitamin-K has a potential role in bone mass building by promoting osteotrophic activity in the bones.

It also has established role in the treatment of Alzheimer's disease patients by limiting neuronal damage in the brain. It is one of the chief sources of some important minerals like zinc, magnesium, copper, iron, and manganese for many inhabitants in the tropical belts. In addition, it has adequate amounts of potassium (271 mg per 100g or 6% of RDA). Potassium is an important component of cell and body fluids that help regulate heart rate and blood pressure (Adnle *et al.*, 2012).

2.6 Anti-nutritional Composition of Cassava

Cassava roots has raised concerns about the effects of the anti-nutrients in this crop on human health. Anti-nutrients are natural or synthetic compounds that interfere with the absorption of nutrients. Common examples like phytate, which forms insoluble complexes with calcium, zinc, iron and copper, another particular widespread form of anti-nutrients are flavonoids, which are a group of polyphenolic compounds that include tannins (Sarkiyayi and Agar 2010). These compounds chelate metals such as iron and zinc, and reduce the absorption of these nutrients. They also inhibit digestive enzymes and may precipitate proteins (Beecher, 2003).

2.7 Natural Toxicants in Cassava

Cassava contains natural toxic cyanogenic glycoside compounds linamarin and methyl-linamarin. Cyanide is toxic to most living organisms due to its ability to bind to metals (Fe, Zn and Cu) functional groups or ligands of many enzymes. Plants produce cyanide as a by-product of ethylene synthesis or a defensive chemical against herbivores. Injury to tuber releases linamarase enzyme from the ruptured cells, which then converts linamarin to poisonous HCN. It is therefore, consumption of raw cassava root results in cyanide poisoning. Soaking followed by boiling in salt-vinegar water results in complete evaporation of this compound and makes it safe for human consumption (Sarkiyayi and Agar 2010). Linamarin has bitter taste hence high cyanide cassava roots are normally bitter and contain >100ppm cyanide, and therefore termed bitter cassava (Nhassico *et al.,* 2008).

2.8 Cassava Processing

In Africa, there are five common groups of cassava products: fresh root, dried roots, pasty products, granulated products and cassava leaves that are prepared traditionally. The three main reasons for processing cassava is to increase shelf life, facilitate transport and remove cyanogens, (Nyirenda *et al.,* 2011). Fresh cassava roots are eaten raw, roasted in an open fire, or boiled in water or fried in oil. The cyanogens in the roots are destroyed by slowly cooking the roots. Drying cassava roots is the simplest method of cassava preparation, whereby sundried cassava is milled into flour and stored or marketed. Since this method is inefficient in the elimination of cyanogens, it is used mostly for preparing sweet cassava varieties, which have low cyanogens content (FAO, 2005).

Pasty products are obtained when the roots are soaked in water for 3 to 5 days in which roots soften and ferment. The soaked roots are manually crushed and sieved by shaking them in a basket in a sack under water, thereby separating the pulp into the sack while collecting the fibre in the basket. Soaking and fermentation helps to reduce cyanogens (Tivana, 2012). Granulates products of cassava involves grating, toasting and addition of palm oil which adequate reduce cyanogens to adequate level. Cassava leaves are important vegetables which are edible and more convenient with nutritive value similar to other dark green leaves and are an extremely valuable source of vitamins A, C, iron and calcium (FAO, 2005).

Cassava roots have a short storage life and begin to deteriorate only 2 to 3 days after uprooting. Apart from leaving the mature roots unharvested till the time they are needed there is no commercial methods for storage of cassava roots for long period of time. Processing remains the best method of preserving the highly perishable cassava toots and removing cyanogens glucosides (Dziedzoave *et al.*, 2006).

2.9 Cassava Processing and Cyanide Levels

Detoxification of cassava, to a large extent, occurs during the processing of the roots when the cell structural integrity is usually lost. The cyanogenic glucosides come into contact with the hydrolytic enzyme linamarase, thus initiating the formation of hydrogen cyanide. 95% decrease in cyanoglycoside content after grating and nearly 98% after fermentation of cassava during gari creamy white flour manufacture (Akingbala and falade, 2008). Lactic acid fermentation, which is generally employed in processing cassava products, also assists in hydrolysis of the cyanogenic glucosides to sugar and volatile HCN, which is removed during further processing by heating.

Apart from the detoxifying effect on cassava, it is safe to presume that lactic acid fermentation also confers on cassava products such as fufu and fermented flours the same advantages it confers on milk, nuts and other proteinous products, e.g. increased digestibility, increased protein content, improved protein quality and increased vitamin content (Akingbala and falade, 2008).

2.10 Variation of Cassava Nutrient Contents in Different Recipes

Cassava root can be cooked and eaten fresh or processed into flour (Montagnac *et al.*, 2009). Preparation of cassava roots prior to consumption varies according to preferences. Processing cassava can affect the nutritional value of cassava roots through modification and losses in nutrients of high value. Analysis of the nutrient retention for each cassava edible product has been conducted by researchers (Montagnac *et al.*, 2009) in South Africa and found that raw and boiled cassava root keep the majority of high-value macro and micronutrients compared to processed cassava. For example, vitamins like thiamin and riboflavin were found to be higher (20µg and 16µg) in boiled cassava compared to cassava flour (9µg and 11µg) respectively, carbohydrate and protein were recorded at 27.4g and 0.38 in boiled roots while in cassava flour were 23g and 0.19 respectively. However, no evaluation has been done for the different consumed cassava recipes in Mtwara district where cassava is staple, thus calling for the present research.

2.11 Cassava Consumption

The form in which cassava is consumed varies in different regions of the country. Bitter cassava varieties must be processed to reduce or eliminate cyanogenic content. The roots are boiled, sundried, fermented, grated, roasted or made into flour. Sweet varieties are mainly eaten fresh. Products that can be made from either bitter or sweet varieties include breads, biscuits, cakes and beverages (Salvador *et al.*, 2014).

2.12 Children Dietary Diversification

Dietary diversity gives a clear picture of how many food groups are consumed in a particular area and which ones are mostly consumed. The number of foods consumed across and within food groups over a reference time period is widely recognized as a key dimension of dietary quality. It reflects the concept that increasing the variety of foods and food groups in the diet helps to ensure adequate intake of essential nutrients, and promotes good health (Kennedy *et al.*, 2009).

Dziedzoave *et al.*, 2006 reported that, cassava meal alone cannot cater for the body nutrients requirement, however, can only be improved by in cooperating other foods to make cassava diet nutritious. When people cannot afford to diversify their diets with adequate amounts of fruits, vegetables or animal-source foods that contain large amounts of micronutrients, deficiencies usually occur due to monotony and nutritional inadequacy. Lee, (2014) explain that inadequate dietary intake and prolonged undernourishment can lead to short term and long term consequences, which can deplete financial, physical, and social capital, further exacerbating the cycle of under nutrition, poverty, and unhealthy household environment that most food-insecure families already have. Dietary imbalance for nutrients body needs during early stage of child development can affect growth of the child, dietary diversity score is a good indicator to assess quality of children’s diet.

2.13 Recommended Dietary Allowance for Children

The Recommended Dietary Allowance (RDA) is set in order people to understand the amount of nutrients required for normal growth. It can be defined as the levels of in-take of energy and dietary components which, on the basis are considered adequate for the maintenance of health and well-being of a healthy person in the population. Children are vulnerable to malnutrition and thus a group of interest to follow up on whether their meals meet the RDA. Poor nutrition can have a devastating impact in their growth and development. The RDA’s for various macro and micro nutrients required for children aged 6-59 months are as follows: Protein is 24g, Fat is 31g-40g , Fibre is 19-25g , Carbohydrates is 95-130g, Calcium is 400-800mg, Magnesium is 80-130mg, Potassium is 3000-3800mg, Zinc is 4mg, Copper is 340-440µg, Iron is 10mg, Manganese is 1.2-1.5mg, Cyanide safe is WHO level is 10ppm, Phytate tolerable level is 25 mg/100g (FNB *et al.*, 1989) and (DRI, 2002/2005).

2.14 Nutrition Status of Children Aged 6-59 Months in Cassava Consuming Communities

A study carried out by Nungo *et al.,* 2012 in Nambale, Busia of Western Kenya assessed the nutritional status of children aged 6-59 months. The findings showed poor nutrition status of children (<-2 SD), 26.6% were stunted, 13.9% underweight, and 10.1% were wasted. Furthermore malnutrition had reached its peak during the third year affecting boys more than girls despite a high mean score (9.2) for household dietary diversity. The findings established cassava utilization to be high (94.3%) and mainly as “porridge, boiled roots and ugali”. Eight staples including cassava were used for complementary feeding and 66.4% of the children were fed three times daily.

Another study conducted in Costal Kenya by Nginya, (2015) also had shown that children of 2-5years obtained up to 28% of their daily energy from every cassava consumption time, the dietary diversity score was 5.2 and the children of this area ate protein rich foods three times a week, where by the stunting prevalence was found to be 29%. These data sugest the importance of also examining the impact experienced by the cassava consuming population in Tanzania.

2.15 Importance and Industrial Use of Cassava

As stated previously, cassava is the third most important source of calories in the tropics, after rice and corn (FAO, 2004). Millions of people depend on cassava in Africa, Asia and Latin America. It is grown by poor farmers, many of them women, often on marginal land. The crop is vital for both food security and income generation (FAO, 2004). The Strategy, initiated in 1996, aimed identifying opportunities and constraints at each stage of the cassava development cycle from production to consumption.

Cassava has big potential in industries, since it is used as a raw material for various productions. For instance cassava starch in direct form is used as a raw material for textile and production drilling, cassava starch hydrolysates including glucose, fructose, maltose, sucrose and syrup is used for pharmaceuticals, syrup concentrate for soft drinks, dried cassava roots for beer and ethanol making (Nweke *et al.*, 2001).

2.16 Importance of Nutrition Status Assessment

Nutrition assessment involves collecting, integrating and analysing nutritional related data, to evaluate individual's nutrition status and the extent of malnutrition. Nutritional assessment helps to identify individuals or population groups at risk of becoming malnourished. This helps to screen populations to identify individuals at risk of under nutrition (or over nutrition) and the degree and severity of under nutrition, i.e. mild, moderate or severe from which the nutritional status of different population groups and nations can be compared (Gibson, 2005). Anthropomentric measures are the ones most apparently affected by ageing process used at present to assess nutritional status of all the parameters.

Common anthropometric measures are height, weight, and mid-upper arm circumference (MUAC). Some measurements are presented as indices, including height-for-age (HFA), weight-for-age (WFA), weight-for-height (WFH), MUAC-for-age, and body mass index (BMI)-for-age. Each index is recorded as a z-score that describes how far and in what direction an individual's anthropometric measurement deviates from the median in the 2006 WHO Child Growth Standards for his or her sex.

The anthropometric measurements (Height and Weight and age of children) among under five were computed using World Health Organization (WHO) Anthro Plus to obtain z-scores for Height for age (HAZ), Weight for age (WAZ) and Weight for

Height (WHZ) according to WHO growth standards of 2006 taking -2SD as cut-off points. The Z-scores were used to classify children into levels of nutritional status (stunting, wasting and underweight). To identify the SAM and MAM children.

The measurements are used to identify stunting, underweight and wasting. Age of a child is a prerequisite before taking any measurements because undernutrition among Tanzanians is manifested at an early age, therefore great emphasis is placed on monitoring child nutrition to avoid or minimise the adverse consequences of malnutrition.

The findings of which helps in developing health care programs that meet the community needs which are defined by the assessment, measure the effectiveness of the nutritional programs and intervention once initiated. Malnutrition which is poor nutritional status, can lead to disability, illness and death and jeopardize future economic growth by reducing the intellectual and physical potential of the entire population.

It is important to conduct nutritional assessment of the population in which cassava is a staple food so as to assess whether cassava based recipes and eating behavior supports nutrition security and the extent to which it affects children nutrition status.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

Mtwara Rural district is one of the five districts of Mtwara region. The prevalence of chronic malnutrition was found to be 31.65% for Mtwara Rural District (TFNC, 2014), which still calls for attention in nutrition assessment and analysis. Cassava is grown in all regions of Tanzania but the main producing areas include Mtwara (FAO, 2001). Mtwara District is 650 km from Dar es Salaam. The main tribe in the district is Makonde and Makua. It is bordered by Lindi District (Lindi Region) to the North, by the Indian Ocean to the East, the Republic of Mozambique to the South and Tandahimba District of Mtwara Region to the West. The District has an area of 3,597 km^2 of which 72% is arable. The total area which is under cultivation is 48% of the total arable land. Altitude ranges between zero meters along the Indian Ocean coast and 350 metres above sea level in Njengwa, the highest area in the District (Baraldes, 2003). It comprises of 28 Wards and 156 villages (Kuchengo, 2013).

3.2 Study Design

The study employed a cross-sectional design in which data is collected only once and an experimental study which employs laboratory investigation with the standards procedures for a required analysis.

3.3 Study Population, Sampling Frame and Sampling Technique

The study population consistuted of the children aged 6-59 months from six wards, Nanguruwe, Mbawala, Libobe, Mpapura, Mayanga and Mkunwa with a total of 14 villages. Households were randomly sampled from different wards. The reason of using random sampling was to increase the accuracy and to get good result for the research without any bias. The study sample included children aged 6-59 months and their mothers/caregivers as they are the ones responsible for taking care of them including preparation of their foods in the households. The study excluded the children of this age group that are not mentally fit.

The sampling frame for the study population was obtained from the ward's office of each ward of the district that was engaged in the collection of the required infornmation. Based on the available sampling frame of households with children aged 6-59 months, each ward with 20 to 30 households that fit the study criteria was considered for the study, from which households with children of the age 6 months to 59months were randomly selected from the indicated wards so as to conduct the interview.

3.3.1 Sample Size

The sample was computed from the formula reported by Magnani (1997) as described hereunder:

$$n = \frac{t^2 \times p(1-p)}{m^2}$$

Where

n=required sample size

t=Confidence Interval level 95% (standard value 1.96)

p=estimated malnutrition prevalance

m=margin error at 5% (0.05).

With the estimated prevalance of stunting of children below five years of age at 31.65% an average for Mtwara Region, which gives Mtwara Rural district same prevalence (TFNC, 2014). The sample size was thus computed as follows:

$n=1.96^2 x31.65\% (1-31.65\%)/(0.05)^{2,}$

n=332.42

Thus the required sample size was 332 based on the 31.65% prevalence of malnutrition in underfive children in Mtwara districts identified by Kuchengo, 2013.

3.4 Data Collection

3.4.1 Determination of the Nutritional and Anti-nutritional Composition

The Laboratory analysis to determine the nutrients and anti-nutrients content was done the identified cassava roots recipes. The common cassava recipes and methods for their preparations were identified through a dietary consumption assessment method using the 24hours dietary recall questionnaire. The name and proportion of each ingredient used in preparation of cassava food were recorded in the 24 hours dietary recall in which mothers/caregivers responsible for food preparation and feeding children were interviewed. The questionnaires were administered to mothers/caregivers of the physically and mentally able under-five children who could describe properly the diet fed to their children daily.

3.4.1.1 Preparation of Samples of Cassava Recipes

Preparation of the commonly identified cassava recipes were done. Two households were randomly selected under the criteria that, they were involved in data collection from the firststage as respondents and were willing to participate and assist in the study without constraints. The two selected households were asked to prepare cassava meal samples according to each identified recipe. The samples were prepared in duplicates by each household to minimise error.

The ingredients used for preparation of the respective cassava based recipes described during the interview were obtained from a local market, then hamogenization was done accordingly using an electric blender in a well cleaned and dried container for each sample from two different hoseholds. This was done in order to correct the possibles sources of errors that might results during the cooking procedures. The recipes and cooking procedures were simple and clearly described to give the reality of the study and maintaining the consistence of the cooking procedures. The recipes prepared were, coconut recipe, tomato recipe, groundnuts recipes and plain boiled cassava.

After cooking, the samples were left at room temperature 30◦C to cool down for about one hour then packed in duplicates in the freezer bags which were then stored in the freezer model WestPoint (Tropical, made in France) with the temperature set at -20ºC. Freezing reagents offered from the laboratory were also available which were placed in the cool box to contain the samples from the freezer so as to maintain the temperature of the samples during transportation from the study area (Mtwara Rural District) to the laboratory at SUA-Morogoro for analyses.

(i) Preparation of the Plain Cassava Recipe

Fresh cassava was pilled, washed with water and then chopped into small pieces which were placed in a cooking pan. The pan was filled with water up to a level when cassava pices were fully covered and boiled on a firewood stove until when fully cooked and ready for consumption. Only salt was added during cooking to enhance the taste.

(ii) Preparation of the Tomato Cassava Recipe

Fresh cassava was prepared in a similar way as explained in (i). During cooking salt was added and chopped tomato slices was also added when at boiling point. The mixture was then mixed using a wooden spoon to ensure it homogenity and was left to further boil to make a good sauce which was then ready for consumption.

(iii) Preparation of the Coconut Cassava Recipe

The sliced fresh cassava prepared (as described in i) was cooked in cooking pot. Salt was then addeded followed by coconut milk and left to boil until ready for consumption. Coconut milk was obtained by grating and then squeezing the coconut milk out using locally made gadgets.

(iv) Preparation of the Groundnuts Cassava Recipe

The sliced fresh cassava prepared (as described in i). Groundnuts were also peeled and then ground to powder form. During cooking powdered groundnuts was added to prepared The sliced fresh cassava prepared (as described in i) was cooked in cooking pot he cassava before being subjected to boiling because groundnuts need a longer cooking time to get well cooked into desired sensory characteristics. The mixture was then boiled with occassional mixing using a wooden spoon in a firewood stove and further boiled until is ready for consumption.

3.4.1.2 Laboratory Study

This involves analysis of the cassava recipes prepared in accordance to the identified recipes in the study area, in which the nutritional composition of the recipes were determined. Samples from the freezers were defrosted in the oven of brand name Wagtech manufactured in Britain with a temperature set at 40℃ for ten minutes before analysis. The analysis was done for proximate compositiiton of the cassava recipes which are Crude fat, Crude fibre, Crude protein, Moisture content, ash content and total carbohydrates, minerals which are iron, zinc, copper, pottasium, calcium, magnesium and manganeseand Anti-nutrients content which are Phytates and Cyanide.

(a) Proximate Analysis

(i) Determination of Moisture Content

Moisture analysis was be carried out using the drying oven method (AOAC, 1990). This involves measurement of weight loss due to evaporation of water on drying. The loss in weight encountered during drying is equal to the moisture content of the sample. Petri dishes were weighed and their masses recorded. In this study, 0.5 g initial mass of the sample of each sample was weighed into pre-weighed Petri dishes and dried in the drying oven at 105°C overnight. They were cooled in desiccators for 1 hour and re-weighed to give the mass after three hours in grams.

The percentage moisture content was determined according to the formula:

$$Percentage\ Moisture = \frac{Initial\ Mass(g) - Mass\ After\ 3h(g)\ x\,100}{Mass\ of\ \ Sample}$$

(ii) Determination of Ash Content

Ash content was analyzed as per method outlined in the AOAC (1990). Ash (the inorganic residue remaining after the organic matter has been burnt away) is determined by incineration of 2g of each sample in a muffle furnace (Lenton Furnaces, England) at 600ºc for 4 hours. The empty crucibles were weighed with lid on an analytical balance, then 2g of each sample was accurately weighed into the crucibles, the crucibles were be heated on a hot plate until smoke ceased then the crucibles and the lid were transferred into a cool muffle furnace which was set at 600^0C for four hours. When the ash became white, the crucibles were allowed to cool until about 150^0C which were then stored in the desiccator until completely cooled. The crucibles and lids were weighed and weight of ash were determined and the percentage calculated as follows:

$$Percentage\ Ash = \frac{Mass\ of\ \ Ash(g)\ x\,100}{Mass\ of\ \ Sample(g)}$$

(iii) Determination of Protein Content

The Kjeldahl method (AOAC, 1990) was used for proteinanalysis, which is a standard method for determining total nitrogen in foods. This method is based on the assumption that a mixture of pure proteins will contain 16% nitrogen. The nitrogen concentration is determined by converting the nitrogen present in the sample to ammonium sulphate by digesting it in concentrated sulphuric acid (H_2SO_4). The digested sample is then made alkaline with 40% sodium hydroxide (NaOH) (m/v). The ammonia was distilled into excess 4% boric acid solution and was determined bytitration with standardized 0.1N H_2SO_4. Protein content was obtained by multiplying the percentage determined nitrogen by the appropriate factor, which is 6.25.

One gram of each homogenized sample was weighed and transferred into a clean dry digestion tube. The samples were digested with concentrated sulphuric acid for about 3 hours with selenium as a catalyst so as to convert organic nitrogen into ammonium ions. Alkali (NAOH) was added and the liberated ammonia was distilled into a boric acid solution with methyl red and bromocresol green as an indicator which was then titrated against 0.1N hydrochloric acid, in which the end point was detected by grey colour.

The percentage nitrogen content was calculated as follows:

$$\%N = \frac{(Sample\ titre\ in\ ml - blank\ in\ ml)\ x\ 1.4\ x\ Normality\ of\ acid\ x\ 100}{Mass\ of\ sample\ x\ 10}$$

The percentage protein content was calculated as follows:

$$\%\,\mathrm{Pr}\,otein = 6.25\ x\ \%N$$

(iv) Determination of Fat Content

The Soxhlet method was used to determine total fat (AOAC, 1990). Crude lipid was extracted with n-hexane in a soxhlet extractor which was fitted with a reflux condenser and a 250ml round bottom flask containing 150ml of petroleum ether, 0.5g of each sample was weighed into a thimble which was previously dried in the oven then a thimble was plugged lightly with a cotton wool and then placed in the extractor. The source of heat was boiling the solvent which was left to siphon over for 8 hours. After then the condenser was detached to remove the thimble. The round bottom flask containing solvent and the extracted fat was also detached. The flask was placed in the oven at 100^0C and dried to constant weight, which was then cooled in the desiccator and weighed.

The fat percentage was determined from the following formula:-

$$Percentage\ Fat = \frac{Mass\ of\ \ flask\ after\ drying - Initial\ Mass\ of\ \ flask\ x\ 100}{Mass\ of\ \ sample}$$

(v) Determination of Fibre Content

Crude fiber was determined by Kirk and Sawyer (1991) method. Accordingly, 2gm of the sample was defatted in boiled 200cm^3 of 0.1275M sulphuric acid solution for 30 minutes with constant agitation. The boiling mixture was poured into a Buckner funnel and washed with Acetone. Then, the residue was boiled in a 0.313M sodium hydroxide solution for 30 minutes with constant stirring. The residue was mixed with boiling water followed by 1% hydrochloric acid, then washed with boiling water until free from acid. It was dried in an oven to a constant weight.

$$\%Fibre = \frac{Weight\ of\ \ residue - Weight\ of\ \ ash\ x\ 100}{Sample\ weight}$$

(vi) Determination of Total Carbohydrates

The percentage of total carbohydrate was calculated by the difference method of summing the percentage values of moisture, crude protein, ash and crude fat and subtracting the sum from 100 (McDonald *et al*; 1973).

(b) Mineral Analysis

Cassava recipes were analyzed for the minerals (iron, zinc, copper, pottasium, calcium, magnesium and manganese) using the atomic absorption spectrophotometer model iCE3000series (Eslami *et al.,* 2007). Cassava recipes were oven dried and blended into fine powder. Then 20ml HNO_3 was added to 10.0g of the sample portion, and allowed to stand for 15minutes. The mixture was heated until the liquid was reduced to 5ml. After cooling, 20ml of HNO_3, 10ml of H_2SO_4 and 8ml of H_2O_2 was added and the contents were evaporated to 5ml. After cooling, to eliminate residual acid, 10ml deionized H_2O was added and the mixture was boiled for 10min. After cooling the digest was filtered into 25ml volumetric flask and made up to mark with deionized H_2O. Then digestion solutions were subsequently analyzed for iron, zinc, copper, selenium and manganese using Atomic Absorption Spectrometer – Solar in the flame mode.

(c) Anti nutrients Analysis

(i) Phytates Analysis

Phytate content of the samples were done as described by Davis (1981) where 0.1g of finely ground 40 mesh was sample taken into 125ml Erlenmeyer flask. 10ml of 3% TCA solution was added and left to stand for 45 minutes with occasionally swirling. The suspension transferred into 10ml falcon conical centrifuge tubes, 4ml of 0.04M Ferric Chloride in 3%TCA added. The contents were heated in a boiling water bath for 45 minutes followed by centrifugation for 15 minutes at 3000rpm. The supernatant was discarded and residues washed twice with 10ml of 3% TCA in boiling water bath for 10 minutes. The acid washed out with distilled water and 3ml of 1.5N NaOH added and vortex mixed for 1 minute.

The mixer was centrifuged again, supernatant was discarded and precipitates were dissolved with 40ml of hot 3.2N Nitric acid into 100ml and distilled water added to

70ml and 20ml of 1.5N Potassium thiocyanate was added and volume to 100ml volume with distilled water and absorbances at 480nm read within 1 minute using UV-Visible spectrophotometer (X-ma Spectrophotometer, Human Corporation, UK). Standard stock solution was prepared by taking 4.33mg/ml $Fe(NO_3)_3$ into 100ml of a 250ml volumetric flask to make the working solution with the concentration of 0.0433mg/ml $Fe(NO_3)_3$. Serial dilution made to concentrations of 0, 0.0011, 0.0022, 0.0043, and 0.0087mg/ml $Fe(NO_3)_3$ by taking 0, 1, 5, 10 and 20ml of the working standard solution followed by coloration and absorbances read at 500nm. Standard plot of concentration against standard absorbance plot and linear regression equationin the Figure 3.1 was obtained and concentration of unknowns done as presented in Table 4.4.

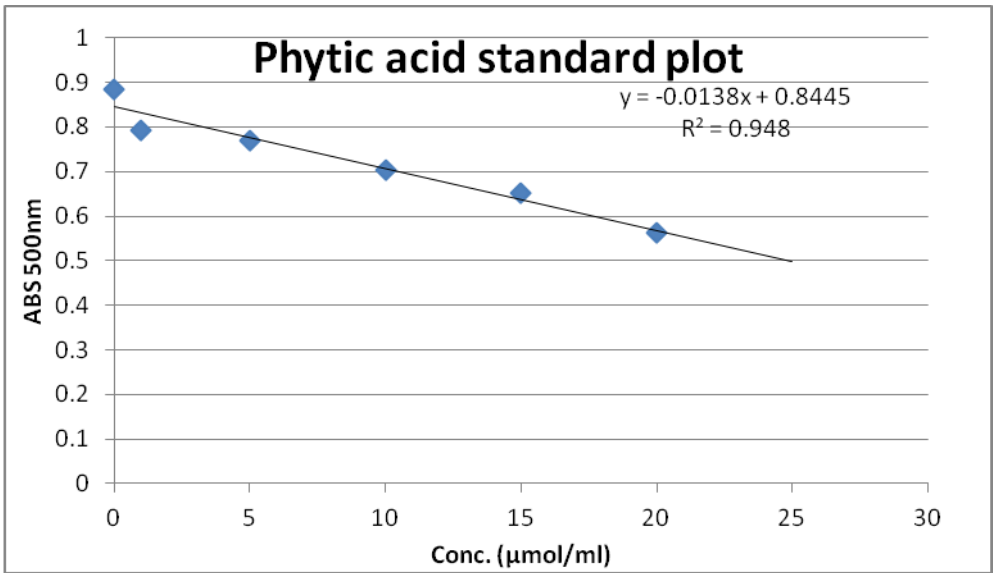

Figure 3.1: Phyid Acid Standard Plot

(ii) Cyanides Analysis

Total HCN (ppm) in the samples was analyzed using the alkaline titration method as obtained from AOAC (1990). 20g of homogenized sample was taken into 800ml Kjeldahl flask, and 200ml of distilled water was added and left stand for 2 hours at room temperature to allow autolysis this followed by steam distillation and 150ml distillate collected 20ml of in 1.6N NaOH. 100ml of distillate was taken into 250ml Erlenmeyer flask, 8ml of 6N NH4OH and 2ml of 5% KI and the mixture was titrated against 0.02N AgNO3. End point was faint but permanent turbidity. The total HCN content in mg/kg was calculated as follows.

1ml 0.02N AgNO3 1.08= 1mg HCN

HCN content =1.08xTV

Where; TV = titre value

3.4.2 Determination of the Cassava Consumption Frequency and Dietary Diversity Score for Children

This involves dietary assessment in which the 24 hrs dietary recall questionnaire was used to obtain the feeding pattern and type of food per day including the recipes used in food preparation. Food Frequency Questionnaire (FFQ) was used to determine frequency of consumption of different food groups in the households in order to derive more habitual intake. In addition Dietary diversity score was computed to determine the composition of their diet as it includes the number of food groups consumed in a meal. Adults were asked to recall for children the exact food taken during previous 24 hours in order to determine individuals usual food intake.

3.4.2.1 Construction of Dietary Questionnaires

Questionnaires were prepared to obtain information about dietary diversity of the selected household and frequency of consumption of different food groups in the households. Also it was designed to obtain information mainly on cassava staple in order to identify different recipes commonly used to prepare cassava for meals, the methods for preparation of the identified cassava meals and the mostly prefered recipes. The questionnaires were constructed in a three stage multiple pass interview (Gibson, 2005), in which the first pass involved a 24-hour dietary recall, second pass involved a food frequency questionnaire and the third part involved dietary diversity to measure food groups consumed.

3.4.2.2 Administration of Dietary Questionnaires

Two enumerators were deployed for the study. One-day training was conducted to teach the enumerators on the aim of the study, familiarise with the methodology of the study specifically on how to conduct the interviews and how to take anthropometric measurements. Pre testing of the questionnaire was also done in nearby households of Mtwara Urban during the training day, the responces had shown the questionnaire to fit for collecting the required information except for anthropometric measurements sections that was incomplete as well as the section on how cassava recipes were prepared, this led to modification of the questionnaire to obtain all required information for a successful study.

3.4.2.3 Dietary Diversity Score

Dietary diversity score assessment was done using a set of food groups as elaborated by Swindale and Bilinsky (2006) written in the questionnaires, questionnaire was used to record responces of the caregivers or mothers if a child consumed any kind of food group mentioned in the questionnaire in the past 24 hours. If the respondent mention that the particular food group was given to the child it was given a score of 1, if not it was given a score of 0.

(i) Determination of Targeted Individual Dietary Diversity Score

The potential score for children range is 0-8 for IDDS (not 0-12 which is the number of food groups in an individual above 5 years of age) that is used to compute each score. An average score for individual dietary diversity score was computed from the score of every household for a particular food group over the overall groups of 8 food groups. See Appendix 5

Individual dietary diversity score (IDDS) was computed based on a set of 8 food groups consumed by members, through the following procedure

$$i.e.\ \ Sum\ IDDS = (S_1 + S_2 + S_3 + S_4 \ldots \ldots \ldots + S_{329})$$

Where S is the score for every single household.

The eight food groups used in the computation of IDDS are (i) Roots and tubers; (ii) Available Vitamin A rich foods (Pumpkin, sweet potatoes, carrots); (iii) Fruits and fruit juices; (iv) Meat, Sea foods and Poultry; (v) Legumes and nuts; (vi) Milk and Milk products; (vii) Eggs; and (viii) Fats and Oil. The average IDDS was computed using the below formula

Computing Individual Average Dietary Diversity Score. DDS (0-8)	Total number of food groups consumed by members of the household. Values for through eight food groups are either "0" or "1" i.e. Sum IDDS=(S_1+S_2+S_3+S_4…….+S_{329}) =808 Where by s- is the score for every single child

$$Average\ IDDS = \frac{Sum(IDDS)}{Total\ Number\ of\ Children}$$

(ii) Determination of IDDS Target for a Particular Population

It is desired that the changes in IDDS be compared to some meaningful target level of diversity. Unfortunately, normative data on 'ideal' or 'target' levels of diversity are usually not available but options are available to determine appropriate target levels whereby an IDDS target for the population can be established by taking the average diversity of the 33 percent of individuals with the highest diversity score (upper tercile of diversity) within the population (Swindale and Bilinsky, 2006).

3.4.3 The Contribution of Cassava to the Recommended Dietary Allowance of Iron, Zinc, Protein and Fat Among the Children Aged 6-59 Months

To obtain the contribution of cassava to the recommended dietary allowance of iron, zinc, protein and fat, the computation of RDA Percentages from cassava meal was obtained from the formulas indicated in the sections below based on the amount of nutrient intake by a child from a cassava meal.

3.4.3.1 Determination of Nutrient Intake of the Study Population out of Cassava Consumption

The average amount of nutrient intake were derived from the amount of cassava meal consumed (grams) in a day by each child under the study, from which the average amount (in grams) of cassava meal consumed by all children was obtained by summing up and dividing by the total number of children. This provided a leading value (average amount consumed) which was used to calculate the amount of nutrient intake for each particular nutrient selected in the study.

Amount of nutrients taken from proximates was computed as follows:

$$Nutrient\ Intake\% = \frac{Quantified\ Nutrient\ Content\ in\ a\ Sample(\%)\ x\ Average\ Cassava\ Intake\ Per\ Day(g)}{Sample\ Weight(g)}$$

Amount of nutrients taken from minerals was computed in weight basis as follows

$$Nutrient\ Intake(mg) = \frac{Quantified\ Mineral\ Content(mg)\ x\ Average\ Cassava\ Intake\ per\ Day(g)}{1000g}$$

3.4.3.2 Computation of RDA Percentages from Cassava Meal

The percentage of RDA's was computed from the formula below based on the amount of nutrient intake by a child from a cassava meal. The percentages that nutrients from both proximates and minerals contributed to the standard RDA were calculated from the formula below:

$$Percentage\ of\ a\ Nutrient\ in\ RDA = \frac{(Amount\ of\ Nutrients\ Taken)\ x\,100}{RDA\ Amount}$$

3.4.4 Determination of Nutrition Status of the Children

Nutrition status of children was determined by using anthropometric measuremenst. Children were made to minimal clothing following standard procedures for measurements to ensure accuracy in all measurements taken.

3.4.4.1 Height

Height was measured by using a Heigh Board (Stadiometer) of UNICEF manufactured in Maryiland. The children age 6 -24 months was placed to the nearest 0.5 cm along length board then measurement was taken and the children above 24 months stood straight along length board then measurement was recorded.

3.4.4.2 Weight

Chidren's weight was measured using Weighing Scale (UNISCALE) with a brand name SECA manufactured in German modal 874 1021659, scale was be adjusted to zero before starting the measurements. Children's weight were recorded, but for a child that was carried by a caregiver on a weighing scale, to obtain the weight of this child, the recorded weight of the caregiver alone was substracted from the recorded weight of the caregiver + child and recorded.

3.4.5 Assossiation Between Children's Cassava Consumption Frequency and Their Nutritional Status

The cassava consumption pattern documented for each individual and the anthropometric measurements recorded were used to evaluate the existence of any association between cassava consumption and the nutritional status of the children aged 6-59 months. Descriptive statistics were used to determine the associations by cross tabulations.

3.5 Statistical Analysis

Objective 1: Nutritional composition (proximate composition and minerals) and anti-nutritional factors (phytates and cyanides) of the identified cassava recipes. In the identification of the most consumed cassava root recipes in Mtwara Rural District, data gathered through questionnaires were subjected to statistical analysis. Descriptive analysis was used to analyze data on recipes used to prepare cassava prior meal in order to establish the commonly consumed cassava recipes. SAS statistical package was used for analysis in which the variability of nutrients between recipes was tested among the test treatments. The nutrients levels obtained from each treatment was subjected to statistical analysis using one way analysis of variance (one way ANOVA) test and the difference in means will be compared using the t-test Least Significant Difference at ($p \leq 0.05$).

Objective 2: The cassava consumption pattern and individual's average nutritional intake per day.

Descriptive statistical analysis was used to establish frequencies and percentages of various variables of the dietary diversity and cassava intake as well as the mean frequency of cassava and dietary intake. Information from the questionnaires were coded and analyzed by using IBM SPSS Statistical Package version 20.0.

Objective 3: Contribution of cassava to the recommended dietary allowance of selected nutrients among the children aged 6-59 months.

Univeriate regression analysis was used to establish association between RDA as a dependent variable and nutrient from cassava as independent variables that contribute to the total RDA intake.

Objective 4: The nutrition status of the children aged 6-59 months through anthropometric measurements.

WHO Anthro (World Health Organization Anthro) growth standards of 2006 taking -2SD as cut-off points was used to convert raw anthropometric data (weight, height and age of the children) into anthropometric Z-score for Height for age (HAZ), Weight for age (WAZ) and Weight for Height (WHZ) that was used to classify children into levels of nutritional status (stunting, wasting and underweight). The statistical significancy difference of the nutrition status between the two categories of male and female was analysed using chi-square test.

Objective 5: To evaluate the assossiation between individuals cassava consumption pattern and their nutritional status.

Chi square was used to analyse and establish association between the variables cassava consumption frequency, gender and nutrition status of the children aged 6-59 months using cross tabulation.

3.6 Ethical Considerations

Permission to conduct research in the Region was sought by Regional Administrative Secretary who directed to obtain the district permission sought by the District Executive Director and he directed the permissions to enter in the district wards to be sought by the District Administrative Secretary to the district officers. Oral consents were obtained from children's parents or caretakers.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion of the study. It is divided into five sections which are refelective of five study objectives. Section one focuses on determination of the nutritional composition of proximate and minerals as well as anti-nutritional factors of phytates and cyanides of the identified common cassava recipes in Mtwara district. Section two presents the cassava consumption frequency and dietary diversity score for children. Section three covers the contribution of cassava to the recommended dietary allowance of iron, zinc, protein and fat among the children aged 6-59 months. Section four determines the nutrition status of the children aged 6-59 months.. Section five evaluates the assossiation between individuals cassava consumption pattern and their nutritional status. The study data are based on 329 eligible children instead of 332 targeted sample size due to some exclusion criteria. This indicates a participation rate of 99.1%.

4.2 Nutritional and Anti-Nutritional Composition of Cassava Based Recipes

The nutrients levels of Carbohydrates, crude protein, crude fibre and crude fat, and minerals namely Ca, Mg, K, Zn, Cu, Fe and Mn as well as the anti nutrients such as cyanides and phytates in the four cassava based recipes were analysed following the identification of most common cassava recipes consumed by children.

4.2.1 The Most Consumed Cassava Root Recipes for Children

Cassava is a staple crop in Mtwara Region and there are several cassava based recipes that are consumed by the population within the Region. It was therefore important to identify the mostly consumed cassava root based recipe to be able to determine the their nutritional and antinutritional composition. Four cassava based recipes were identified which included coconut cassava recipe (CCR), groundnut cassava recipe (GCR), tomato cassava recipe (TCR) and plain cassava recipe (PCR) (Table 4.1).

Even though several other recipes were mentioned and described but only those four were identified as the most commonly consumed recipes. In terms of consumption frequency. Of the four cassava based recipes it was indicated that PCR was the most commonly used cassava based recipe at the frequency of about 97% and GCR was the least used cassava based recipe at a consumption frequency of 2.13%. On the other hand, CCR (40.7%) and TCR (6.7%) ranked second and third respectively. The percentages were obtained from the total number of study population which is 329, every individual was asked to describe the recipe they use to prepare cassava staple, not necessarily in a single day but on frequency of consumption. Davidson *et al.*, (2017) also indicated about 92% of the study population had consumed cassava-based dish within 24 hours prior to an interview in the study conducted in Nigeria. Total number of individuals consuming a similar recipe was computed for each recipe to obtain the score in percentage of individuals consuming one recipe over the whole study population, the reasons behind use of certain recipes were described. The reasons for the high consumption frequency of PCR and CCR in the present study were indicated to be affordability of the former as it was the cheapest of all and also the readily availability coconut for CCR preparation, coconut is one of the most cultivated perennial crops in the district. Despite PCR being the most consumed recipe the mostly liked recipe (D. Nicodemas per comm.) was indicated to be CCR due to its delicious taste which is attributed to coconut as one of the ingredient (Usmal *et al.*, 2015). Though CCR is costly, however in special occasions is the mostly consumed recipe especially during fasting seasons, and is locally known as Futari (*Iftar*).

According to Usmal *et al.*, (2015) dietary fats that provide essential fatty acids have been shown to enhance the taste and acceptability of foods, slows gastric emptying and intestinal motility thereby prolonging satiety and facilitating the absorption of liquid soluble vitamins. This could as well explain the reason for high preference of CCR to other recipes by the majority of the respondents as coconut juice has considerable amounts of fats compared to other nuts like groundnuts (Okorie *et al.*, 2012).

The percentage of individuals consuming a certain recipe over other recipes described does not necessary indicate the score of its use in the population as other households were using more than one recipe to prepare cassava meal.

Table 4.1: Cassava Recipe Users in a Study Population on Daily Basis Among Children

Recipe	**N=329**	**%**
CCR	134/329	40.7
PCR	319/329	96.9
GCR	7/329	2.13
TCR	22/329	6.7

CCR: Coconut cassava recipe, PCR: Plain Cassava Recipe, GCR: Groundnuts Cassava Recipe, TCR: Tomato Cassava Recipe

4.2.2 Nutritional and Anti-nutritional Composition in Cassava Based Recipes

The nutrients levels, that is, Carbohydrates, crude protein, crude fibre and crude fat, and minerals namely Ca, Mg, K, Zn, Cu, Fe and Mn as well as the anti nutrients such as cyanides and phytates in the four cassava based recipes are presented in Table 4.2. The nutrients and anti-nutrients content show both significant ($p<0.05$) and non significant ($p \geq 0.05$) variations among cassava recipes (Table 4.2).

4.2.2.1 Proximate Composition of the Identified Cassava Recipes

The proximate composition among different recipes (Table 4.2), show non significant variation among recipes in protein and fibre contents but significant variations in fats, moisture contents, minerals, ash and carbohydrates. The fat content indicated significant differences ($P < 0.05$) between CCR and the rest (TCR, PCR, GCR) but no significant differences ($P \geq 0.05$) were observed among TCR, PCR and GCR on fat composition. The highest fat content was recorded in CCR (3.67±0.20%) and the lowest in PCR (0.18±0.13%). The protein content did not show significant variations among the four cassava recipes. The highest but insignificant protein content was recorded in CCR (0.53±0.47%) and the lowest in TCR (0.06±0.00%). The minimum and maximum fibre content was 3.20±0.78% and 1.87±0.05% for CCR and TCR respectively. The differences in fibre contents were however insignificant ($p<0.05$) between the four recipes. The moisture content was found in the range of 73.55±0.27 and 67.28±0.18% where as the highest moisture content was recorded for PCR and the lowest for CCR. Significant difference in moisture content ($P <0.05$) was between PCR and the other three recipes, that is, CCR, GCR and TCR. However, no significant difference was recorded ($P \geq 0.05$) among those other three recipes.

On the other hand carbohydrate content ranged from 21.69±0.67 to 24.4±0.39% with the lowest carbohydrate content found in PCR and the highest in CCR The variations in carbohydrate content was however insignificant ($P < 0.05$) among CCR, GCR and TCR but were significant between CCR and PCR. The order of variation in a decreasing order was CCR > TCR > GCR > PCR.

Table 4.2: Proximate Composition of the Four Cassava Recipes

Recipe	%Protein	%Fat	%Fibre	%Moisture	%Ash	%CHO
CCR	0.53^{a}±0.47	3.67^{a}±0.20	3.20 ^{a}±0.78	67.28 ^{b}±0.18	1.34^{c}±0.01	24.44^{a}±0.39
PCR	0.07^{a}±0.01	0.18^{b}±0.13	2.63 ^{a}±0.55	73.55 ^{a}±0.27	1.87^{a}±0.02	21.69^{b}±0.67
GCR	0.12^{a}±0.00	0.39^{b}±0.02	3.06 ^{a}±0.12	71.64 ^{a}±0.21	1.53^{b}±0.03	23.25^{ab}±0.37
TCR	0.06^{a}±0.00	0.32^{b}±0.04	1.87 ^{a}±0.05	72.47^{a}±0.39	1.23^{c}±0.01	24.05^{ab}±0.36

CCR -Coconut cassava Recipe meal, PCR - Plain cassava recipel, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe. Values with different superscripts down the column are significantly different from each other at $p<0.05$

(i) Protein

Protein content did not show any significant variations between recipes. However, contrary to the results of the previous study, Awad (2013) found higher protein content in pure groundnuts than in pure coconut which was attributed to the inclusion of groundnuts, he also said nuts play an important role in manufacturing of various functional food products due to high protein. Bankole *et al.*, (2013) demonstrated increased protein content when cassava was fortified with groundnut flour. Such inconsistencies could be attributed to several factors that influence the protein contents of groundnuts such as environmental conditions such as temperature, moisture content, initial quality and mycoflora that affect protein viability during storage (Jyoti and Malik, 2013).

Generally the protein content recorded in the present study (0.06±0.00 to 0.53±0.47%) was lower than those reported by Odebunmi *et al.*, (2007) for cassava of 2.84±0.00%. However it has been indicated that the nutritional content of cassava depends on specific plant part roots or leaves, geographic location, variety, age of the plant and environmental conditions (Salvador *et al.*, 2014).

Protein is an important nutrient in addressing protein energy malnutrition hence recommended for supplementing meals of communities consuming cassava (Ouattara, 2015). Also nutritional importance of groundnuts is due to the energy and growth supplementing constituents present in them which include protein, thus groundnuts, which are a rich source of protein and essential amino acids, can help in preventing malnutrition as well (Settaluri *et al.,* 2012). Therefore consumption of nuts will help to supplement the nutrients of stable carbohydrate foods such as cassava as seen in the study to the poor who cannot afford enough protein foods of animal origin. This implies that the incoperation of nuts for human nutrition supplements protein for body and health requirements.

(ii) Fat

Fat contents of the four recipes indicated significant difference between coconut cassava recipe (CCR) and the other recipes (TCR, PCR, GCR) ($P < 0.05$) but no significant ($P \geq 0.05$) differences were observed among TBR, PCR and GCR. The fat content in descending order was as follows; CCR > GCR > TCR > PCR (Table 4.2). The highest significant amount of fat recorded in CCR could be attributed to coconut milk due to its richness in the same. The study conducted by Okorie *et al.* (2012) also observed higher fat content in coconut than in groundnuts. A similar observation was also documented by Ayoolo *et al.* (2012). On the other hand, Omosuli (2014) in his research on the nutritional content of raw and boiled cassava indicated a reduction in fat content in boiled cassava compared to raw cassava. Those findings could also explain the lowest fat content recorded in PCR in the present study. The fat contents in the recipes that ranged from 0.18±0.13 to 3.67±0.20% compare well with those reported by Odebunmi *et al.* (2007) for cassava (0.18±0.03%).

The results of the present study indicate that coconut cassava recipe is the best recipe as a source of energy. Coconut milk contains a very high level of saturated fats, but the saturated fats found in coconut milk are mainly short and medium chain fatty acids, which are usually not stored by the body as fats (Patrick, 2013). Instead, such short and medium chain fatty acids have been found to provide instant energy to the body for proper growth, and for keeping you healthy. A completely fat-free diet would not be healthy.

(iii) Fibre

In terms of fibre contents similarly no significant variations were observed though the highest amount was observed in CCR and lowest in tomato cassava recipe. High fibre content was also recognized by Usmal *et al.* (2015) who recommended addition of coconut in breakfast cereals which serves as a nutritious and healthy source of dietary fiber in the food products that were under study. The results of this study also indicates that ingredients such as nuts coconut and groundnuts are richer sourses of fibre compared to tomatoes. Fibres are recognized for their physiological role of maintaining an internal distension for peristaltic movement of the intestine (Makori *et al.*, 2017) thus higher fibre contents are not advisable in infant foods. The fibre content for the recipes which ranged from 1.87$\pm$0.05 to 3.20$\pm$0.78% was slightly higher than that reported by Odebunmi *et al.* (2007) of 1.38$\pm$0.03% for cassava. This could well be due to the inclusion of other ingredients and / or due to factors explained by Salvador *et al.* (2014) as determinants of nutritional variations in cassava. However established content levels are lower than the recommended fibre level of 19-25g (FNB *et al.*, 1989) for children below five years of age.

Dietary fibre has been shown to have important health implications in the prevention for risk of chronic diseases such as cancer, cardiovascular diseases and diabetes mellitus. Eating a meal rich in fibre has been shown to reduce the risk of heart diseases. High-fibre foods are of more benefit than foods with fibre supplements (Otles and Ozgoz, 2014). Crude fibre helps in the maintenance of normal peristaltic movement of the intestinal tract hence; diets containing lower fibre could cause constipation, and eventually lead to colon diseases (Omosuli, 2014).

(iv) Moisture

The levels of water in the four recipes were in this descending order; PCR > TCR > GCR > CCR (Table 4.2). The moisture content indicated significant differences (P <0.05) between PCR (which had the highest content) and the other three recipes, that is, CCR, GCR and TCR. The low moisture in other recipes could be attributed to significant electrolyte contents of the added ingredients. According to Usman *et al.*

(2015) moisture content has an implication on their stability and overall quality. Nevertheless the moisture content reported in the current study (67.28+0.18 to 73.55+0.27%) compared well with that reported by Odebunmi *et al.* (2007) of 68.8+0.08%.

The fact that CCR has highest fat content it has impact on its moisture content making it lowest, this series is linked to GCR which has high fat content and low moisture content next to CCR. This was proved by a study conduccted by Tyasia (2016) found that the lower moisture content also had much greater amounts of surface oil than the higher moisture content which can also be proved in this study as the PCR has the highest moisture content but the lowest fat content.

The higher the moisture content the low the shelf life of a product and viceversa. This could be why cassava utilization of the fresh roots has been limited by the extreme perishability when stored, that is why it is mostly stored in dry form in areas where cassava is staple.

(v) Ash

Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within a food. The content of ash was significantly higher ($P < 0.05$) in PCR than in the other three recipes (CCR, GCR, and TCR) and also the significant variations ($P < 0.05$) were observed between GCR and both CCR and TCR but the variations were not significant ($P \geq 0.05$) between CCR and TCR. The ash mineral levels in these recipes were in this order PCR > GCR > CCR > TCR (Table

4.2), which implies the possibility of dilution of the mineral levels due to the addition of other ingredients in the preparation of those recipes. Various studies have supported these findings, for example the study conducted by Emmanuel *et al;* 2012 has found the ash content of 2% in cassava.

A study conducted by Ayoola *et al.,* 2012 has shown the ash content of 1.4% in groundnuts. Another study conducted by Alyaqoubi *et al.,* 2015 has shown that the ash content in plain coconut is 0.8%, Romero *et al.,* 2008 have shown the ash content of 0.6% in plain tomato. These findings cleary supports the findings that PCR > GCR > CCR > TCR and this is how it has contributed to the ash content of cassava meals under the study

(vi) Carbohydrates

Carbohydrate contents also did not show significant difference ($P < 0.05$) among CCR, GCR and TCR but the differences were significant between CCR and PCR at $p \geq 0.05$, GCR and TCR. The GCR and TCR recipes did not differ in carbohydrate content significantly of 23.25±0.37% and 24.05±0.36% respectively with the PCR having least carbohydrate content of 21.69±0.67% (Table 4.2), the order of variation in a decreasing order was CCR > TCR > GCR > PCR. The higher carbohydrate content in CCR and its richness in fat contents imply a high calorific value of the recipe (CCR) in which raw cassava was seen by another researcher to provide 667kj which is twice the one provided by potatoes (Nginya 2015).

Furthermore, carbohydrates contribute to the taste, texture and appearance of foods and help to make the diet more varied and enjoyable (EUFIC, 2012), this is also proved from this study through usage rate over the recipe to other recipes (refer to objective 1), this could as well assist to explain the high consumers' use of CCR to other recipes.

On the other hand the carbohydrate content recorded in the present study of 21.69±0.67 to 24.4±0.39% was slightly lower than that reported by Odebunmi *et al.* (2007) of 28.05±0.06%. Salvador *et al.* (2014) linked the variations in nutritional content of cassava with specific plant part of roots or leaves, geographic location, variety, age of the plant and environmental conditions. Coconut recipe makes cassava meal a good provider for readily accessible fuel for physical performance. This is supported by a study conducted by Omotosho, 2012 who found the macro nutrient-glucose coconut very rich and more abundant than in other analysed products. This implies that coconut as a recipe for cassava meal, makes it a good source of energy.

In view of the specific daily nutrient body requirements as described by the Dietary Reference Intakes (2014), the RDA for protein for the children aged 6months to 59 months ranges from 11g/l to19g/l and the RDA for carbohydrates for children aged 1-5 years is 130g/d and 95g/d for children aged 6 months. However the maximum protein and carbohydrate contents recorded among the four cassava recipes were 0.53+0.47% and 24.4+0.39% respectively both for CCR. Based on those RDA for both protein and carbohydrate for the under-fives and the maximum amount of the same recorded among the four cassava recipes suggest that the RDAs for both macronutrients based on the identified cassava based recipes can hardly be met unless the formulations are further improved and diversified. However this could well be verified based on the amount that could be supplied by the recipes per day.

4.2.2.2 Mineral Composition of the Identified Cassava Recipes

Minerals are important micronutrients in maintaining human health and have varied roles. Various minerals for the commonly consumed cassava recipes were also quantified. The results as seen in Table 3 have shown that there is significant difference in minerals composition among different cassava recipes. Where by other recipes did not show the significant difference in some minerals.

The calcium content ranged from 70.95+2.42 to 96.5±0.14 mg/kg, with the highest calcium content found in CCR and the lowest observed in TCR. PCR and GCR were 2nd and 3rd respectively in terms of calcium contents. Significant variations in Ca ($P < 0.05$) were recorded between CCR and both GCR and TCR and also between TCR and both PCR and GCR. Magnesium content varied between 243.77+7.48 and 309.62+0.02mg/kg whereas the highest was recorded in GCR and lowest in PCR. CCR was next in richness to GCR. Significant difference ($P < 0.05$) in magnesium content was observed between CCR and PCR and between PCR and GCR but no significant variation ($P \geq 0.005$) were observed among CCR, GCR and TCR. On the other hand, potassium content ranged from 0.02+0.00 to 0.03+0.00 mg/kg, with the lowest amount recorded in PCR and the highest in CCR, TCR and GCR which had equal amounts.

Similarly the variation was significant ($P < 0.05$) between PCR and the rest (CCR, TCR and GCR). The highest zinc content was found in CCR (2.78+0.26mg/kg) and the lowest in PCR (1.91+0.48mg/kg), however the variations were insignificant ($P \geq 0.05$) among the four recipes. In terms of copper, TCR had significantly high levels of copper (3.04+0.67mg/kg) compared to the other recipes. However, no significant variations (P≥0.05) were observed among CCR, PCR and GCR. The lowest copper content was recorded in GCR (1.52+0.16mg/kg). Iron content on the other hand varied between 4.41+1.12 and 7.46+0.25mg/kg with the highest iron content quantified in TCR and the lowest in PCR. Iron content varied significantly (P < 0.05) between CCR and TCR and between PCR and TCR but no significant differences were observed between CCR, PCR and GCR. Manganese content varied between 1.77+0.06 and 3.71+0.01mg/kg, with the highest content recorded in CCR and the lowest in TCR. Significant variations (P < 0.05) were found between CCR and the rest (PCR, GCR and TCR) and between PCR and TCR but were insignificant (P≥0.05) between GCR and TCR.

Table 4.3: Minerals Composition of the Four Cassava Recipes

Recipe	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)
CCR	$96.50^{a}\pm0.14$	$288.24^{ab}\pm2.37$	$0.03^{a}\pm0.00$	$2.78^{a}\pm0.26$	$1.63^{b}\pm0.00$	$6.78^{cb}\pm0.82$	$3.71^{a}\pm0.01$
PCR	$91.24^{ab}\pm5.74$	$243.77^{c}\pm7.48$	$0.02^{b}\pm0.00$	$1.91^{a}\pm0.48$	$1.66^{b}\pm0.42$	$4.41^{c}\pm1.12$	$2.90^{b}\pm0.37$
GCR	$84.23^{b}\pm2.62$	$309.62^{a}\pm0.02$	$0.03^{a}\pm0.00$	$1.99^{a}\pm0.18$	$1.52^{b}\pm0.16$	$5.28^{cb}\pm0.87$	$2.24^{cb}\pm0.01$
TCR	$70.95^{c}\pm2.42$	$261.59^{bc}\pm10.84$	$0.03^{a}\pm0.00$	$1.98^{a}\pm0.07$	$3.04^{a}\pm0.67$	$7.46^{b}\pm0.25$	$1.77^{cd}\pm0.06$

CCR-Coconut Cassava Recipe, PCR-Plain Cassava Recipe, GCR-Groundnuts Cassava Recipe, TCR-Tomato Cassava Recipe

Values with different superscripts down the column are significantly different from each other at p<0.05.

(i) Calcium

Significant variation in calcium (P < 0.05) was recorded between CCR and both GCR and TCR and also between TCR and both PCR and GCR. The current findings which indicated CCR to be the richest source of calcium are supported by Omotosho and Odeyemi (2012) whose research on coconut bio-nutrients constituents indicated that macro nutrient calcium was significantly high in coconut milk. The literature has shown that nuts are good source of calcium but coconut is richer in calcium than groundnuts as evidenced by the present study. The findings of Udeze *et al.* (2014) who measured the minerals content of beverage blended with coconut and groundnuts similarly showed that coconut was making the beverage richer in calcium.

In the present study the calcium content which varied between 70.95+2.42 to 96.5+0.14 mg/kg was higher than that reported by Odebunmi *et al.* (2007) for dried cassava flour of 1.11 mg/kg. The variation could be attributed to processing method, inclusion of other ingredients in the recipes or to factors described by Salvador *et al.* (2014) as determinants of nutrient variations as well as geographical location, variety, plant age and environmental condition (Montagnac *et al.,* 2009). Calcium is responsible for bone formation in conjunction with phosphorus, magnesium, manganese, vitamin A, C and, chlorine and protein (Omosuli, 2014). This is why education on nutritional diversification is important to ensure a healthy and a nutrition secured community.

(ii) Magnesium

The findings indicated higher amount of magnesium in GRC than in other recipes which varied significantly ($P < 0.05$) with the Mg contents of both PCR and TCR but varied insignificantly ($P \geq 0.05$) with the Mg content of CCR. The results agrees well with previous findings which examined the minerals contents of groundnuts and coconut and found that groundnuts were richer in magnesium content, that is, 0.176% (Settaluri *et al;* 2012) and 0.18% (Ayoola *et al.,* 2012) as compared to coconut that had less amount, 0.095% (FAO, 2017).

However the findings of the present study for magnesium contents which ranged from 243.77+7.48 to 309.62+0.02mg/kg was extremely higher than that reported by Odebunmi *et al.* (2007) of 12.54mg/kg for dried cassava. This variation could be attributed to the composition of the cassava based recipes, processing methods and other determining factors (Salvador *et al.,* 2014). Magnesium is an important requirement for normal functioning of both anaerobic and aerobic metabolism and activation of some critical enzyme systems (watts, 1988).

(iii) Potassium

The potassium content was similar between coconut cassava recipe (CCR), tomato cassava recipe (TCR) and groundnut cassava recipe (GCR) all of which had same concentration of 0.03 ±0.00mg/kg and the lowest content was recorded in plain cassava recipe (PCR) which also varied significantly ($P < 0.05$) from the rest. The findings correlate the results of a coconut study by Omotosho and Odeyemi, 2012 who said that potassium is not only the most abundant mineral in human body but it is also one of the most abundant in coconut fruit. Among the many functions of potassium in the body are regulation of the heartbeat and the functions of the muscles.

(iv) Zinc

None significant ($P \geq 0.05$) variation was observed among recipes in zinc content. However, the high insignificant zinc content in CCR was in agreement with previous findings (Omotosho and Odeyemi, 2012) that recorded high zinc contents in coconut milk for culinary use. On the other hand the significantly high ($P < 0.05$) copper content found in TCR is supported by Aydinalp *et al.* (2012) who also found higher copper in tomato than in other plant fruits. Odebunmi *et al.* (2007) reported 0 mg/kg zinc content in dried cassava contrary to the present findings in zinc content which varied from 1.91+0.48 to 2.78+0.26mg/kg. The earlier explanation for the variations reported for other minerals could as well explain this variation. With coconut consumption cases such as growth retardation and infertility can be reduced because 50% of daily dietary requirement of zinc can be provided (Omotosho and Odeyemi, 2012).

(v) Copper

Results on copper content indicated that Tomato cassava recipe has significantly high levels of copper compared to the other recipes. No significant variations ($P \geq 0.05$) were observed among the remaining cassava based recipes (Table 4.3). These results are in agreement with the observation by Aydinalp *et al.*, 2012 who found that tomato had significantly high copper content compared to other plant fruits that had less copper content.

(vi) Iron

Iron content varied significantly ($P < 0.05$) between CCR and TCR and between PCR and TCR but no significant differences were observed between CCR, PCR and GCR. Omosuli, (2014) in his investigation of the nutritive composition of raw and boiled cassava, indicated that mineral contents of cassava tubers were not affected significantly by boiling except iron. This could as well explain the lowest iron contents recorded in PCR. On the other hand the higher content of iron in other cassava based recipes could be attributed to the inclusion of other ingredients which possibly enriched and / or counteracted the effect of boiling. The highest amount of iron was recorded in TCR. The findings of the present study generally indicate that plant products like coconut, groundnuts and tomatoes are valuable sources of minerals and other nutrients which could carter for the nutritional needs of the population at a minimal cost. Nevertheless iron content for the recipes recorded in the present study (4.41+1.12 to 7.46mg/kg) was lower than that reported by Odebunmi *et al.* (2007) for dried cassava (18.8 mg/kg). This variation could as well be due to the composition of the cassava based recipes, processing methods and other determining factors (Salvador *et al.,* 2014).

The higher content of iron in cassava based recipes implies that the added ingridients contributed to that increase as earlier said. Mirsm *et al.,* (2014) also reported significantly higher iron content in iron (65.78mg/l) compared to iron content in coconut documented by Omotosho and Odeyemi to be (24.56 mg/l) which further indicates its significance in raising the iron content of the cassava meal when used as a recipe.

(vii) Manganese

Managanese (Mn) concentrations were highest in CCR and lowest in TCR. Plain cassava recipe-PCR was second in terms of Mn concentration and GCR was third with a concentration. The richness of CCR in Mn content which varied significantly from the rest could be explained by the inclusion of coconut milk. Similarly the higher content of Mn recorded in the present study that varied between 1.77+0.06 and 3.71+0.01mg/kg compared to that reported by Odebunmi *et al.* (2007) for dried cassava (0.34mg/kg) could be linked to similar factors explained earlier. This shows how coconut has added value to cassava meal making it potential in meeting human needs requirements which appears to be a minimum intake of 2.5 to 7 milligrams per day (Watts, 1990). Manganese is vital for metabolic and neurological functions of the body. Different studies conducted on the manganese content in edible parts of plants have shown tomato to have a manganese content of 7.1mg/kg (Bosiacki and Tyksinski 2009) and coconut has a manganese content of 13.04 mg/kg (USDA, 2004) which is far more from tomato, the difference in nutritional value of recipes is what reflects their contribution to the highest and lowest manganese content of cassava recipes identified.

On the other hand, the RDAs for various micronutrients for children aged 6 months to five years are 260mg/l to 1000mg/l for calcium, 75mg/l to 130 mg/l for magnesium, 0.7mg/l to 3.8mg/l for potassium, 3mg/l to 5mg/l for zinc, 10mg/l to 11mg/l, 0.6mg/l to 1.5mg/l for manganese and 220mg/l to 440mg/l for copper (Dietary Reference Intakes, 2014). In view of the maximum amounts of the same micronutrients recorded for the cassava based recipes, Calcium 96.6 mg/kg in CCR, Magnesium 309.6 mg/kg in GCR, potassium 0.03mg/kg in CCR, zinc 2.78mg/kg zinc in CCR, iron 7.46 mg/kg for TCR, manganese 3.71mg/kg for CCR and copper 3.04 mg/kg, the RDA for some minerals magnesium and manganese can easily be met while for the other minerals calcium, potassium, zinc, iron and copper can hardly be met without proper dietary formulation, diversification and / or supplementation.

4.2.2.3 The Anti-nutrients Composition of the Four Cassava Recipes

The present study also examined the two anti-nutritional factors namely cyanide and phytate in the four cassava based recipes. The results for cyanide and phytate content are presented in Table 4.4. The cyanide content ranged from 0.32µmol/g to 0.43µmol/g, with the highest content found in CCR and GCR (which had equal amounts of cyanide) and the lowest cyanide content was recorded in PCR. Phytate contents varied significantly among recipes with GCR registering the highest content (712.18+16.0 mg/100g) and CCR the lowest phytate content (78.73+0.57 mg/100g). Other recipes (TCR and PCR) had 677.10 ±3.31mg/100g and PCR 319.78± 0.48mg/100g respectively.

Table 4.4: Anti-nutrients Composition of the Four Cassava Recipes

Recipes	Cyanide Conc (mgHCN/100g)	Phytate (μmol/g)
CCR	$0.43^{a}\pm0.00$	$78.73^{d}\pm0.57$
PCR	$0.32^{b}\pm0.00$	$319.78^{c}\pm0.48$
GCR	$0.43^{a}\pm0.00$	$712.18^{ab}\pm16.00$
TCR	$0.38^{ab}\pm0.05$	$677.10^{b}\pm3.31$

CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe. Values with different superscripts down the column are significantly different from each other at $p<0.05$

NB: conversion factor of cyanide from (μmol/g) to ppm is 23.4 (JAMA, 2000).

(i) Cyanide

The highest but equal amounts of cyanide were recorded in CCR and GCR, nevertheless the levels of cyanide in all four recipes were within the safe WHO level of 0.43μmol/g (Cardoso *et al.,* 2005). However, these results contradict previous findings on cyanide contents. Olorunfemi and Afobhokhan (2012) determined enzymically the cyanide content in dried cassava cake (*garri*) in two varieties of the tubers which are Tropical Manoic Selection 1 and Tropical Manoic Selection 91954 treated with palm oil, groundnut oil and coconut oil. Their results revealed that treatment of cassava mash with the vegetable oils yielded about 99.8% reduction in the total cyanogenic content at seven days of fermentation. From an initial concentration of 10.35 mg HCN eq/mg in the sweet variety of fresh cassava tubers which is Tropical Manoic Selection1, the cyanogenic content at the end of fermentation period was reduced to 0.02500, 0.02550 and 0.0253 mg HCN eq/mg by palm oil, groundnut oil and coconut oil respectively.

Similarly, they indicated bitter cassava variety which is Tropical Manoic Selection 91954 was reduced from 14.54 mg HCN eq/mg to 0.03080, 0.02520 and 0.02560 mg HCN eq/mg by palm oil, groundnut oil and coconut oil respectively. The argument behind was that vegetable oils increased the temperature of grated cassava varieties to allow breakdown of cyanogenic glycosides and facilitated volatilisation after processing into *garri*. From their findings one would have expected PCR to be richer than both CCR and GCR in cyanide content however that was not the case. This could probably be attributed to the acidic nature of the recipe due to fermentation and the time duration for storage of the recipes.

Cardoso *et al.,* (2005) also documented that, the losses of cyanide on steaming, baking or frying are much smaller than on boiling because of the stability of linamarin in neutral or weak acid conditions to temperatures of 100^0C. Therefore this implies that the boiling of cassava recipes might have reduced the anti-nutrients greatly. Hence, it is important to suggest that cassava tubers should be properly processed before consumption either by boiling or soaking to allow leaching of anti-nutrients into water. Omosuli, 2014 indicated high levels of the antinutrients in raw cassava tubers make them unsafe and unsuitable for human consumption except after processing.

Also on the other hand, Salvador *et al.,* 2014 reported that boiling of cassava is proved to reduce cyanide content because high temperature achieved during boiling, allows enzyme linamarase to inactivate cyanide in bitter cassava roots. Cyanide is very poisonous because it binds cytochrome oxidase and stops its action in respiration, which is a key energy conversion process in the body. Elusiyan and Oboh (2007) reported that sometimes people eating cassava with exceeding limit of safe cyanide levels results to death due to cyanide poisoning.

(ii) Phytate

Phytate contents varied significantly among recipes with GCR having 712.18 mg/100g registering the highest contents and CCR the lowest phytate content having 78.73mg/100g. Other recipes of TCR and PCR had 677.10 mg/100g and PCR 319.78 mg/100g respectively. Earlier studies (Mazahib *et al.,* 2013) have shown higher contents of phytates in groundnuts than any other anti-nutrient which is in agreement with the present findings. It's also indicated that such toxic substances can be reduced during processing of cassava, for example through cooking, fermentation and soaking.

Sarkayayi and Agar, (2010) indicated that cooking and fermentation destroy anti-nutritional factors. Modgil *et al.* (1993) examined the effect of oil treatments (Coconut, groundnut and mustard oil) on the levels of anti-nutritional factors in *Callosobruchus chinensis* (L.) infested stored pulses for 6 months, and observed at monthly intervals for anti-nutritional factors (phytic acid, trypsin inhibitor activity (TIA) and saponins). The values of phytic acid and TIA of treated and untreated pulses were similar at month one. From month two to six the untreated controls had progressively more anti-nutritional factors than their oil treated counterparts.

In mustard and groundnut oil treated pulses, the anti-nutritional factors remained static for 6 months, however, coconut oil treated pulse had increased anti-nutritional from end of month four onwards. The storage period was associated with the level of insect infestation which in turn influenced the anti-nutritional contents of pulses. Thus the results of the present study can be attributed to the time duration for storage and similarly the acidity nature of the medium due to fermentation as explained earlier.

Phytate levels above the tolerable level of 25 mg/100g (Sarkiyayi and Agar 2010) could have a nutritional implication. Phytates interact and form insoluble complexes with calcium, zinc, iron and copper and flavonoids which are a group of polyphenolic compounds that include tannins chelate metals such as iron and zinc and reduce their absorption (Sarkiyayi and Agar 2010). The complexing of phytate with nutritionally essential elements and the possibility of interference with protolytic digestion have been suggested as responsible for anti-nutritional activity. Phytate is negatively charged with phosphate compound that binds minerals and inhibits absorption (Abebe *et al.*, 2014).

This renders the metals metabolically unavailable. It is desirable that Phytates levels are lowered as much as possible, ideally to 25 mg or less per 100 g or to about 0.03% of the phytate-containing food eaten. At this level, micronutrient losses are minimized (Etsuyankpa *et al.*, 2015).

Generally boiling is found to reduce the anti-nutrients at high level which is supported by a study conducted by Omosoli, (2014) who found that the raw cassava tuber was significantly higher in phytate than boiled cassava tubers. Hence, consumption of raw cassava tubers may be detrimental to humans, since it could result in neurotoxicity. Boiling of cassava is also reported by other authors to reduce phytate content due to either the formation of insoluble complexes between phytate and other components, such as phytate-protein or phytate-protein-mineral (Adane *et al.*, 2013).

4.3 Cassava Consumption Frequency and Dietary Diversity Score of Children

Consumption is an integral part of life, in which the pattern changes for micro and macro reasons depending on a country and culture. In this study, the cassava consumption frequency for a reason of it being a staple food that is readily available and easily grown in the environment was examined for its impact on the individual basis of average nutritional intake per day. The Children's Dietary Diversity Score was computed with regard to the cassava consumption frequency established (Table 4.5).

4.3.1 Frequency of Cassava Consumption

Frequency of cassava consumption varies among children aged 6months to 59 months as shown in Table 4.5 below. The findings are grouped into two age categories. One is age of six to ten months and the other is age of eleven to fifty nine months.

The 6-10 months age group constituted less than 10% of the entire study sample. In this age group the majority (3.65%) did not consume cassava based meals which implies that children were either being breastfed or were fed on other foods other than cassava. Similarly none among the 6-10 months aged children did consume cassava based meals for the entire week.

Table 4.5: Frequency of Cassava Consumption in a Week in Two Age Categories

Frequency in a week (number of days)	Age categories				Overall total	
	Children at 6 – 10 months		Children at 11 – 59 months			
	Number (n)	Percentage (%)	Number (n)	Percentage (%)	Number (n)	Percentage (%)
0	12	3.65	8	2.43	20	6.08
1	3	0.91	15	4.56	18	5.47
2	6	1.82	121	36.78	127	38.60
3	2	0.61	66	20.1	68	20.67
6	1	0.31	91	27.66	92	27.96
7	0	0	4	1.22	4	1.22
Total number of children & percentage in each age category	24	7.29	305	92.71	329	100

The feeding frequency of 2 days in a week was dominant for children of 6-10 months. Of the children aged 11-59 months the dominant consumption frequencies in a week of cassava based meals were two days (36.78%), three days (20.1%) and six days (27.66%). In this age category only few of them (2.43%) did not consume cassava based meals at all. Overall the largest fraction (64.74%) of all the children aged 6-59 months had a feeding frequency of cassava based meals of 2 days (36.78%), 3 days (20.1%) and 6 days (27.66%) in a week. The daily feeding frequency of 7days in a week was less practiced in both age groups. These variations in the consumption frequency of cassava based meals may have an implication on their nutrition status.

Generally this study has shown a great percentage of children aged 6-59 months were consuming cassava almost every day. It was also observed that children that were feeding themselves were eating from same plate with adults in almost all households while they have different nutritional needs. This implies that within households children did not receive any special treatment during meals in terms of quality and quantity.

Furthermore, it was observed that intra-household food distribution was poor, in almost all households; about 92.7% (Diana, per comm.) of children were eating from same pots with adults without offering any special treatment to children during meals. This may imply inequality in food distribution and accessibility which is likely to lead to food insecurity and hence malnutrition because food security is a key factor in good nutrition (FAO, 2008). This could further explain the high rate of malnutrition documented in the present study.

4.3.2 Dietary Diversity for Children

The diversification of the children diet in the study area is presented in Table 4.7. This is in accordance to FANTA system of grouping children's diet in determining individual dietary divesity score. The number of foods consumed across and within food groups over a reference time period is widely recognized as being a key dimension of diet quality. It reflects the concept that increasing the variety of foods and food groups in the diet helps to ensure adequate intake of essential nutrients, and promotes good health (Kennedy *et al.*, 2009).

The results of the study show that in the diet of Mtwara rural district children aged 6-59 months from the previous two weeks. 74.8% of the study population was taking white cassava/potatoes and any other root crops or foods made from this group. Vitamin A rich vegetables were consumed by only 5.8% of the study population. Other fruits were consumed by 21.6%. 0.6% of the study populations were consuming eggs.

Fish, meat and poultry were consumed by 43.2% of the study population, a good number of the population consuming fish is seen in Mtwara Rural district because the district has a lake where fish accessibility is less expensive to the community compared to other areas where fish is expensive to access for food which gives a low average of number of food groups consumed as shown in TDHS, (2014) for most regions.

Table 4.6: Dietary Diversity for Study Children

Food Groups	% of individuals consuming / not consuming a particular food group			
	Yes	**(%)**	**No**	**(%)**
White potatoes, white yam, white cassava, or other foods made from roots	246	74.8	83	25.2
Pumpkin, carrot, squash, or sweet potato that are orange inside + *other locally available vitamin A rich*	19	5.8	310	94.2
Other fruits, including wild fruits and 100% fruit juice made from these	71	21.6	258	78.4
Meat, poultry, fresh or dried fish or shellfish/seafood	142	43.2	187	56.8
Dried beans, dried peas, lentils, nuts, seeds or foods made from these (e.g. hummus, peanut butter)	91	27.7	238	72.3
Milk, cheese, yogurt or other milk products	68	20.7	261	79.3
Eggs from chicken, duck, guinea fowl or any other egg	2	0.6	327	99.4
Oil, fats or butter added to food or used for cooking	169	51.4	160	48.6
Sum IDDS	808			
Average IIDS	2.5			
Target IIDS for the population	5.0			

Fish is a very nutritious food group because it has a complete and unique source of both the macro- and micronutrients required in a healthy diet,the intervention of food based strategies to promote consumption of locally available nutritious food has utilized fish instead of supplement distribution as a stable way to tackle micronutrient deficiencies (Kawarazuka, 2010). The data on a good percentage of the population consuming seafood marks the population into the exposure of nutritional benefits of seafood consumption in diversifying diet. This information shows that children aged 6-59 months can consume seafood to obtain nutrients at recommended intake which can be attained if there is a nutritional education to improve feeding behaviours to ensure utilization. There are varied and complicated reasons to constraits in increasing fish consumption in developing countries which includes economics and knowledge (Thilsted *et al.,* 2017).

Legumes was consumed by 27.7% of the study population, also 20.7% of the study population has shown to consume milk and its products food group. Oil and fat group of foods were consumed by 51.4% of the study population, which was mainly from coconut which is mostly calculated in the district. According to this information collected, most of the population from 48.6% to 56.8% lack balanced diet and mostly protein source, readily available vitamin and minerals source.

There is less evidence from developing countries where monotonous diets relying mostly on a few plant based staple foods (Kennedy *et al.,* 2009). Micronutrient malnutrition remains a problem of public health concern in most developing countries, partly due to monotonous undiversified diet.

4.3.2.1 Children’s Dietary Diversity Score Indicator

Dietary diversity score (DDS) is often used as a proxy measure of the nutritional quality of an individual’s diet. In this study IDDS is used as an indicator guide to understand the position of children aged 6-59 months in a particular population towards well being as far as nutrition security is concerned.

Average IDDS	$\frac{Sum(IDDS)}{Total\ number\ of\ children}$ =808/329 =2.5

From this score it means that, the average dietary diversity for Mtwara rural district children is 2.5. It is way below the average score of 4. This may indicate the use of diverse foods of these families interviewed, or in household food insecurity or lack of knowledge in child feeding. Therefore, any interventions to improve food access, household food security, nutrition care for children in Mtwara rural district, this IDDS indicator could be useful to set the IDDS target level.

It is desired that the changes in IDDS must be compared to some meaningful target level of diversity. Unfortunately, normative data on 'ideal' or 'target' levels of diversity are usually not available but options are available to determine appropriate targets whereby an IDDS target can be established by taking the average diversity of the 33 percent of individuals with the highest diversity (upper tercile of diversity) (Swindale and Bilinsky, 2006). From this study 10 children had the highest IDDS of 5, therefore from the formula of determining the IDDS target by considering the average diversity of 33% of 10 individuals with the highest diversity you get 3.3, which is approximately 3 children.

Therefore,

IDDS = (5+ 5+5)/3 = 5

This shows that 5 IDDS score show a meaningful target level of diversity for children in Mtwara rural district, which has to be attained over the 2.5 average dietary diversity.

Thus a 2.5 IDDS score obtained from this study implies that there is no improvements in terms of the average food groups consumed by the children based on the findings of the previous study conducted (TDHS, 2014) which showed an average of less than 5 IDDS for many regions. An increase in the average number of different food groups consumed provides a quantifiable measure of improved household food access.

In general, any increase in IDDS reflects an improvement and changes in the individual’s diet. Overall there is low consumption of foods of animal origin rich in iron and vitamin A rich foods (Table 4.7). This could be among the contributing factors leading to the higher prevalence of malnutrition in Mtwara region. Therefore when there is food insecurity there is a high likelihood of lack of food diversification as such consumers’ eat what is readily available leading to imbalanced diet.

(i) Root Crops

They are cheap but nutritionally rich staple food in starch that meet the dietary demands in Africa. They address food and nutrition security and produce more food per unit area of land (Sanginga, 2015). Of all the root crops, cassava is proved in Mtwara rural district the mostly growing cassava area to be consumed by 74.8% of the population as a staple food. Cassava was the mainly consumed root crop compared to other root crops since it the most, easy grown and readily available crop in the district with easily accessibility for food security. Cassava could be eaten raw as snack or cooked raw with different recipes as described in objective one to obtain meals or can be processed into flour for cooking cassava different products such as porridge and snacks.

(ii) Vitamin A Rich Fruits

This food group is rich in micronutrients, the nutrients needed in the body in minute amount play leading roles in production of enzymes, hormones and other substances. They also help to regulate growth activities, development and functioning of the immune and reproductive system (Ekweagu *et al.*, 2008). Only 5.8% of the population is seen to consume vitamin A rich fruits. There could be factors behind the less consumption of vitamin A rich fruits or vegetables such as poor knowledge and ignorance on the importance of Vitamin A fruits/vegetables for health and development of children and community at large (Okidi *et al.*, 2018).

(iii) Other Fruits

Fruits and vegetables play an important role in human nutrition and health, particularly as sources of vitamin C, thiamine, niacin, pyridoxine, folic acid, minerals and dietary fibre. Low intake constitute a risk factor for chronic diseases such as cancer, coronary heart disease (CHD), stroke and cataract formation (Oguntibeju, 2013).

Oother fruits like oranges than are seen to be available in the district can be seasonally accessed by only a 21.6% of the population. Fruits are important to make the non bioavailable nutrients from green vegetables consumed be absorbed thoroughly to make them bioavailable for body use (Gerber, 2007).

(iv) Meat and Seafood

Flesh meat is an important source for some essential trace elements (Iron, Zinc and Selenium), and vitamin B6 which are either not present in plant derived food or have a poor bioavailability (Gerber, 2007). Zero percent of the population consumes organ meat which is best recommended for bioavailable source of iron and vitamin A in the body. 0.6% of the study population is seen to consume flesh meat food group.

Fish and seafood are important sources for vital nutrients such as proteins, vitamin D, vitamin B12, selenium and iodine. Seafood has a favourable fatty acid composition. Main beneficial health effects of consuming sea food are linked to omega-3 fatty acids a long-chain polyunsaturated and vitamin D, which is favorable with respect to both cardiovascular diseases and foetal development (CESHH, 2011). The study has indicated that, 43.2% of the population consumed fish.

(v) Legumes

Legumes provide a range of essential nutrients including protein, low glycemic index carbohydrates, dietary fibre, minerals and vitamins. Legumes are uniquely rich in both protein 17%-20% dry weight in peas and beans, 38%-40% in soybeans and lupins) and dietary fibre 5%-37% dry weight.This contrasts with the protein content of cereals which is about 7%-13% (FAO, 2014). Only 27.7% of the study population has shown to be consuming legumes in the previous two weeks.

(vi) Milk and Milk Products

Milk is a nutrient-dense food supplying energy and significant amounts of protein and micronutrients (FAO, 2013). The percentage of 20.7 of the study population is found to consume this group of food for the previous two weeks. The inclusion of dairy products adds diversity to plant-based diet. From this study, it shows how risk the population is at lacking the essential nutrients provided from milk and milk products as they rarely consume it and it's by few people, others do not consume at all.

(vii) Eggs

Eggs are classified as the "food protein group". Eggs contain high quality protein, with 100% of chemical score (essential amino acid level in a food protein divided by the level found in an "ideal" food protein). The essestial amino acids in an egg contribute more than 60% of the dietary requirement for children aged 6-11months (Yalcin and Yalcin, 2013). The study has shown that only 0.6% of the children aged 6-59 months in the district consume eggs, therefore most children are exposed to the risk of lacking essential amino acids obtained from eggs that are required for optimal health growth and development.

(viii) Oils/Fats

Fats and oil are of importance in human health due to its prime importance is their role as a calorie-dense food component. They have nine kilocalories per gram versus four kilocalories per gram for starch or protein. Fat also makes other positive nutritional contributions. It carries fat-soluble vitamins (A, 0, and E). Thus lacking fats and oil in food component would result into macro and micronutrients deficiency. The study has indicated a 51.4% of the study population is found to use this food group in the previous two weeks mainly from coconut because it is also a well grown crop in the district. However coconut being a cultivated crop in the district that is readily preferred as a fat source, the results have shown that, it is consumed by almost half of the population only.

4.4 Contribution of Cassava to the Recommended Dietary Allowance of Iron, Zinc, Fat and Protein Among the Children Aged 6-59 Months

Establishing the contribution of cassava staple RDA would form a base that is appropriate for dietary diversity intervention and also broaden awareness among the affected population. It is thus important to evaluate how cassava based meals can adequately contribute to RDA for healthy life. The aim of this study was therefore to evaluate the contribution of cassava staple to the recommended dietary allowance of selected nutrients among the children aged 6-59 months in Mtwara rural district. Since plain cassava recipe was the mostly consumed recipe (see Table 4.1) , it was worth to establish its nutritional quality in order to evaluate and understand its contribution to the RDA of selected nutrients. The nutrient contents obtained (refer Table 4.2 and 4.3) were used to determine the contribution of this particular meal to RDA for under five children for the selected nutrients.

The nutrients content obtained in the plain cassava recipe (Table 4.8) indicates a very low contribution of cassava recipes to RDA of the selected nutrients. This observation supports the statement that cassava meal alone cannot cater for the body nutrients requirement as Dziedzoave *et al.,* 2006 reported. This further justify the need for improved dietary diversity and reduce nutrient gaps by inclusion in their diets the under consumed food groups. Dietary diversification can be improved by incorporating foods such as coconuts, fish, poultry by increasing their consumption frequencies to make the cassava staple meal nutritious (Dziedzoave *et al.,* 2006).

Table 4.7: Nutrition Composition of Plain Cassava Recipe and the Recommended Dietary Allowance, Adequate Intakes and Acceptable Macronutrient Distribution Range for Children Aged 6-59 Months

Nutrients	Sample weight	Nutrient content in cassava meal	RDA*/ AI**/ AMDR***	Average nutrient intake per day	% intake/day
Protein	0.3g	0.07±0.01%	24g	1.024g	4.2%
Fat	5.0g	0.18±0.13%	31g*-40g [a]	0.158g	0.51-0.395%
Fibre	1g	2.63+0.55%	19-25g *	-	
Moisture	12g	73.55+0.27%	-	-	
Ash	27g	1.87+0.02%	-	-	
Carbohydrates	-	21.69+0.67%	95-130g	19.23g	20.2-14.8%
Calcium	1.5g	91.24+5.74mg/kg	400-800mg	40.11mg	10.03-5.01%
Magnesium	1.5g	243.77+7.48mg/kg	80-130mg	107.16mg	133.9-82.4%
Potassium	1.5g	0.02+0.00mg/kg	3000-3800mg	0.009mg	0.0003-$2.6x10^{-6}$%
Zinc	1.5g	1.91+0.48mg/kg	4mg	0.84mg	21%
Copper	1.5g	1.66+0.42mg/kg	340-440µg	0.73mg	214.7-165.9%
Iron	1.5g	4.41+1.12mg/kg	10mg	1.94mg	19.4%
Manganese	1.5g	2.90+0.37mg/kg	1.2-1.5mg	1.275mg	106.3-85%
Cyanide	10.5g	0.32+0.00 µmol/g (7.44ppm)	safe WHO level is 10ppm	-	
Phytate	0.35g	319.78+0.48mg/100g	tolerable level is 25 mg/100g	-	

Source:

*: FNB *et al.* (1989) as cited by Amosu et al; 2011 , RDA=Recommended Dietary Allowance

/*: Dietary Reference Intake (2002/2005), AI= Adequate Intake, AMDR= Acceptable Macronutrient Distribution Range

These results well indicates that cassava meal nutrients contribution to dietary requirements is far less below the RDA levels. The result (Table 4.8) also presents the levels of ant-nutritional factors namely phytate and cyanide in plain cassava meal. Phytate content is far above the tolerable level of 25 mg/100g which could have a nutritional implication of chelating metals such as iron and zinc and reduce their absorption (Sarkiyayi and Agar 2010) where as cyanide is within the acceptable level. This suggests that phytate could also be a contributing factor to high prevalence of malnutrition in this area due to high cassava consumption rate.

4.4.1 Contribution of Selected Nutrients from Plain Cassava Recipe to the Total RDA

The percentage contribution of selected cassava nutrients to the RDA of the respective nutrient is presented in Table 4.9. This was established from the amount of nutrient intake in relation to the required level of the same nutrient in meeting the RDA for each particular nutrient.

Table 4.8: Percentage of Contribution of a Selected Nutrient into Total RDA

Nutrient	RDA values for children aged 6-59 months	Amount of nutrients taken	% RDA cassava contributes	Statistical Significance (P <0.05)
Iron	10mg	1.94mg	19.4	0.59
Zinc	4mg	0.84mg	21	
Protein	24g	1.024g	4.26	
Fat	30g*	0.158g	0.527	

RDA: FNB *et al.* (1989) cited by Amosu *et al;* 2011, *Adequate Intake: Dietary Reference Intake (2002/2005)

4.4.1.1 RDA for Macronutrients

The RDAs for protein and fat were selected for evaluation, due to their importance on children’s optimal growth and development. Carbohydrate deficiency is so rare among children, as it is so abundant in common diets. The results show that regardless of the high consumption rate, cassava provided an average of 4.26% to the protein RDA which is extremely low. This imply its contribution to protein RDA is negligible in view of the amount of protein the body requires (p=0.59) since it supplies only 1.024 g/d of protein while the required amount is 24g/d (Table 4.9), thus the amount of protein plain cassava meal supplies per day, that is, only 4.2%.

The findings of this study which indicate little contribution of cassava to protein RDA agree with those of Nginya (2015) who observation that protein content among common cassava cultivars is classically only 1% (Stupak, 2006). He further indicated that, populations that consume large amounts of cassava may as well be at risk for inadequate dietary protein intake. Nyinga, (2016) argument was based on the results of an observational study that was conducted in Kenya and Nigeria, that eating cassava as a staple food places children 2-5 years old at risk for inadequate protein intake.

Stephenson *et al.* (2010) found insufficient protein intake in the diets of Nigerian and Kenyan children eating cassava as a main food (Stephenson *et al.*, 2010). The other study that involved 2-5 years children which was conducted in Ede-Oballa community indicated that the contribution of starchy root was only 1.72±0.2g out of 16g of Food and Agriculture Organization/World Health Organization protein requirement which further supports the present findings.

Figure 4.1 shows the percentage score of each child for cassava contribution to protein RDA which ranged from 1.45% to 7.29 % among the children population depending on their consumption frequency of cassava. The results provide the average percentage contribution of 4.26% of cassava in children’s RDA as presented in Table 4.9.

The link between growth and protein intake, as established by Lee, 2014 do not verify a causal relationship, in particular since the amount of micronutrient in the diets as well as other ecological factors are likely to be confounding factors. Nonetheless, the proof from observational human studies and animal intervention studies (Lee, 2014) suggests that stunting occurs if a least amount of protein to energy ratio is not achieved. From the dietary diversity and consumption pattern among children in Mtwara rural district as indicated in Table 4.3, protein can be obtained from food sources like meat/poultry/fish and beans/legumes food groups which are however poorly consumed. Therefore provision of nutrition education and counseling is important to enhance consumption of other food groups to increase dietary availability of protein.

It was important to evaluate the RDA for dietary fat due to its importance as a superior source of necessary fatty acids (e.g. omega 3 fats) and concentrated energy. Energy balance is vital to sustaining healthy body weight and guaranteeing best possible nutrient intakes. Fats and fatty acids are metabolized and used in the body, change cell membrane function, manage gene transcription and expression, and interact with one another. Fats specifically long chain poly unsaturated fatty acids has a role on newborn mental advancement, as well as advancement role in safeguarding long-term health and avoidance of specific chronic diseases (FAO, 2010).

The findings of this study show that cassava contributed 0.527% to the total fat RDA of 30g required by the under five children. Figure 4.4 shows the percentage of each child which ranges from 0.18% to 0.9%, which clearly implies the low contribution of plain cassava meal to the amount of fat required by the body for optimal growth and development. Previous intervention researches (FAO, 2010) from developed countries suggest that diets with lower % of energy from fat tend to be hypo caloric and are therefore associated with short term weight loss.

This could imply that children who are underweight might have experienced a hypo caloric condition and might require diets enriched fat to re-gain healthier weight. The results on dietary diversity (Table 4.7) indicate that only 51.4% households consume fat/oils food group, which implies the need for more emphasis to food diversification to meet the body's requirements using the locally available food sources such as coconuts.

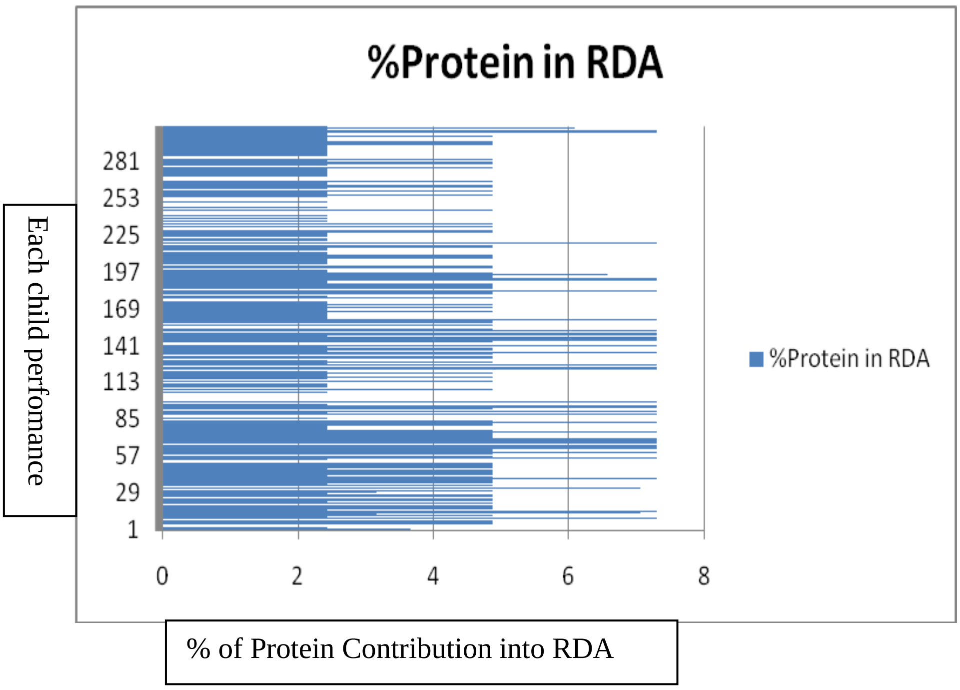

Figure 4.1: % of Protein Contribution into its RDA Among Children Aged 6-59 Months

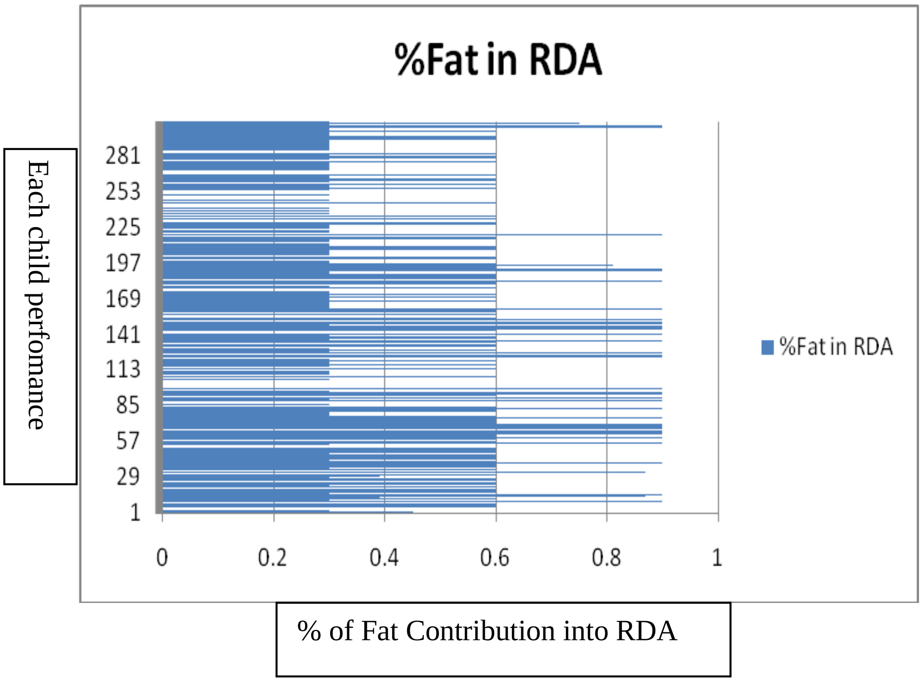

Figure 4.2: % of Fat Contribution into its RDA Among Children Aged 6-59 Months

4.4.1.2 RDA for Micronutrients

Micronutrients are chemical elements including vitamins and minerals that are required in trace amounts for good health, normal growth and development of human and other organisms. Iron is an essential nutrient that is involved in oxygen transport, energy metabolism, immune response, and plays an important role in brain/cognitive development. The results of the present study show that the mean / average amount of iron and zinc that is consumed from plain cassava recipe is 1.94mg/day and 0.84mg/day respectively which contribute 19.4% and 21% respectively of the required RDA (Table 4.9). This is far below even half of the body requirements for these potential minerals. This further suggests the need for food diversification in order to meet the RDA for both iron and zinc especially in areas where cassava is consumed as a staple food. Results in Table 4.7 indicate that sea foods and foods from animal sources as well as fruits and vegetables which are rich in iron and zinc are rarely consumed.

Figures 4.3 and 4.4 show the percentage score of cassava contribution to iron and zinc RDA for each child which ranges from 6.62% to 33.08% and 7.16% to 35.81% for iron and zinc respectively as further indicated in Table 4.9. It is well documented that (Domellof *et al.,* 2014) young children are vulnerable to the effects of iron deficiency (ID) because of rapid growth and development of their brain and other organs that occurs from birth to the age of three. Low intake of iron can contribute to anemia which indicates the vulnerability of this age group to the same.

Iron scarcity (ID) is the most common micronutrient deficiency world-wide and young children are a special risk group because infant becomes dependent on additional dietary iron and, because of rapid growth, iron requirements per kilogram body weight are higher than during any other period of life The previous situation of iron deficiency rates shows 35% of children aged 6-59 months 6-59 months had moderate anaemia and the anemic children were 59% (NBS, 2010), and the recent study shows that 30% Tanzanian children have moderate anaemia and 58% are anemic (NBS, 2015). This shows poor progress in reducing iron deficiency rate among children. Consumption of foods such as meat, fruits, cereals and fortified formulas seem to protect against iron deficiency. However, a study by Kolapo and Sanni (2009) has proved the effective means of meeting the daily requirements of minerals, protein, and energy is through fortification of cassava products. This further suggests that in areas where cassava is a staple food with limited food diversity, food fortification could be a viable option.

Globally, zinc deficiency has been reported to contribute to substantial morbidity and mortality in developing countries due to the low intake of animal protein and high intake of phytates (Sarkiyayi and Agar 2010). The results of this study also show that the phytate contents in plain cassava recipe (PCR) is 319.78mg/100g which is far above the tolerable level of 25 mg/100g. This could thus have a nutritional implication as phytates could interact and form insoluble complexes with iron and zinc thus reducing their absorption (Sarkiyayi and Agar 2010).

There is some evidence that malnourished children gain weight more quickly when they are given zinc supplementation (Silva *et al.*, 2006). According to estimates by the International Zinc Nutrition Consultative Group (IZiNCG), 37.5% of the Tanzanian population is at risk of inadequate zinc intake (IZiNCG, 2004). The documentation by URT, 2015 also indicate that zinc deficiency is a public health problem in which case high phytate levels could be one of the main contributing factors.

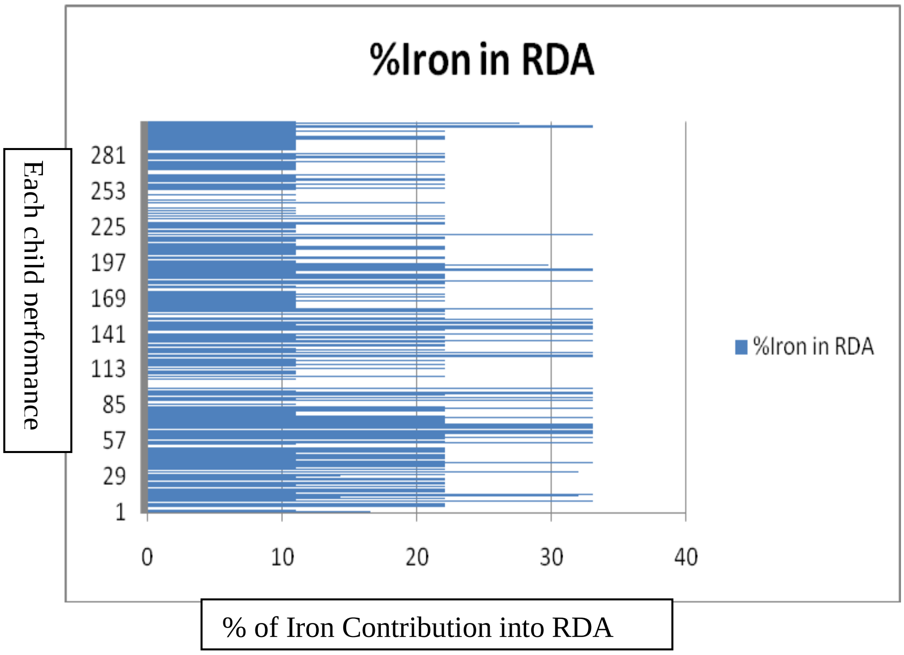

Figure 4.3: % of Iron Contribution into its RDA Among Children Aged 6-59 Months

Lack of zinc is known to impair the immune system and children with marginal nutritional status are at significant risk of developing zinc depletion. Hence appropriate nutritional interventions in addressing micronutrient deficiencies are required to address the problem.

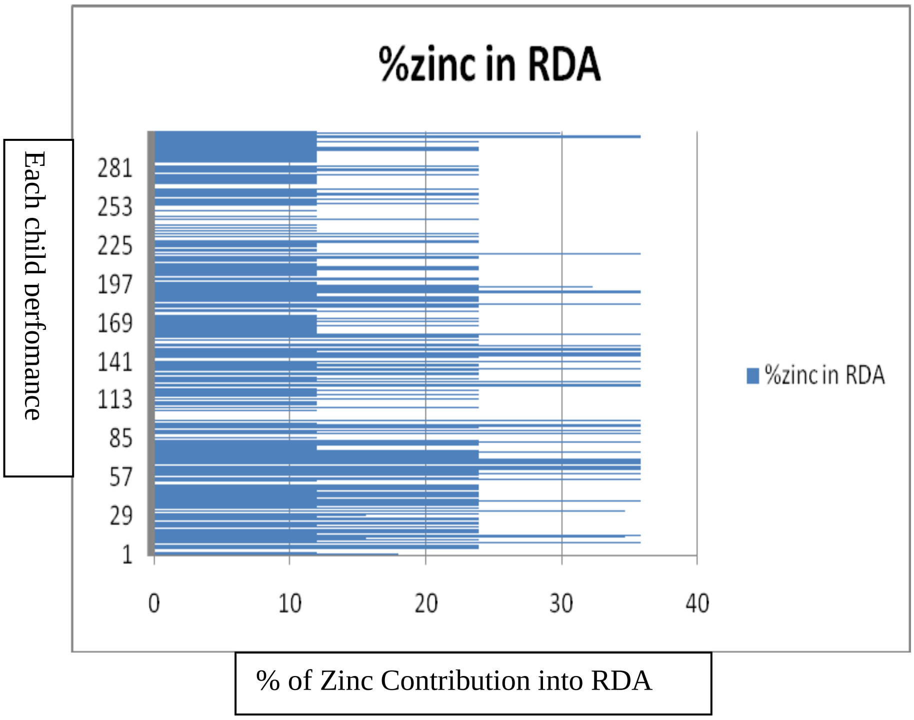

Figure 4.4: % of Zinc Contribution into its RDA Among Children Aged 6-59 Months

4.5 Nutrition Status of the Children Aged 6-59 Months

4.5.1 Child Information

A total number of 329 out of 332 recruited children were eligible for the study based on the inclusion and exclusion criteria such as age group and mental health The recruited children were of the age of 6 to 59 months. Mean age for children was 31 months, mean weight was 11.7kilograms and mean height was 84.8 centimeters. The study had more female children than male where by 170 children (51.7%) were female and 159 children were male (48.3%). The results also show that female children were more malnourished than male **(Table 4.9a)** however, there is no significance association (**p≥0.05, p= 0.382**) between gender and nutrition status, implying that both genders were more or less equally impacted.

4.5.2 Nutrition Status

The results on the nutritional status of children are presented in Table 4.9a and the the statistical outputs of the same are presented in Table 4.9b. The results on nutritional status are further discussed in 4.5.2.1 to 4.5.2.3.

Table 4.9(a): Nutrition Status of Children Aged 6-59 Months in Female and Male

Nutrition status%	Normal		Moderate		Severe		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
Stunting	29.2	30.1	13.6	14.3	5.5	7.3	48.3	51.7
Underweight	40.4	40.7	5.5	8.8	2.1	2.4	48.0	51.9
Wasting	47.1	48.0	1.8	1.8	0.3	0.6	49.2	50.4

Table 4.9b: Chi-Square Tests of the Nutrition Status Between Male and Female

	Value	Df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)		
				Sig.	99% Confidence Interval	
					Lower Bound	Upper Bound
Pearson Chi-Square	16.000[a]	15	.382	.709[b]	.697	.720
Likelihood Ratio	22.181	15	.103	.709[b]	.697	.720
Fisher's Exact Test	14.928			.709[b]	.697	.720
N of Valid Cases	18					

4.5.2.1 Height-for-Age Z-score Index

The height-for-age z-score (HAZ) index reflects on the linear growth for age. Low height for- age indicates a child whose height for age is below minus two standard deviation (-2 SD) from the median of reference population. Stunting reflects chronic under nutrition during the most critical periods of growth and development in early life. It is defined as the percentage of children aged 0 to 59 months whose height for age is (≥-3 and <-2 z- score) for moderate stunting and (<-3 z-score) for severe stunting from the median of the WHO Child Growth Standards. The results in Table 4.9 indicate the stunting prevalence of 41%.

Table 4.10: Height-for-Age Z-score Index

Nutritional status Categorization	**N**	**%**
Severe stunting (<-3 z-score)	43	13
Moderate stunting (≥-3 and <-2 z- score)	92	28
Total stunting	**135**	**41**
Normal (≥ -2 z-score)	194	59
Total	**329**	**100**

According to (TFNC, 2014), in Tanzania 34.4% of children below five years are stunted, so despite the efforts to alleviate malnutrition, stunting is still a problem especially in Mtwara Rural District which according to this study, stunting was found to be 41%. This can be related to the fact that poor attitude on nutrition and feeding practices is still a problem for mothers and caregivers (Guled *et al.*, 2016). Poor nutrients intake during pre-conception and in pregnancy. One of a factor contributing to high prevalence of stunting is poor dietary intake. The dietary intake from the current study is characterized by high carbohydrate and low protein content as indicated in the dietary diversity. This kind of feeding is likely to affect growth pattern of children as well as their nutritional status.

Furthermore, continued low intake of zinc in children might increase prevalence of stunting. Caulfield and Black (2005) showed that diets rich in zinc improved growth (increase in weight and height) of stunted children in Ethiopia and this was attributed to the ability of zinc to reduce morbidity due to infection and increase appetite which all have positive effect on growth in terms of weight and height. Cassava contains little zinc, iron, and β-carotene, yet it is the primary staple crop of over 250 million Africans (Gegios, 2010).

It was also noted that, most of the households accessibility to adequate foods is limited, thus no diversification in food intake as they eat what is readily available at their place which brought about imbalanced diet in most times. Globally, over one third of children in rural households are stunted compared to one quarter in urban households. Children in the poorest households are more than twice as likely to be stunted as children in the richest households (UNICEF, 2013). There is no special meals and treatment for young children which thus impairs growth and development in the critical growth stages of children due to nutrients requirements that are not met.

4.5.2.2 Weight-for-Height-Z-score Index

Weight-for-height reflects the effects of acute malnutrition which is wasting. Wasting in children therefore symbolizes deficit in tissue and fat mass compared with their peers of the same height. Wasting reflects acute under nutrition. It is defined as the percentage of children aged 0 to 59 months whose weight for height is below minus two standard deviations for moderate wasting and minus three standard deviations for severe wasting from the median of the WHO Child Growth Standards. The results in

Table 4.9 indicated that severe and moderate wasting were 2.4% and 4.9% respectively

Table 4. 11: Weight-for-Height-Z-score Index

Nutritional status Categorization	N	%
Severe wasting (<-3 z-score)	8	2.4
Moderate wasting (≥-3 and <-2 z- score)	16	4.9
Total wasting	**24**	**7.3**
Normal (≥ -2 z-score)	305	92.7
Total	**329**	**100**

The district has not been affected by wasting at large, only few children (7.3%) are recognized to be wasted. The prevalence of wasting could be attributed to poor intra-household food distribution. Tanzania is seen to be on track in reducing wasting prevalence as it is not among the ten countries that have wasting burden in the world. This shows a good progress in nutrition programming in the country on wasting reduction (TDHS, 2011).

In many households both adults and children eat from the same plate and in such a situation the young ones cannot compete with the older family members, this leads to reduction in the amount of meal taken due to food shortage and the intake of unbalanced diets. Some of children due to illness increases their vulnerability.

Factors like increased infection due to malaria, reduced appetite, reduced intake of zinc and vitamin C, inadequate care, and inadequate family income exacerbated the severity of malnutrition among children. Infections like malaria increase body activities that is metabolism and therefore demand for energy. Failure to cope with the demand by intake of more nutrients during illnesses, increase the use of body fat reserves and muscles as alternate sources of energy (Schaible and Kaufmann 2007).

4.5.2.3 Weight-for-Age Z-score Index

The weight-for-age z-score (WAZ) reflects the effects changes in the nutritional status both acute (wasting) and chronic (stunting) under nutrition. It is a composite form of under nutrition that includes elements of stunting and wasting. It is defined as the percentage of children aged 0 to 59 months whose weight for age is below minus two standard deviations for moderate underweight (14.3%) and minus three standard deviations for severe underweight (4.5%) from the median of the WHO Child Growth Standards. The results for underweight are indicated in table 4.10 below, shows the prevalence of 18.8%.

Table 4.12: Weight-for-Age Z-score Index

Nutritional status Categorization	**N**	**%**
Severe underweight (<-3 z-score)	15	4.5
Moderate underweight (≥-3 and <-2 z- score	47	14.3
Total underweight	**62**	**18.8**
Normal (≥ -2 and ≤2z-score)	264	80.2
Over weight	3	1
Total	**329**	**100**

According to UNICEF (2013) Tanzania was on track towards reducing under nutrition prevalence as a way towards meeting sustainable development goals one target that aim to halve the proportion of people who suffer from hunger between 1990 and 2015 through measures of the children aged 6-59 months (MDG 1, 2017).

The prevalence of underweight documented in this study which is 18.8% could be due to poor intra-household food distribution, which is a common practice in many households. It was also noted that, complementary foods provided to these children were balanced diets thus could not meet nutritional requirements. Adequate breastfeeding, combined with timely and proper complementary feeding are important in ensuring children have good health and normal growth (Kirsten *et al.,* 2001). The most common complementary food for children under two years were made from cassava which includes cassava flour porridge and boiled cassava.

According to the findings of the present study, the cause for underweight among children could be due to poor dietary intake as reflected by the dietary diversity table (Table 4.7). Furthermore, according to khattak *et al.,* 2007 poor mothers nutrition knowledge is among the causes of malnutrition among children since nutritionally educated mothers can bring up children in a healthy way.

The presented details of results on nutritional status assessment for children under the age of five based on anthropometric indices mean Z-score, have shown that, while acute under-nutrition and wasting are not a major concern, stunting in children under the age of five is a huge problem. Stunting and other forms of under nutrition are clearly a major contributing factor to child mortality, disease and disability. For example, a severely stunted child faces a four times higher risk of dying, and a severely wasted child is at a nine times higher risk. Knowledge of the impact of stunting and other forms of under nutrition on social and economic development and human capital formation has been supported and expanded by more recent research (UNICEF, 2013).

4.6 Association between Individual's Cassava Consumption Frequency and Nutrition Status of Children Aged 6-59 Months

The cassava consumption pattern of children in the district was examined to see how is associated with under nutrition stunting, underweight and wasting. This would reflect on the contributing factors to poor nutrition status observed among the children aged 6-59 months in the district. A cross tabulation was used to capture the association between cassava consumption variables and nutrition status of the under five children.

4.6.1 Association between Cassava Consumption Frequency and Height for Age Z-score

Table 4.13 indicates the association between the variables of cassava consumption pattern and the Height for Age Z-score. Chi-square test was used to test whether there is significant association ($P \geq 0.05$) between cassava consumption score and HAZ and also between cassava meal consumption frequency and HAZ. The findings indicated that though the most affected children were those consuming cassava than those not consuming the association was insignificant ($P \geq 0.05$). Similarly neither higher nor low frequencies of cassava consumption had any significant effect on the stunting of children. The results generally indicate that stunting is neither related to cassava consumption score nor cassava consumption frequency but could rather be due to a synergistic effect of several factors including poor dietary diversity as reflected by the IDDS. The computed dietary diversity of 2.5 is far below the recommended dietary diversity of 5 in Mtwara region justifying low dietary diversity among children.

The present findings however, contradicts the results of Nungo *et al.* (2012) who conducted a research in Western Kenya and indicated that children were malnourished due to high cassava consumption at a frequency of up to three times in a day mainly as porridge, boiled cassava and ugali (stiff porridge) prepared from cassava flour. This means the higher prevalence of malnutrition in the region could be attributed to a combination of several factors as indicated earlier.

Table 4.13: Association Between Cassava Consumption Frequency Variable and Height for Age Z-score

HAZ	**Severe n(%)**	**Moderate n(%)**	**Normal n(%)**	**Total n(%)**	**Chi-square**	**df**	**p-value**
Cassava Consumption in a week							
Yes	38(11.6)	68(20.7)	140(42.6)	246(74.9)	1.848	2	0.432
No	8(02.4)	23(7.0)	52(15.8)	83(25.2)			
Frequency of Cassava consumption							
Never	0(00.0)	4(01.2)	15(04.6)	19(05.8)	11.750	12	0.514
Less than 1 time per week	0(00.0)	0(00.0)	1(00.3)	1(00.3)			
1-3times per week	1(00.3)	4(01.2)	12(03.6)	17(05.2)			
4-6times per week	20(06.1)	32(09.7)	75(22.8)	127(38.6)			
1time per day	8(02.4)	24(07.3)	36(10.9)	68(20.7)			
2-3times per day	17(05.2)	25(07.6)	51(15.5)	93(28.3)			
4 or more times per day	0(00.0)	2(00.6)	2(00.6)	4(01.2)			

4.6.2 Association Between Cassava Consumption Frequency and Weight for Age Zscore

Table 4.14 indicates the association between the variables of cassava consumption pattern and the Weight-for-Age-Z-score.

The results have shown no significance association between the cassava consumption score in the study population (p=0.237) and frequency of cassava consumption (p=0.584) with underweight situation among children in Mtwara rural district (18.8%). The results imply that underweight among children aged 6-59 months could be attributed to a combination of several factors such as age, diseases, food security, gender division of labour and other factors as reported by Shoo (2011).

Table 4.14: Association Between Cassava Consumption Frequency and Weight for Age Zscore

WAZ	Severe n(%)	Moderate n(%)	Normal n(%)	Total n(%)	Chi-square	Df	p-value
Cassava consumption in a week							
Yes	15(04.6)	37(11.2)	194(59.0)	246(74.8)	3.212	2	0.237
No	1(00.3)	13(04.0)	69(21.0)	83(25.2)			
Frequency of Cassava consumption							
Never	1(00.3)	0(00.0)	18(05.5)	19(05.8)	10.077	12	0.584
Less than 1 time per week	0(00.0)	0(00.0)	1(00.3)	1(00.3)			
1-3times per week	0(00.0)	2(00.6)	15(04.6)	17(05.2)			
4-6times per week	4(01.2)	22(06.7)	101(30.7)	127(38.6)			
1time per day	3(00.9)	12(03.6)	53(16.1)	68(20.7)			
2-3times per day	8(02.4)	14(04.3)	71(21.6)	93(28.3)			
4 or more times per day	0(00.0)	0(00.0)	4(01.2)	4(01.2)			

Moreover, Peiris and Wijesinghe (2010) indicated that though inadequate food intake is a basic cause of underweight; several other factors such as living standards, water and sanitation, birth weight, birth interval and parity, complementary feeding practices and mother's nutritional knowledge have been identified as contributing to malnutrition among children. Therefore the observed results may have been due to a combination of all those factors.

4.6.3 Association Between Cassava Consumption Frequency and Weight for Height Z-score

Table 4.15 indicates the association between the variables of cassava consumption pattern and the Weight-for-Height-Z-score.

The wasting rate among children aged 6-59 months was 7.3% which is reasonably low and was indicated to be independent of the cassava based meal consumption pattern and frequency. This is evidenced by lack of significant association ($P \geq 0.05$) between wasting and cassava consumption score and frequency. Frozanfah *et al.* (2016) in the study conducted in Afghanistan indicated significant association between acute malnutrition (wasting) among U5 and education level of household heads, age of household heads, income, education level of mothers, history of children with diarrohea in the last two weeks of data collection, water sources and iodized salt. In view of this a similar argument can be made regarding the prevalence of malnutrition in Mtwara.

Also the study by Frozanfah *et al.* (2016) indicated that an increase in education level of parents, household income, and quality of water sanitation and hygiene would result in a significant decrease in prevalence of wasting among children aged 6-59 months. The combination of all these factors could also be of significant effect to the acute malnutrition rate observed from this study. This implies that the effects due to an individual variable could be negligible but are rather amplified and become noticeable when they act synegetically.

Table 4.15: Association Between Cassava Consumption Frequency and Weight for Height Z-score

WHZ	Severe n(%)	Moderate n(%)	Normal n(%)	Total n(%)	Chi-square	df	p-value
Cassava consumption in a week							
Yes	6(01.8)	10(03.0)	230(69.9)	246(74.8)	1.747	2	0.456
No	1(00.3)	6(01.8)	76(23.1)	83(25.2)			
Frequency of Cassava consumption							
Never	1(00.3)	3(00.9)	15(04.6)	19(05.8)	11.520	12	0.353
Less than 1 time per week	0(00.0)	0(00.0)	1(00.3)	1(00.3)			
1-3times per week	0(00.0)	0(00.0)	17(5.2)	17(05.2)			
4-6times per week	2(00.6)	9(02.7)	116(35.3)	127(38.6)			
1time per day	2(00.6)	1(00.3)	65(19.8)	68(20.7)			
2-3times per day), does not seem to be affected by	2(00.6)	3(00.9)	88(26.7)	93(28.3)			
4 or more times per day	0(00.0)	0(00.0)	4(1.2)	4(01.2)			

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study identified four commonly consumed cassava based recipes namely CCR, GCR, TCR and PCR. The proximate composition results showed that CCR had the best composition compared to the other cassava recipes where as the poorest proximate composition was recorded in PCR. Similarly, in terms of mineral composition CCR had the highest Ca, Zn and Mn contents and TCR had the highest amount of Fe and Cu. GCR on the other hand had the highest Mg levels.

Data on anti-nutrients indicated that CCR and GCR had the highest and equal contents of cyanide and PCR had the lowest content. GCR on the other hand had the highest phytate content and CCR had the lowest phytate content. Though cyanide contents in all recipes were within the acceptable safe WHO level of 10ppm, phytate contents were above the tolerable of 25mg/100g which could thus affect the mineral contents of the recipes due to its interactivity nature. However, a clear disntictive and reflective view of the nutritional value of the recipes can be well gauged based on the evaluation of RDA.

The results shows poor nutrition status and high level of malnutrition among children aged 6-59 months. Stunting was the most prevalent form of malnutrition at a rate of 41%, followed by underweight (18.8%) and wasting (7.3%). However no significance association ($p \geq 0.05$) was recorded between gender and nutrition status, both genders were more or less equally impacted with malnutrition. Cassava feeding frequencies varied among households and between and within the two age groups, (6 – 10 months) and (11-59 months). Half of the children aged 6 – 10 months did not consume cassava at all and the remaining consumed cassava at varying frequencies of 1, 2, 3 or 6 days per.

In the age group of 11-59 months the dominant consumption frequencies were 2 and 6 days per week. Overall 87.23% of all the children aged 6-59 months had a feeding frequency of 2 days, 3 days or 6 days in a week. Nonetheless the results indicated no significant association between cassava consumption frequency and high prevalence of stunting.

The results of the present study also indicated poor contribution of plain cassava recipe to the RDA for protein, fat, zinc and iron. The DDS of 2.5 was similarly far below the targeted population IDDS of 5 implying poor dietary diversity among population members. This could be among the contributing factors to higher prevalence of malnutrition in Mtwara rural district. The anti nutritional factors in particular phytate which was far above the tolarable level is likely to chelate such minerals like zinc and iron and reduce their bio-availability.

This could in turn expose the population to malnutrition especially young children. The higher prevalence of malnutrition in the region could thus be attributed to a combination of several factors. Thus the high prevalence rate of malnutrition in Mtwara rural district may not be due to cassava consumption frequency but rather to a synergistic effect of several factors which should be researched for a more effective intervention to be implemented.

5.2 Recommendation

In view of the present results the following recommendations are made

(i) Develop stratergies which can encourage and make it easy for diatery diversification to be implemented among community members in order to complement cassava based recipes with readily available foods rich in macro and micro nutrients. This would enrich the diets with a diverse of nutrients and meet the nutritional requirements of children.

(ii) Fortification of cassava based food products to ensure the daily requirements of macro and micronutrients are met.

(iii) To develope processing treatments that can ensure the reduction of antinutrients factors in particular phytates to within accepatble levels.

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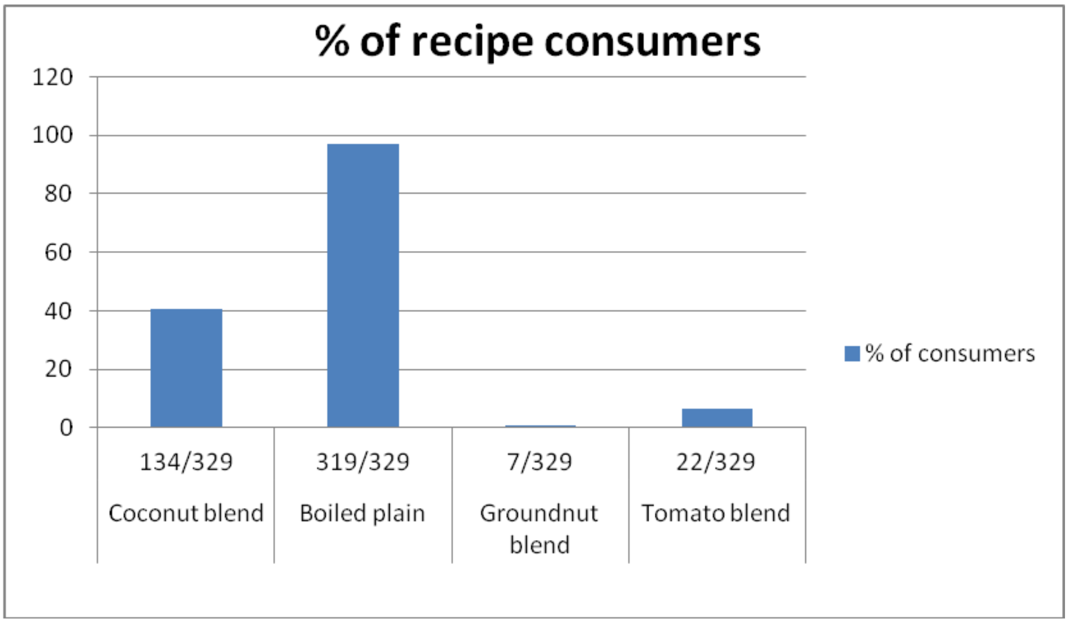
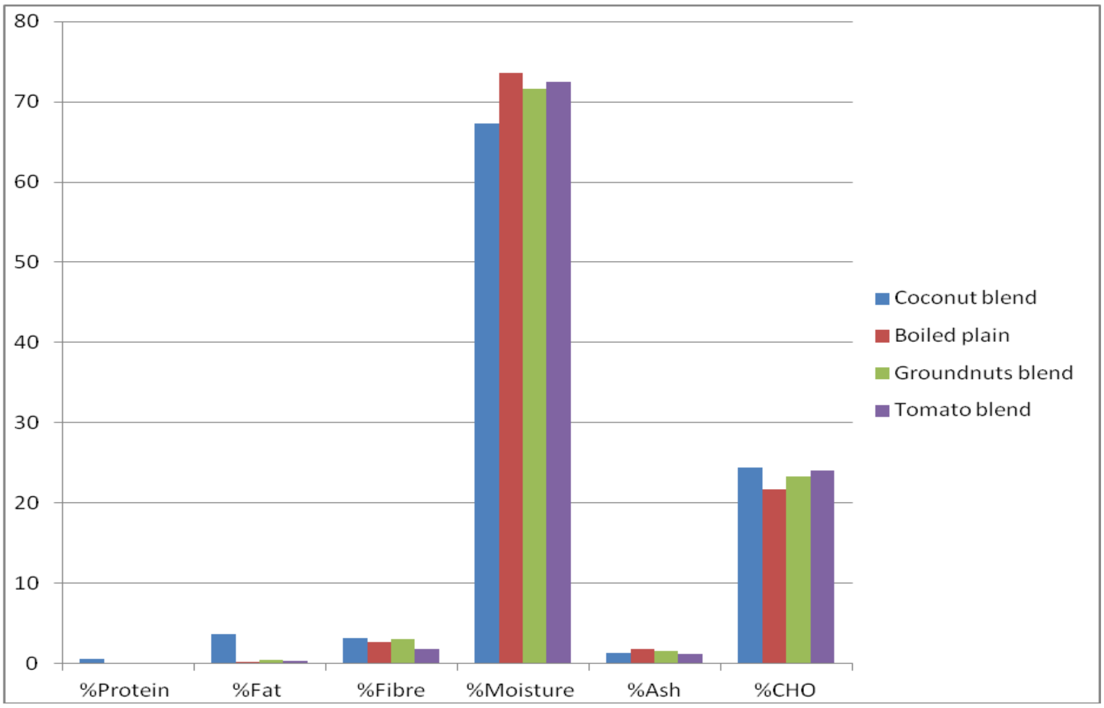
APPENDICES

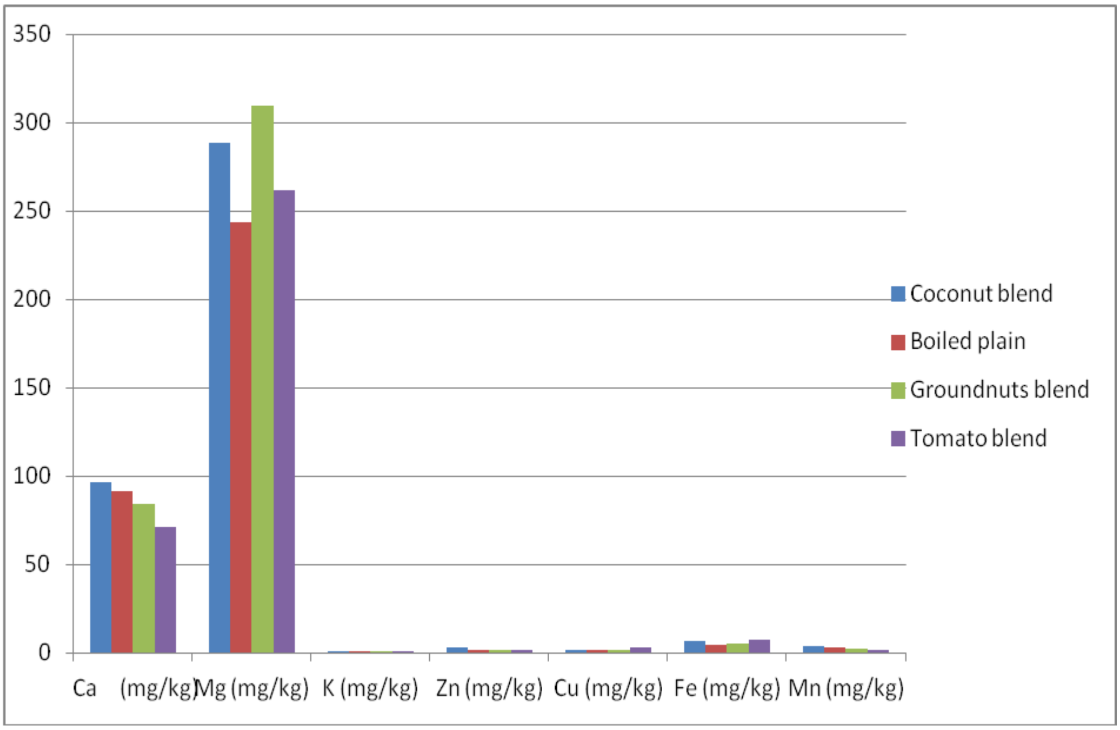
Appendix 1: percentage of a population consuming a recipe



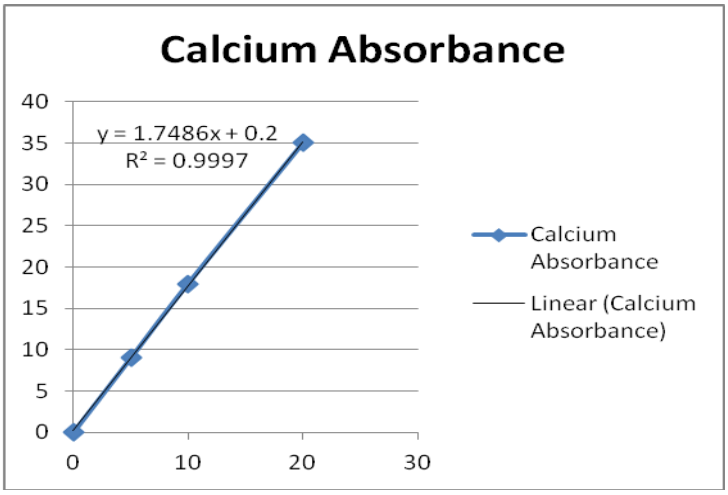
Appendix 2.1: percentage of proximate composition in cassava recipes



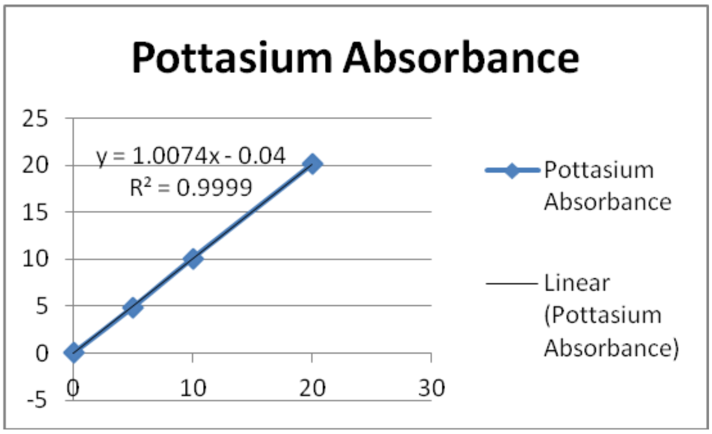
Appendix 2.2: Mineral composition score in cassava recipes



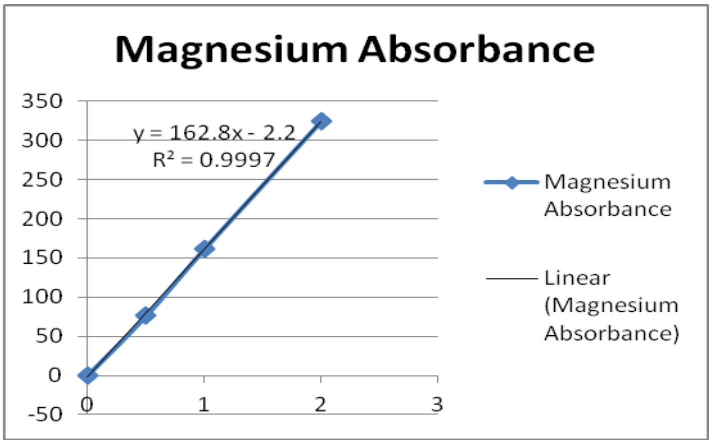
Appendix 2.2.1: Calcium Absorbance



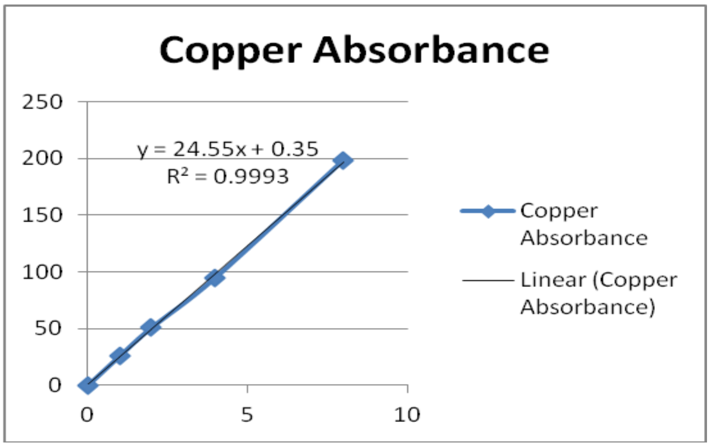
Appendix 2.2.2: Pottasium absorbance



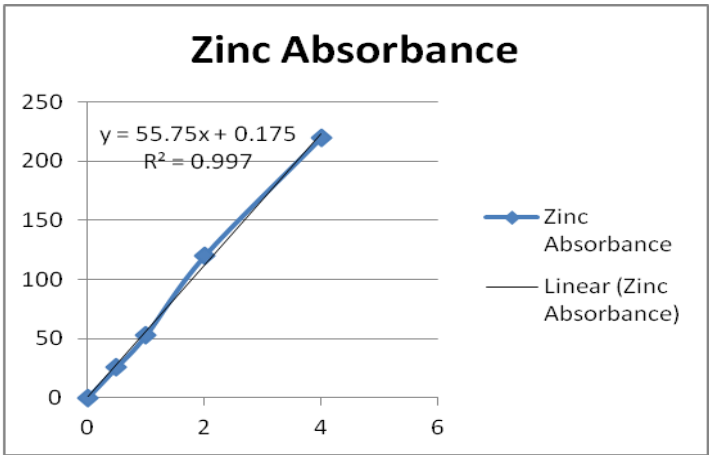
Appendix 2.2.3: Magnesium absorbance



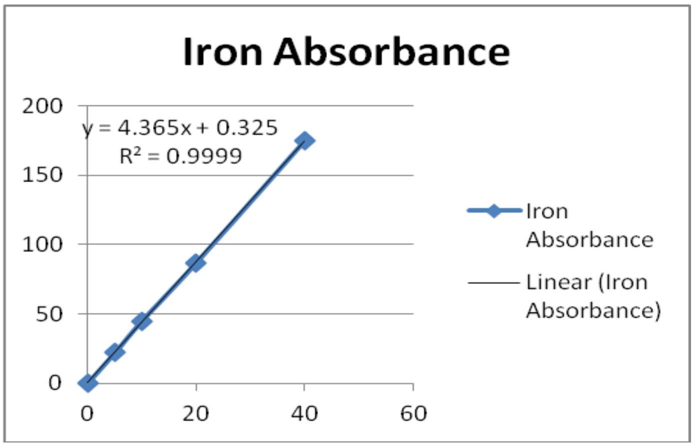
Appendix 2.2.4: Copper absorbance



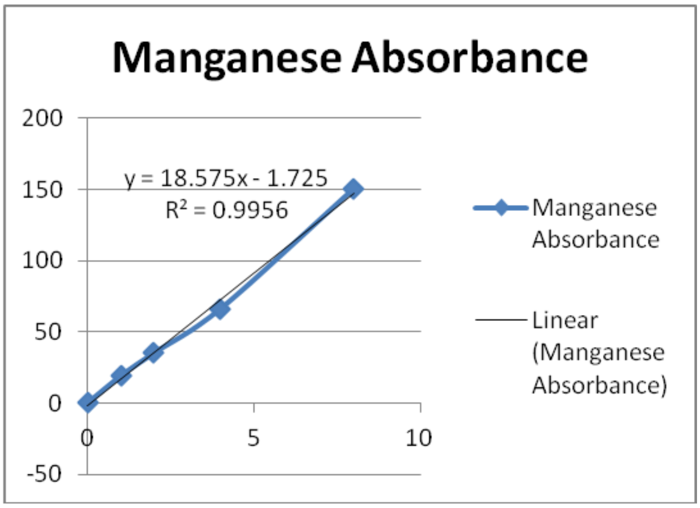
Appendix 2.2.5: Zinc absorbance



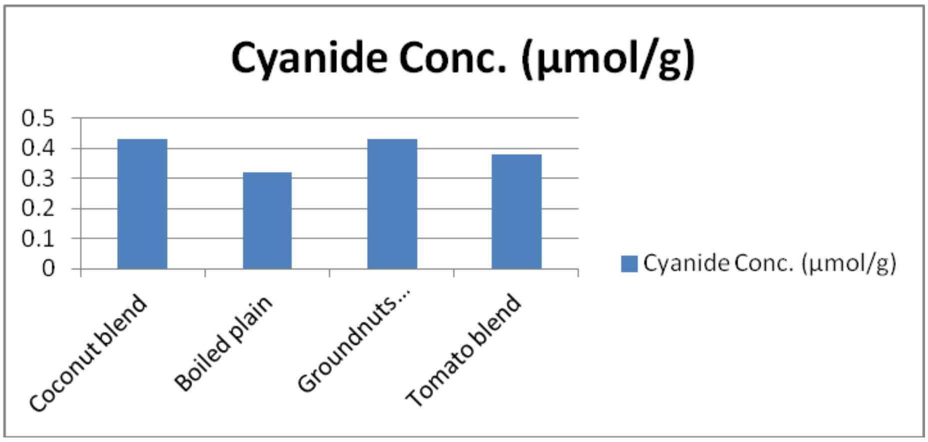
Appendix 2.2.6: Iron absorbance



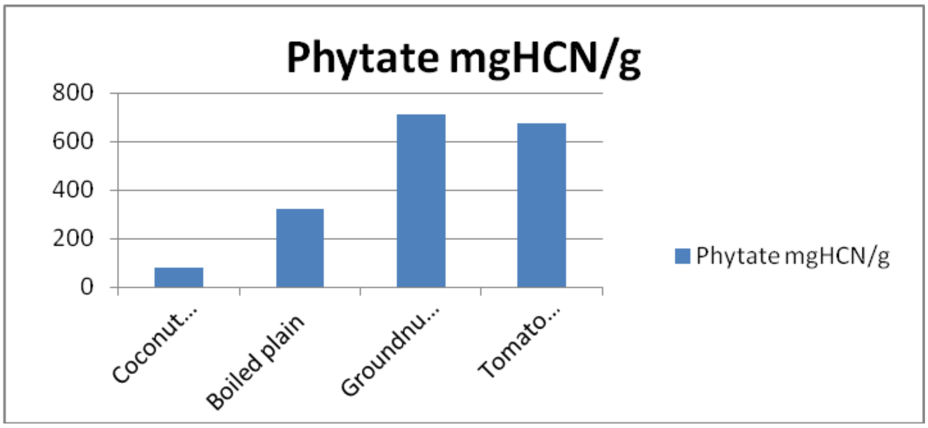
Appendix 2.2.7: Manganese absorbance



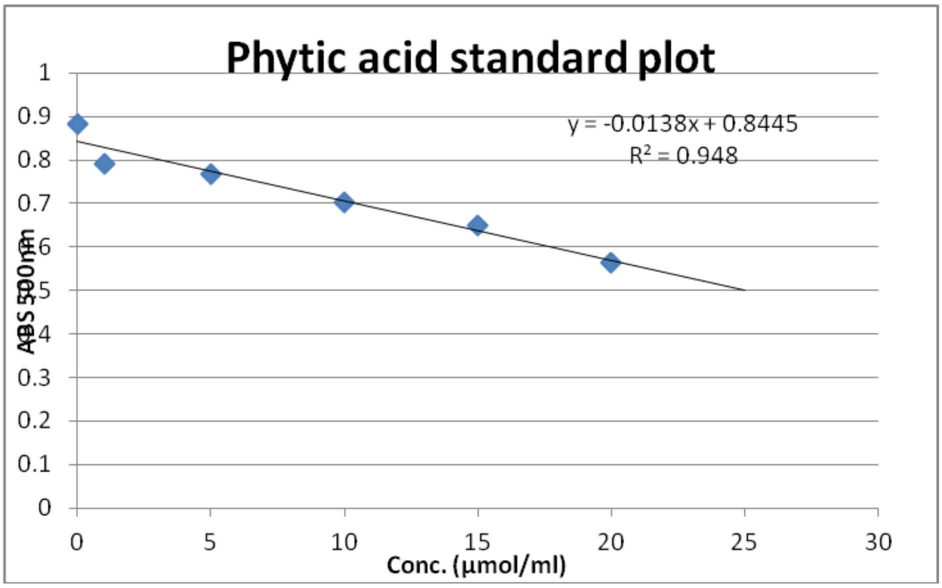
Appendix 2.3.1: Cyanide concentration in cassava recipes



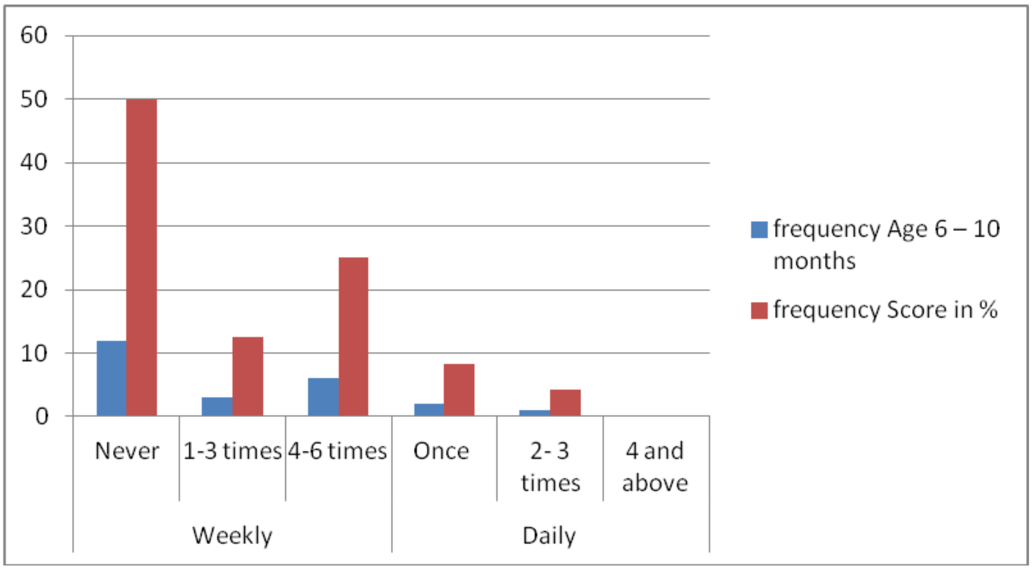
Appendix 2.3.2.a: Phytate concentration in cassava recipes



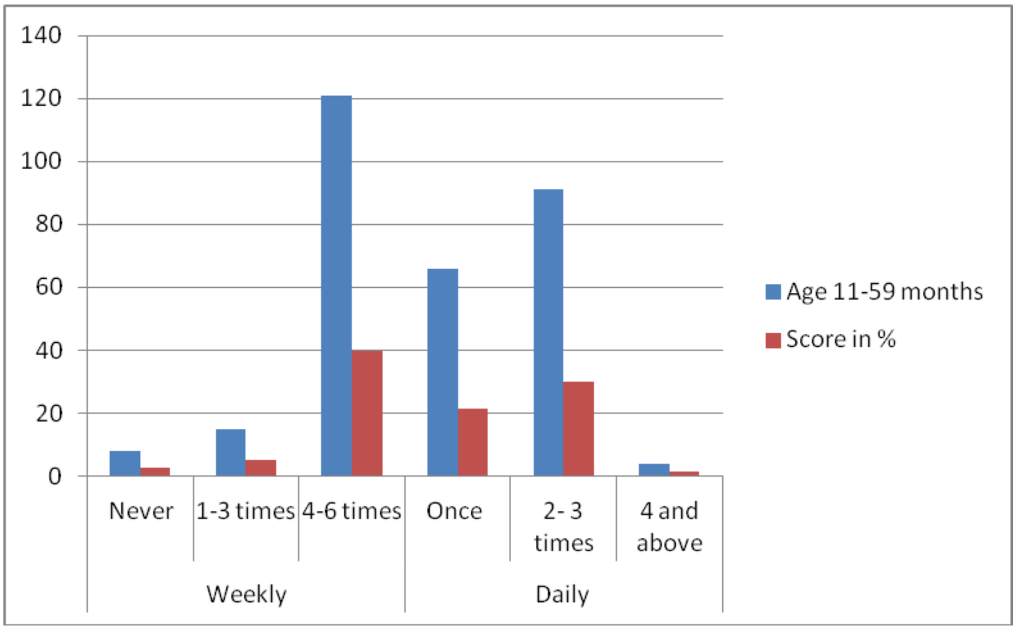
Appendix 2.3.2.b: concentration of phytic acid against absorbance standard plot



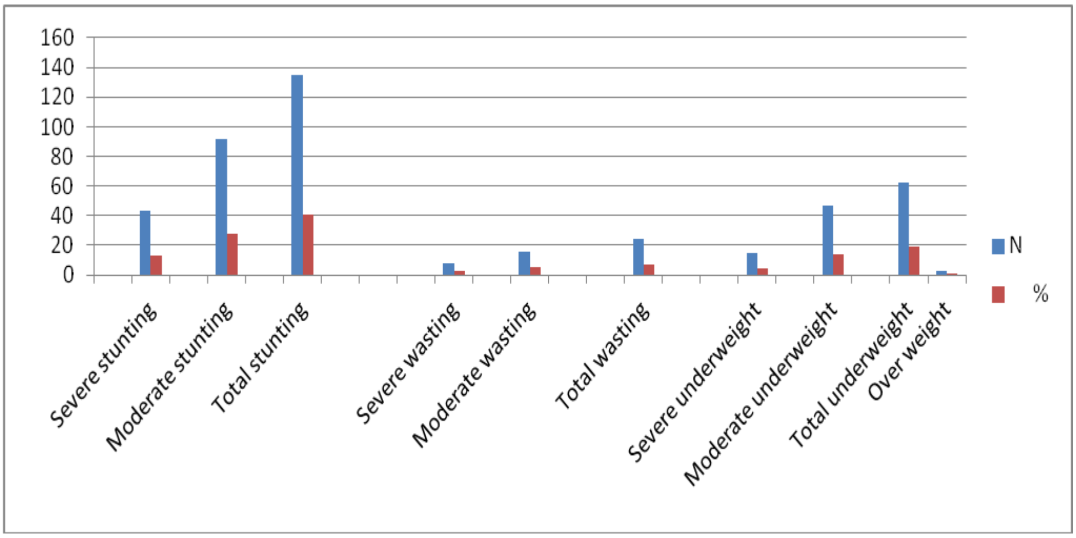
Appendix 2.4.1: Percentage and frequency of cassava consumption in children of 6-10 months



Appendix 2.4.2: Percentage and frequency of cassava consumption in children of 11-59 months



Appendix 2.5: percentage score and number of stunting, wasting and underweight in children



Appendix 3: 24 HOURS DIETARY RECALL

Name: ______________________Date:___________
Day of the week: Monday Tuesday Wednesday Thursday Friday Saturday Sunday
Does this day represent your typical eating habits? Yes/ No
Please be as specific and honest as possible for review with the Registered Dietitian.
Thank you

Time	FOOD/BEVERAGE	METHOD OF PREPARATION/RECIPE	Amount/ Serving size
Morning			
Mid-Morning			
Lunch			
Mid-Lunch			
Dinner			

1. How many different cassava dishes do you prepare at your household?
2. Mention each dish and the method of preparation in detail
3. Generally which one do you mostly prefer?

Is the one mostly preferred you prepare it more frequently, if No why?
Child's Height: Child's birth date:
Child's Weight:

Appendix 4 : Measuring Dietary Diversity for children

Name: ______________________Date:___________

Does this day represent your typical eating habits? Yes/ No

Please be as specific and honest as possible for review with the Registered Dietitian. Thank you

Question number	**Food group**	YES=1 NO=0
1	White potatoes, white yam, white cassava, or other foods made from roots	
2	Pumpkin, carrot, squash, or sweet potato that are orange inside + *other locally available vitamin A rich*	
3	Other fruits, including wild fruits and 100% fruit juice made from these	
4	Meat, poultry, fresh or dried fish or shellfish/seafood	
5	Dried beans, dried peas, lentils, nuts, seeds or foods made from these (e.g. hummus, peanut butter)	
6	Milk, cheese, yogurt or other milk products	
7	Eggs from chicken, duck, guinea fowl or any other egg	
8	Oil, fats or butter added to food or used for cooking	

Appendix 5: Food Frequency Questionnaire

How often in the past three months, did you eat the following	**never**	**Less than 1 time per week**	**1-3 times per week**	**4-6 times per week**	**1time per day**	**2-3 times per day**	**4 or more times per day**	**What was your usual serving size relative to the following**	**1**	**½ or less**	**1 ½ or more**
Fruits (apples, banana, oranges, etc)								1 whole fruit, ½ a piece, ¼ a piece of fruits.			
Vegetables (carrots, mushroom, sweet potatoes etc)								Bowl, cup, plate, glass, table spoon, cooked,1 carrot			
Poultry (fried, boiled, grilled, in soup, etc)								Medium serving			
Fish and sea food (crab, shrimps, tuna)								Medium Serving			
Pork and beef (pork chops, ribs, meat balls, steak)								3-6slices roasted beef, 1 pork chop			
Other meat(goat, lamb, turkey, duck)								3-4oz, a piece about the size of your palm			
Nuts (almonds, cashews, walnuts)								¼ cup or 1hand full, 20 almonds			
Pulses (Beans peas, pigeon peas)								½ cup(500mls) cooked pulses, ¼			

								cup			
Diary (cheese, milk, yogurt)								slices of cheese, 1 cup milk, 1 cup yoghurt			
Eggs								Whole egg, scrambled egg salad			
Grains (pasta, rice, breads)								slice of bread/pizza, plate, bowl			
Caffeinated soft drinks (cola, diet cola, soft drinks, etc)								Glass or Cup, 500mls bottle, 350mlsbottle			
Coffee and tea								Cup, 250mls glass			
Tubers (cassava)								Number of whole pieces, medium, or small			
Other root crops (potatoes, cocoyams								Medium or small size, number of whole pieces			
Other foods											

Appendix 6: Research Clearance Letter

THE OPEN UNIVERSITY OF TANZANIA

DIRECTORATE OF RESEARCH, PUBLICATIONS, AND POSTGRADUATE STUDIES

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Fax: 255-22-2668759,
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Date: 18 May 2016

Regional Administrative Officer,
Regional Commissioners Office,
P.O Box 544, Mtwara.

RE: RESEARCH CLEARANCE

The Open University of Tanzania was established by an act of Parliament No. 17 of 1992, which became operational on the 1st March 1993 by public notice No. 55 in the official Gazette. The act was however replaced by the Open University of Tanzania charter of 2005, which became operational on 1st January 2007. In line with the later, the Open University mission is to generate and apply knowledge through research. To facilitate and to simplify research process therefore, the act empowers the Vice Chancellor of the Open University of Tanzania to issue research clearance, on behalf of the Government of Tanzania and Tanzania Commission for Science and Technology, to both its staff and students who are doing research in Tanzania. With this brief background, the purpose of this letter is to introduce to you **Ms. Diana Nicodemus –** our PhD student in the Faculty of Science Technology and Environmental Studies. We hereby grant her a clearance to conduct a research entitled, **"Nutritional Qualities of Cassavas based Recipes and its Implication on the Nutrition Status of the U5 in Mtwara District."** She will conduct her research in Mtwara Region from 18/05/2016 to 18/07/2016, and we kindly ask you to support her research.

In case you need any further information, kindly do not hesitate to contact the Deputy Vice Chancellor (Academic) of the Open University of Tanzania, P.O. Box 23409, Dar es Salaam. Tel: 022-2-2668820.We lastly thank you in advance for your assumed cooperation and facilitation of this research academic activity.

Yours sincerely,

Prof Hossea Rwegoshora
For: VICE CHANCELLOR
THE OPEN UNIVERSITY OF TANZANIA

Appendix 7: List of published papers

1. D. Nicodemas, L.W.T Fweja* and S.H. Magoha (2019). Association between feeding patterns and nutritional status of the under five children (6-59 months) in Mtwara Rural District, Tanzania. *Journal of Food, Nutrition and Agriculture*, 2(1): 20-26.

2. Diana Nicodemas, Leonard William Tungaraza Fweja* and Happy Steven Magoha (2019). Evaluation of the Contribution of Cassava Staple to the Recommended Dietary Allowance of Selected Nutrients among the under Five Children in Mtwara Rural District, Tanzania. C*urrent Research in Nutrition and Food Science,* 7(1): 190-201.

3. Nicodemas, D, Magoha, S.H and Fweja, L.W.T* (2018). The Nutritional and Anti-Nutritional Composition of The Common Cassava Recipes in Mtwara Rural District, Tanzania. *International Journal of Science, Environment and Technology,* 7 (6): 1846 – 1860.

Journal of Food, Nutrition and Agriculture, 2019: 2(1) 20–26
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Research Article

Association between feeding patterns and nutritional status of the under five children (6-59 months) in Mtwara Rural District, Tanzania

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Abstract

This study was conducted to determine the association between feeding pattern and nutritional status of the under-five children in Mtwara rural district. Nutritional assessment information was collected using three survey tools: food frequency survey, 24 hours diet survey and anthropometric assessment survey. Anthropometric measures of weight and height were used to assess the nutritional status and WHO Anthro Plus was used to compute the anthropometric data to obtain Height for Age Z-score, Weight for Age Z-score and Weight for Height Z-score. The questionnaire was administered to mothers / caregivers of 329 children aged 6 -59 months. The children's feeding patterns were determined using the 24-hour dietary recall. Dietary diversity score was computed to understand the quality of the diet consumed by the children. Data were analyzed using IBM SPSS Statistics version 20.0 using descriptive statistics. Chi-square was used to determine the association between nutrition status and the independent variables including gender. The findings indicated 41% stunting rate, 18.8% underweight and 7.3% wasting implying poor nutrition. The cassava feeding frequencies varied among households and between and within the two children age groups, (6 – 10 months) and (11-59 months). Overall 87.23% of children (6-59 months) had a feeding frequency of 2 days, 3 days or 6 days in a week. The dietary diversity indicated an average IDDS of 2.5 implying poor diversity of consumed food groups which was similarly far below the target IDDS of 5 established for this study. The results however indicated no significant association ($p \geq 0.05$) between cassava consumption pattern and prevalence of stunting, wasting and underweight and also between gender and nutrition status. The high prevalence rate of malnutrition could thus be attributed to a synergistic effect of several factors.

Keywords: Cassava, u5 Children, Nutrition Status, Consumption pattern, Individual Dietary Diversity score (IDSS)

Introduction

Over 80% of the African populations live in rural areas with great dependence on agriculture for their livelihoods. Cassava which is one of the most important staple food crops grown in tropical Africa plays an important role in alleviating the continents food crisis because of its efficient production of food energy, year-round availability, tolerance to severe stress surroundings, and suitability to current farming and food systems in Africa (Hahn *et al.,* 1988) and hence ensure food security. Cassava roots have high starch content, about 60%, and therefore a cheap and excellent source of dietary carbohydrate. It is also rich in calcium, thiamine, riboflavin and niacin but contain low amounts of protein and other essential nutrients which are more obtainable in its leaves. In view of this cassava meal can only be improved by in-cooperating other foods to make its diet nutritious (Dziedzoave *et al.,* 2006). The high prevalence of malnutrition which affect growth and development of nearly half of the children population in Tanzania has attracted the attention of nutritionists and health professions and calls for interventions. According to TFNC (2014) the country's average stunting prevalence is 35% but varies between 31.9 to 40.9% in Mtwara region. Malnutrition manifestation has also been observed in other countries where cassava is a staple food. A study conducted by Nungo *et al.* (2012) in Western Kenya indicated that children were malnourished due to high cassava consumption with a frequency of up to three times in a day mainly as porridge, boiled cassava and ugali (stiff porridge) prepared from cassava flour. According to WHO (1997) stunting which is an indicator of under nutrition is regarded to be 'very high' if is greater than 40% in the population. The commonness of cassava as a staple food and the nutritional experience from areas with similar dependence on cassava calls for evaluation of the association between cassava consumption pattern and the nutrition status of the under-five children. It is documented that (Nungo *et al.,* 2012) the nutritional status of children is affected by age, gender, household characteristics, dietary intake and health status which are considered as immediate causes. The authors (Nungo *et al.,* 2012) also describe the following as underlining determinants, food security and community infrastructure including sanitation, safe water and local market conditions.

Nutritional assessment helps to identify the individuals or population groups at risk of becoming malnourished. It facilitates populations screening to identify individuals at risk of under nutrition (or over nutrition) and the degree and severity of under nutrition, i.e. mild, moderate or severe from which the nutritional status of different population groups and nations can be compared (Gibson, 2005). The findings of which would help to develop health care programs which would address community needs and measure the effectiveness of the initiated nutritional programs and intervention. The effects of malnutrition are well recognized e.g. can lead to disability, illness and death and jeopardize future economic growth by reducing the intellectual and physical potential of the entire population. It was thus important to conduct the current study to evaluate the association between cassava recipe consumption pattern and children nutrition status.

Methodology

Study area, design and study population

Mtwara Rural District was purposively selected as a study area due to high cassava production (FAO, 2001) and high malnutrition rate which varies from 31.9 – 40.9% (TFNC, 2014). The study employed a cross-sectional design in which the data were collected only once. The study population constituted of the under five children with their mothers/caregivers responsible for preparing their food who were randomly sampled. The sample size of the study population was computed from the formula

$$n = t^2 \, x \, (1-p) / m^2$$

as reported by Magnani, (1997) where n=required sample size, t=Confidence Interval level 95% (standard value 1.96), p=estimated malnutrition prevalence which is 31.65% (TFNC, 2014) and m=margin error at 5% (0.05) which gave a sample of 332 under five children. Out of 332 children, 329 fully participated and successfully provided useful data for the study.

Collection of Household Information

The information about households were obtained from mothers/caregivers responsible for taking care of the children (including planning and / or preparation of children meals) from six wards (Nanguruwe, Mbawala, Libobe, Mpapura, Mayanga and Mkunwa) with a total of 14 villages namely Ngorongoro, Namahyakata shuleni, Mwindi, Libobe, Mnyinja, Mpapura, Utende, Likonde, Libobe B, Kawawa, Mayanga, Nangumi, Mkunwa and Nanyati who were interviewed.

Anthropometric Measurements

The anthropometric measurements were used to assess the nutrition status of children based on stunting, underweight and wasting conditions. Age of a child (6-59 months) was a prerequisite before taking any measurement because under nutrition is manifested at an early age. Height was measured by using a height board (Stadiometer) of UNICEF manufactured in Maryiland. Children's weight was measured using Weight Scale (UNISCALE) with a brand name SECA manufactured in German, Modal 874 1021659. Children were made to minimal clothing following standard procedures for measurements to ensure accuracy.

Dietary Assessment

The 24h dietary recall was used to collect comprehensive information given by a mother/ care-giver for all foodstuff and drinks eaten by a child for the past 24h. The quantity of food reported to be eaten by children in 24 h dietary recall was approximated by using household utensils such as cups and bowls. Food Frequency Questionnaire (FFQ) was used to determine frequency of consumption of different food groups in the households in order to derive more habitual intake. The rate of consumption of a child was computed based on food portion and meal frequency for each day in a week. The adequacy of nutrient of complementary food was computed based on the quantity of food eaten per day. Computed nutrient intake was evaluated against the RDA of respective nutrient for respective age category.

In addition Dietary diversity score was computed to determine the quality of their diet as it includes the number of food groups consumed in a meal. The questionnaires were constructed in a three stage multiple pass interview (Gibson, 2005), in which the first pass involved a 24-hour dietary recall from which the description of cassava meal recipes including cooking methods was obtained too, second pass involved a food frequency questionnaire to identify frequency of different foods consumed in a week and the third part involved dietary diversity in which the number of food groups consumed were identified to measure dietary diversity of an individual.

Individual dietary diversity score (IDDS) is often used as a proxy measure of the nutritional quality of an individual's diet. The IDDS was computed using the following formula:-

$$Average\ IDDS = \frac{Sum\ IDDS}{Total\ number\ of\ Households}$$

Where *Sum IDDS* = $(S_1 + S_2 + S_3 + S_4 \ldots \ldots \ldots S_{329})$

And S is the score for every household which reflects the number of food groups consumed by every household out of the eight food groups. Thus S is a value through eight food groups that is either "0" or "1". For each household, S value should not exceed 8.

Statistical Analysis

IBM SPSS Statistics version 20 analytical package was used for the analysis of the data. Descriptive statistical analysis was used to establish frequencies and percentages of various variables of the dietary diversity and cassava intake as well as the mean frequency of cassava and dietary intake. Chi-square was used to establish association between the variables such as cassava consumption pattern, frequency of cassava consumption, gender and nutrition status of the under five children. WHO Anthro (World Health Organization Anthro) growth standards of 2006 taking -2SD as cut-off points was used to convert raw anthropometric data (weight, height and age of the children) into anthropometric Z-score for Height for age (HAZ), Weight for age (WAZ) and Weight for Height (WHZ) that was used to classify children into levels of nutritional status (stunting, wasting and underweight).

Results and Discussion

Child Information

A total number of 329 out of 332 recruited children were eligible for the study based on the inclusion and exclusion criteria such as age group and mental health. The recruited children were of the age of 6 to 59 months. The mean age for children was 31 months, mean weight was 11.7 kilograms and mean height was 84.8 centimeters. Of the 329 children who were eligible for the study 170 children (51.7%) were female and 159 children were male (48.3%) which indicates a more or less equal representation between genders.

Nutritional Status of the under five Children

Nutritional survey is important in revealing trends in prevalence of malnutrition. Thus a survey was conducted to examine the prevalence of malnutrition in Mtwara rural district where cassava based meals are consumed as staple food. The findings (Table 1) indicates severe stunting of 12.8% (7.3% female and 5.5% male) and the prevalence of moderate stunting at 28%, giving an overall total stunting of 41% (<-3 and <-2 z- score) among the under five children who were assessed. Underweight and wasting were 18.8% and 7.3% respectively with <-3 and <-2 z- score combined. Generally nutrition status of children in the area was poor (Table 1) and even worse than earlier reported (TFNC, 2014) which indicated malnutrition rate of 31.65% for the entire region. The difference from the current observation could be attributed to the nutritional status of children in other district that might have lowered the overall region average. The current study was done in Mtwara rural district. And according to UNICEF (2013) global data indicate that over one third of children in rural households are stunted compared to one quarter in urban households.

The findings also show no significance association (p≥0.05) between gender and nutrition status, both genders were more or less equally impacted with malnutrition. The current findings are consistent with the findings of Schoenbaum *et al.* (1995) which indicated insignificant differences between genders in terms of the prevalence of malnutrition.

Table 1. Nutrition status of the u5 children in male and female

Nutrition status	Normal (>+2 SD)		Moderate(<–2 SD)		Severe (<–3 SD)		Total %	
	Male%	Female%	Male%	Female%	Male%	Female%	Male%	Female%
Stunting	29.2	30.1	13.6	14.3	5.5	7.3	48.3	51.7
Underweight	40.4	40.7	5.5	8.8	2.1	2.4	48.0	51.9
Wasting	46.1	47.0	2.4	2.5	1.0	1.4	49.2	50.4

Table 2. Cassava consumption frequency in a week -between age categories

Frequency in a week (number of days)	Age categories				Overall total	
	Children at 6 – 10 months		Children at 11 – 59 months			
	Number (n)	Percentage (%)	Number (n)	Percentage (%)	Number (n)	Percentage (%)
0	12	3.65	8	2.43	20	6.08
1	3	0.91	15	4.56	18	5.47
2	6	1.82	121	36.78	127	38.60
3	2	0.61	66	20.1	68	20.67
6	1	0.31	91	27.66	92	27.96
7	0	0	4	1.22	4	1.22
Total number of children & percentage in each age category	24	7.29	305	92.71	329	100

According to NBS (2011), the stunting prevalence rate in the country was 42% whereas the findings of the present study indicates about 41% prevalence rate of stunting (that is, moderate plus severe stunting, Table 1). These findings imply that, despite all the efforts to alleviate malnutrition in the country, stunting is still a problem. This could possibly be due to inadequate knowledge on nutrition and feeding practices of mothers and/ or caregivers as well as poor nutrient intake during pre-conception and during pregnancy. Furthermore, prevalence of mycotoxins in food can also affect the nutritional status as reported by Magoha *et al*., (2014). There are other causes of malnutrition such as poor sanitation and unavailability of clean water which could lead to diarrhea, high prevalence of diseases such as malaria which all affect the eating habit of the children and can facilitate prevalence of malnutrition (WHO, 2010).

Poor nutrient content of cassava recipe could be another cause for the observed poor nutritional status among children. Cassava is reported to contain little zinc, iron, and β-carotene, yet is the primary staple crop of over 250 million Africans (Gegios, 2010) Mtwara residents inclusive. The continued low intake of zinc in children might increase prevalence of stunting. Caulfield and Black (2005) showed that diets rich in zinc improved growth (increase in weight and height) of stunted children in Ethiopia and attributed it to the ability of zinc to reduce morbidity due to infection and increased appetite.

Barago (2013) in his study conducted in Mtwara Rural revealed that, despite 59.9% of the respondents having excellent knowledge on food security but food insecurity still existed. It is advocated that strategies for reducing food insecurity should involve increasing availability and access to quality nutritious food by diversifying diets. However, the results of the current study have indicated poor food diversification (Table 4). Available global data show that, over one third of children in rural households are stunted compared to one quarter in urban households. Children in the poorest households are more than twice as likely to be stunted as children in the richest households (UNICEF, 2013).

Feeding Patterns and Cassava Consumption Rate

The results in Table 2 indicate variations in the feeding frequencies among households and between and within the two age groups, which are children aged between 6 – 10 months and between 11-59 months. The 6-10 months age group constituted less than 10% of the entire study sample. In this age group the majority (3.65%) never consumed cassava based meals which implies that children were either still being exclusively breastfed or were fed none cassava based complementary foods. Similarly none among the 6-10 months aged children did consume cassava based meals for the entire week. The feeding frequency of 2 days in a week was dominant for children of 6-10 months. Among children aged 11-59 months the dominant consumption frequencies in a week was also that of two days per week (36.78%), three days (20.1%) and six days (27.66%). In this age category only few of them (2.43%) did not consume cassava based

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Table 3. Cassava consumption frequency in a week in each age category

Age category (months)	Number of children (n)	Consumption frequency in a week in each age category (Number of days in a week)					
		0	1	2	3	6	7
6-10 months	24	50	12.5	25	8.3	4.2	0
11-59 months	305	2.6	4.9	39.7	21.6	29.8	1.3
Total	329	52.6	17.4	64.7	29.9	34	1.3

Table 4. Individual Dietary Diversity for children

Food Groups	% of individuals consuming / not consuming a particular food group			
	Yes	(%)	No	(%)
White potatoes, white yam, white cassava, or other foods made from roots	246	74.8	83	25.2
Pumpkin, carrot, squash, or sweet potato that are orange inside + *other locally available vitamin A rich*	19	5.8	310	94.2
Other fruits, including wild fruits and 100% fruit juice made from these	71	21.6	258	78.4
Meat, poultry, fresh or dried fish or shellfish/seafood	142	43.2	187	56.8
Dried beans, dried peas, lentils, nuts, seeds or foods made from these (e.g. hummus, peanut butter)	91	27.7	238	72.3
Milk, cheese, yogurt or other milk products	68	20.7	261	79.3
Eggs from chicken, duck, guinea fowl or any other egg	2	0.6	327	99.4
Oil, fats or butter added to food or used for cooking	169	51.4	160	48.6

meals at all. Overall the largest fraction (64.74%) of all the children (6-59 months) had a feeding frequency of cassava based meals of between 2 to 6 days in a week. The daily feeding frequency of 7days in a week was less practiced in both age groups. These variations in the consumption frequencies of cassava based meals could possibly have an implication on children nutritional status.

Table 3 separately examines the consumption pattern of cassava within each age group, that is, 6-10 months and 11-59 months respectively. For the former age group (6–10 months) half of the children did not consume cassava at all and the remaining consumed cassava at varying frequencies with a quarter of them consuming at the frequency of 2 days per week and the other remaining quarter consuming cassava based meals at a frequency of 1 day per week (12.5%) and 3 days to 6 days per week (altogether constituting 12.5%).

In the age group of 11-59 months the consumption score in percentage indicate that only 2.6% never consumed cassava but the rest were consuming cassava based meals. The dominant consumption pattern was that of 2 days per week (39.7%) followed by 6 days per week (29.8%). The results generally show that over half (52.7%) of children aged 11-59 months had a consumption frequency of cassava based meals of between 3 days to 7 days in a week.

Furthermore, it was observed that intra-household food distribution was poor, in almost all households; about 92.7% (Diana, per comm.) of children were eating from same pots with adults without offering any special treatment to children during meals. This may imply inequality in food distribution and accessibility which is likely to lead to food insecurity and hence malnutrition because food security is a key factor in good nutrition (FAO, 2008). This could further explain the high rate of malnutrition documented in the present study.

Children Dietary Diversity

The findings on children dietary diversity are presented in Table 4. The FANTA system of grouping children's diet was used in determining an individual's dietary diversity score. The number of foods consumed across and within food groups over a reference time period is widely recognized as a key dimension of dietary quality. It reflects the concept that increasing the variety of foods and food groups in the diet helps to ensure adequate intake of essential nutrients, and promotes good health (Kennedy *et al,* 2009).

The IDDS was computed based on a set of 8 food groups consumed by members of the household in view of the usefulness of these food groupings. Values for eight food groups were considered as either "0" or "1" in which case 0 indicates not consuming and 1 indicates consuming a particular food group

$$i.e.\ Sum\ IDDS = (S_1 + S_2 + S_3 + S_4 \ldots \ldots \ldots S_{329}) = 808$$

Where by S- is the score for every single household

$$Average\ IDDS = \frac{Sum\ IDDS}{Total\ number\ of\ Households} = \frac{808}{329} = 2.5$$

It is desired that the average IDDS be compared with some meaningful target level of diversity. Unfortunately, normative data on 'ideal' or 'target' levels of diversity are usually not available but options are available for determining appropriate targets whereby an IDDS target can be established by taking the average diversity of the 33 percent of individuals with the highest diversity (upper tercile of diversity) (Swindale and Bilinsky, 2006). From this study 10 children had the highest IDDS of 5, therefore from the formula of determining the IDDS target by considering the average diversity of 33% of 10 individuals with the highest diversity you get 3.3, which is approximately 3 children.

Therefore,

$$T\ \arg\ et\ IDDS = \frac{(5+5+5)}{3} = 5$$

The 5 target IDDS score shows a meaningful target level of diversity for children in Mtwara rural district which has to be attained over and above the average IDDS of 2.5 that has been attained. Thus a 2.5 average IDDS score obtained from this study implies that there is no improvements in terms of the average food groups consumed by the children based on earlier findings (MoHCDGEC, 2015-16) which showed an average of less than 5 IDDS for many regions. An increase in the average number of different food groups consumed provides a quantifiable measure of improved household food access. In general, any increase in IDDS reflects an improvement and changes in the individual's diet. Overall there is low consumption of foods of different varieties including foods of animal origin which are rich in iron and vitamin A (Table 4). This could be among the contributing factors that lead to higher prevalence of malnutrition in Mtwara region. This can well be explained by the fact that the higher the food insecurity the lower the food diversification ever since consumers' eat what is readily available and so diet imbalance.

Association between nutrition status and feeding pattern

The cassava consumption pattern of children in the district was established to examine its association with under nutrition (stunting, underweight and wasting) (Table 5). These findings would highlight on the contributing factors to poor nutrition status observed among the under-five children in the district.

Table 5. Association between cassava consumption pattern variable and Stunting (HAZ)

HAZ	Severe n (%)	Moderate n(%)	Normal n(%)	Total n(%)	Chi-square	Df	p-value
Cassava consumption score							
Yes(consuming cassava)	38(11.6)	68(20.7)	140(42.6)	246(74.9)	1.848	2	0.432
No(not consuming cassava)	8(02.4)	23(7.0)	52(15.8)	83(25.2)			
Frequency of Cassava consumption							
Never	0(0.0)	4(1.2)	15(04.6)	19(05.8)	11.750	12	0.514
Less than 1 time per week	0(0.0)	0(0.0)	1(00.3)	1(00.3)			
1-3times per week	1(0.3)	4(1.2)	12(03.6)	17(05.2)			
4-6times per week	20(6.1)	32(9.7)	75(22.8)	127(38.6)			
1time per day	8(2.4)	24(7.3)	36(10.9)	68(20.7)			
2-3times per day	17(5.2)	25(7.6)	51(15.5)	93(28.3)			
4 or more times per day	0(0.0)	2(0.6)	2(00.6)	4(01.2)			

Chi-square test was used to test whether there is significant association ($P \geq 0.05$) between cassava consumption score and frequency and prevalence of malnutrition. The findings indicated that though the most affected children were those consuming cassava than those not consuming but the association was insignificant ($P \geq 0.05$) implying negligible effect. Similarly neither higher nor low frequencies of cassava consumption had any significant effect on the nutritional status of children.

The results generally indicate that malnutrition was neither related to cassava consumption score nor cassava consumption frequency but could rather be due to a synergistic effect of several factors including poor dietary diversity as reflected by the computed average IDDS. The computed average IDDS of 2.5 is far below the targeted IDDS of 5 in Mtwara region justifying poor dietary quality among children.

The present findings however, contradicts the results of Nungo *et al.* (2012) who conducted a research in Western Kenya and indicated that children were malnourished due to high cassava consumption at a frequency of up to three times in a day mainly as porridge, boiled cassava and ugali (stiff porridge) prepared from cassava flour which was not the case in this study. This means the higher prevalence of malnutrition in the region could be attributed to a combination of several factors as indicated earlier.

Table 6. Association between cassava consumption pattern and Wasting (WHZ)

WHZ	Severe n(%)	Moderate n(%)	Normal n(%)	Total n(%)	Chi-square	Df	p-value
Cassava consumption score							
Yes	6(1.8)	10(3.0)	230(69.9)	246(74.8)	1.747	2	0.456
No	2(0.6)	6(1.8)	76(23.1)	83(25.2)			
Frequency of Cassava consumption							
Never	1(0.3)	3(0.9)	15(4.6)	19(5.8)	11.520	12	0.353
Less than 1 time per week	0(0.0)	0(0.0)	1(0.3)	1(0.3)			
1-3times per week	0(0.0)	0(0.0)	17(5.2)	17(5.2)			
4-6times per week	2(0.6)	9(2.7)	116(35.3)	127(38.6)			

The wasting rate among the under five children was 7.3% which is reasonably low and was indicated to be independent of the cassava meal consumption pattern and frequency. This is evidenced by lack of significant association ($P \geq 0.05$) between wasting and cassava consumption score and frequency. Frozanfah *et al.* (2016) in the study conducted in Afghanistan indicated significant association between acute malnutrition (wasting) among under-five and education level of household heads, age of household heads, income, education level of mothers, history of children with diarrhea in the last two weeks of data collection, water sources and iodized salt. In view of this a similar argument could be made regarding the prevalence of malnutrition in Mtwara that, is due to synergistic effects of several factors. Though cassava based meals are inadequate by themselves in meeting the children nutritional needs but their effects can only be realized when other determining factors are out of the equation.

The results have shown no significance association between the cassava consumption score in the population (p=0.237), frequency of cassava consumption (p=0.584) with the underweight situation among children in Mtwara

Table 7. Association between cassava consumption pattern and Underweight (WAZ)

WAZ	Severe n(%)	Moderate n(%)	Normal n(%)	Total n(%)	Chi-square	Df	p-value
Cassava consumption score							
Yes	14(4.3)	35(10.6)	194(58.9)	248(75.4)	3.212	2	0.237
No	1(0.3)	12(3.6)	69(21.0)	85(25.8)			
Frequency of Cassava consumption							
Never	1(0.3)	0(0.0)	18(5.5)	19(5.8)	10.077	12	0.584
Less than 1 time per week	0(0.0)	0(0.0)	1(0.3)	1(0.3)			
1-3times per week	0(0.0)	2(0.6)	15(4.6)	17(5.2)			
4-6times per week	4(1.2)	22(6.7)	101(30.7)	127(38.6)			
1time per day	3(0.9)	12(3.6)	53(16.1)	68(20.7)			
2-3times per day	8(2.4)	14(4.3)	71(21.6)	93(28.3)			
4 or more times per day	0(0.0)	0(0.0)	4(01.2)	4(1.2)			

rural district (18.8%). The results imply that underweight among the under-five children could be attributed to a combination of several factors such as age diseases, food security, gender division of labour and other factors as reported by Shoo (2011). Moreover, Peiris and Wijesinghe (2011) indicated that though inadequate food intake is a basic cause of underweight; several other factors such as living standards, water and sanitation, birth weight, birth interval and parity, weaning practices and mother's nutritional knowledge have been identified as contributing to malnutrition among children. Therefore the observed results may have been due to a combination of several factors from among those.

Conclusions

The findings of the present study generally indicate poor nutrition status and high level of malnutrition among the under five children. Stunting was the most prevalent form of malnutrition at a rate of 41%, followed by underweight (18.8%) and wasting (7.3%). However no significance association ($p \geq 0.05$) was recorded between gender and nutrition status, both genders were more or less equally impacted with malnutrition. Cassava feeding frequencies varied among households and between and within the two age groups, (6 – 10 months) and (11-59 months). Half of the children aged 6 – 10 months did not consume cassava at all and the remaining consumed cassava at varying frequencies of 1, 2, 3 or 6 days per. In the age group of 11-59 months the dominant consumption frequencies were 2 and 6 days per week. Overall 87.23% of all the children aged 6-59 months had a feeding frequency of 2 days, 3 days or 6 days in a week. Nonetheless the results indicated no significant association between cassava consumption score and frequency and prevalence of malnultrion (stunting, wasting and underweight).

The average IDDS of 2.5 obtained in this study implies poor diversity of consumed food groups and lack of improvements in the individual's diet including low consumption of foods of animal origin. This could be among the contributing factors to higher prevalence of malnutrition in Mtwara rural district. The higher prevalence of malnutrition in the region could thus be attributed to a combination of several factors. Thus the high prevalence rate of malnutrition in Mtwara rural district may not be due to cassava consumption frequency but rather to a synergistic effect of several factors.

Acknowledgement and Declaration

The authors report no declaration of interest. The authors are responsible for the content and writing of the paper.

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Evaluation of the Contribution of Cassava Staple to the Recommended Dietary Allowance of Selected Nutrients Among the under Five Children in Mtwara Rural District, Tanzania

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Abstract

This study aimed at evaluating the contribution of cassava recipe in meeting Recommended Dietary Allowance (RDA) of the under five children for the selected nutrients (protein, fat, iron and zinc) in Mtwara rural district. This was achieved by identifying the common cassava recipes and the consumption pattern by using a 24h dietary recall and Food Frequency Questionnaire (FFQ). Proximate composition, mineral contents and anti-nutrients (cyanide and phytate contents) were also determined. The rate of consumption of a child was computed based on food portion and consumption frequency in a day. The sufficiency of nutrient of cassava recipes was determined on the basis of the quantity of food eaten per day. Computed nutrient intake was evaluated against the RDA of respective nutrient for respective age category.

The findings indicate that the contribution of cassava to the RDAs of the respective nutrients were 19.4% for iron, 21% for zinc, 0.527% for fat and 4.26% for protein among the under five children which is extremely low. The anti-nutrient (phytate) content was far above the tolerable level of 25 mg/100g but cyanide was within the acceptable level. The computed Individual Dietary Diversity Score (IDDS) of 2.5 was similarly far below the target IDDS of 5. This implies an extremely poor dietary diversity indicative of very low consumption of food varieties including those of animal origin. It is thus important to develop strategies which encourage and make easy for dietary diversification among community members in order to complement

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cassava based recipes with readily available foods rich in macro and micronutrients. The strategy should also consider dietary practices such as control of intake of inhibitors e.g. of iron absorption and increase intake of enhancers of absorption in a given meal. These strategies can also include cassava recipe supplementation and fortification.

Introduction

Malnutrition is a serious issue not only for the reason that great numbers of inhabitants are affected, but also because it is a risk factor for numerous diseases. It is defined as a situation of nutrition in which a shortage or surplus (or imbalance) of energy, protein and other nutrients results in quantifiable undesirable effects on tissue/body form (body shape, size, composition), body function and clinical ending.[1] It is increasingly recognized as a prevalent and important health problem in many developing countries. This has serious long term consequences for the children health and adversely influences their development. The crop plays vital roles in African advancement such as famine reserve, rural foodstuff staple, cash crop and urban food staple.[2] It is extensively grown-up in every agricultural systems due to its adaptableness to various soils and agro-ecological situations. Cassava is an ever more important crop in the country and is the next most vital food crop behind maize in terms of production quantity and per capita consumption, sustaining the living of 37% farmers in rural parts. The greater part of the poorest farmers (59%) are reported to cultivate the crop for food.[3] Tanzania is the fourth producer of cassava in Africa,[4] the main producing areas being the coastal strip along the Indian Ocean (where Mtwara is), around Lake Victoria, Lake Tanganyika and along the shores of Lake Nyasa. Mtwara region is a highly cassava growing area and cassava is the dominant annual crop grown in the region. Its production is the topmost for roots and tuber crops in the region with a sum production of 72,087 tones which represent 99.7% of the total root and tuber produce.[5]

Tanzania's prevalence of malnutrition (stunting which is a chronic form of malnutrition affecting children at high rate compared to other forms of malnutrition) has decreased from 42% to 34.4%.[6] The prevalence of malnutrition however shows much variability between regions within the country. In many regions prevalence of stunting was below 40%, while in Mtwara region stunting prevalence was above 45%.[7] In 2014 however, the prevalence of chronic malnutrition in Mtwara Rural District was found to be 31.65%,[8] which still calls for attention in nutrition assessment and analysis.

Cassava meal alone cannot cater for the body nutrients requirement, however, can only be improved by in cooperating other foods to make cassava diet nutritious.[9] As soon as the population can't afford to broaden the horizons of their diets with sufficient quantities of fruits, vegetables or animal-source foods that contain great quantities of micronutrients, insufficiencies regularly arise due to monotony and nutritional inadequacy. Insufficient dietary intake and extended under nutrition can cause short and long term effects, which can diminish financial, physical, and social capital, further aggravating the cycle of under nourishment, poverty, and unhealthful household situation that the majority food-insecure families already have.[10]

The Recommended Dietary Allowance (RDA) is set in order people to understand the amount of nutrients required for normal growth. It can be defined as the levels of in-take of energy and dietary components which, on the basis are considered adequate for the maintenance of health and well-being of a healthy person in the population. Children are vulnerable to malnutrition and thus a group of interest to follow up on whether their meals meet the RDA. Poor nutrition can have a devastating impact in their growth and development. Thus evaluating the contribution of cassava staple RDA would form an appropriate base that for dietary diversity intervention and also broaden awareness among the affected population. It is thus important to evaluate how cassava based meals can adequately contribute to RDA for healthy life. The objective of this investigation was therefore to evaluate the contribution of cassava staple to the recommended dietary allowances of selected nutrients among the under five children in Mtwara rural district.

Materials and Methods

Study area, Design and Study Population

Mtwara Rural District was purposively chosen as a study location due to high cassava production[4] and malnutrition rate of 45% [7] which has declined to 31.65% [8] but is still reasonably high. The study population constituted of the under five children with their mothers/caregivers responsible for preparing their food. The sample size of the study population was computed from the formula $n = t^2 x \frac{(1-p)}{m^2}$ where n= desired sample size, t=Confidence Interval level 95% (standard value 1.96), p=estimated malnutrition prevalence which is 31.65% [8] and m=margin error at 5% (0.05) which gave a sample of 332 under five children. Out of 332 children, 329 fully participated and successfully provided useful data for the study.[11] The study employed a cross-sectional study design that involved 329 children aged 6 to 59 months. This was complemented with an experimental analysis.

Dietary Assessment

The 24h dietary recall survey was applied to collect comprehensive information given by a mother/ care-giver for every foodstuff and drinks eaten by a child for the previous 24h. The quantity of food indicated to be eaten by children in 24 h dietary recall was approximated by using family utensils such as cups and bowls. Food Frequency Questionnaire (FFQ) was used to determine frequency of consumption of different food groups in the households in order to derive more habitual intake. The rate of consumption of a child was computed based on food share and meal frequency in a day. The sufficiency of nutrient of complementary food was computed on the basis of the quantity of food eaten in a day. Computed nutrient intake was evaluated against the RDA of respective nutrient for respective age category.

In addition dietary diversity score (DDS) was calculated to determine the quality of their diet as it includes the number of foodstuff groupings eaten in a meal. The questionnaire was constructed in a three stage multiple pass interview,[12] in which the first pass involved a 24-hour dietary recall from which the description of cassava meal recipes including cooking methods was obtained, the second pass involved a food frequency questionnaire to identify the consumption frequency of different foods in a week and the third pass involved dietary diversity in which the number of food groups consumed were identified to measure dietary diversity of an individual.

Identification and Preparation of Cassava Recipes

The common cassava recipes and methods for their preparations were identified through a dietary pattern assessment method using the 24h dietary recall and food frequency questionnaire. This was important to collect complete information given by a mother or care giver for all food stuff and drinks eaten by a child in 24h and the frequency of consumption. Plain cassava recipe (which was among the four identified recipes) was used in the present study for

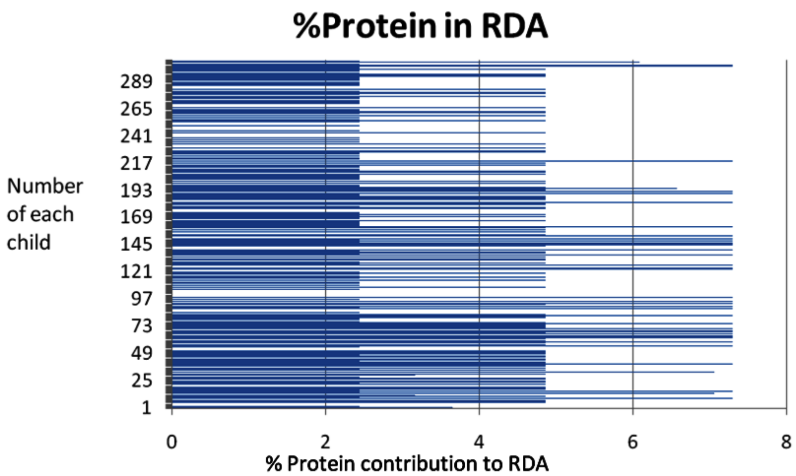

Fig. 1: Protein contribution (%) to its RDA among under five children

evaluation of the RDA of selected nutrients because was the most commonly consumed recipe (97%). Two households from among the households that constituted the study sample were selected for preparation of the identified recipes. The recipes/samples were prepared in duplicates by each household to avoid biasness. The ingredients and other raw materials used for preparation of the various cassava based recipes described during the interview were obtained from a local market. After cooking, the recipes (meals) were left at room temperature (30 °C) to cool down for about one hour then packed in duplicates in the freezer bags which were then stored in the freezer model WestPoint (Tropical, made in France) with temperature set at -20 °C.

Laboratory Analyses

During analysis the frozen samples were defrosted, homogenized and analysed as per analytical method. The laboratory parameters analyzed were proximate composition, minerals contents and anti-nutrients (cyanide and phytates).

Analysis of Nutrients (Proximate Composition and Mineral Contents)

The proximate analysis of moisture, ash content, fat and protein content was carried out.[13] Kjeldahl method was used for the analysis of protein and Soxhlet method for the determination of fat. Crude fiber was determined[14] and total carbohydrate (in percentage) was calculated by subtracting the sum of the percentage values of moisture, crude protein, ash and crude fat from 100%.[15] Cassava recipes were analyzed for the minerals (iron, zinc, copper, potasium, calcium, magnesium and manganese) using the atomic absorption spectrophotometer model iCE3000series.[16]

Analysis of Phytate and Cyanide Contents

Phytate content of the samples was done as described by Davis[17] and total cyanide content in the samples was analyzed using the alkaline titration method using AOAC (1990) methods.[13]

Determination of Targeted Individual Dietary Diversity Score (IDDS)

The IDDS was computed based on a set of 8 food groups consumed by members, through the following procedure[18]

$$i.e.\ Sum\ IDDS = (S_1 + S_2 + S_3 + S_4 \dots \dots \dots + S_{329})$$

Where S is the score for every single household which reflects the number of food groupings eaten by every household from among the eight food groups

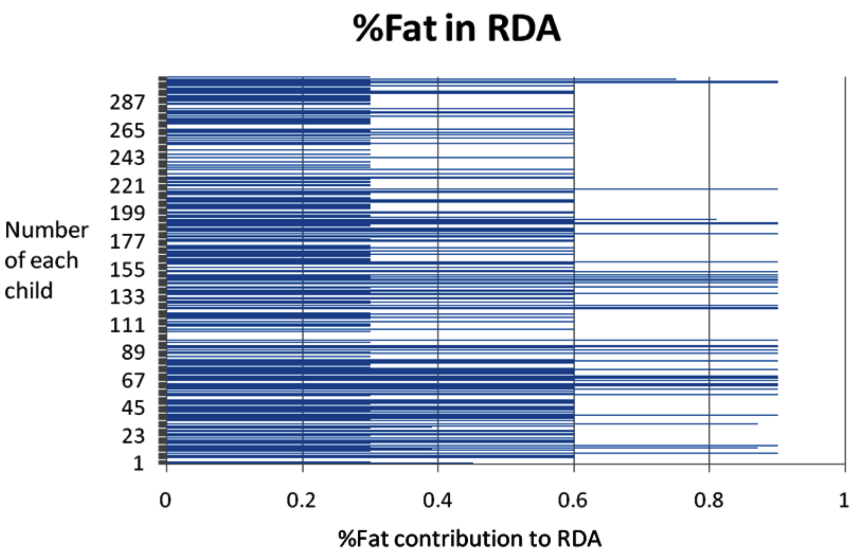

Fig. 2: % of Fat contribution into its RDA in each child among under five children

The average IDDS was computed using the below formula

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

Determination of IDDS target for a particular population

It is desired that the variations in IDDS be evaluated against some important target level of diversity. Regrettably, standard data on 'ideal' or 'target' levels of diversity are generally not existing but choices are available to establish suitable target levels whereby an IDDS target for the population can be determined by taking the average diversity of the 33% of individuals with the uppermost diversity score (upper tercile of diversity) within the population.[18]

Determination of Nutrition Intake for the Study Population

Four cassava recipes were identified however, of the four recipes the most commonly used recipe (97%) was plain cassava recipe hence used for determination of nutrient intake. Amount of nutrients taken from proximates was computed as follows

Nutrient Intake % = Quantified Nutrient Contentin a sample (5) χ Average Cassava Intakeper Day(g) / Sample Weight (g)

Amount of nutrients taken from minerals was computed in weight basis as follows

Nutrient Intake (Minerals)mg = Quantified Mineral Content(mg) χ Average Cassava Intake per day(g) / 100g

Computation of RDA Percentages from Cassava Meal

The percentage of RDA's was computed from the below formula based on the amount of nutrient intake by a child from a cassava meal.

The percentage contribution of both proximate components and mineral contents to the standard RDA were calculated from the formula below

Table 1: Nutrition Composition of Plain Cassava Recipe and the Recommended Dietary Allowance (RDA), Adequate Intakes (AI) and Acceptable Macronutrient Distribution Range (AMDR) for under five children

Nutrients	Sample weight	Nutrient content in cassava meal	RDA*/ AI**/ AMDR***	Average nutrient intake per day	% intake/ day
Protein	0.3g	0.07±0.01%	24g	1.024g	4.2%
Fat	5.0g	0.18±0.13%	30g*	0.158g	0.51 -0.395%
Fibre	1g	2.63+0.55%	19-25g *	-	
Moisture	12g	73.55+0.27%	-	-	
Ash	27g	1.87+0.02%	-	-	
Carbohydrates	-	21.69+0.67%	95-130g	19.23g	20.2-14.8%
Calcium	1.5g	91.24+5.74mg/kg	400-800mg	40.11mg	10.03-5.01%
Magnesium	1.5g	243.77+7.48mg/kg	80-130mg	107.16mg	133.9-82.4%
Potassium	1.5g	0.02+0.00mg/kg	3000-3800mg	0.009mg	0.0003-2.6x10-6%
Zinc	1.5g	1.91+0.48mg/kg	4mg	0.84mg	21%
Copper	1.5g	1.66+0.42mg/kg	340-440µg	0.73mg	214.7-165.9%
Iron	1.5g	4.41+1.12mg/kg	10mg	1.94mg	19.4%
Manganese	1.5g	2.90+0.37mg/kg	1.2-1.5mg	1.275mg	106.3-85%
Cyanide	10.5g	0.32+0.00 µmol/g) (7.44ppm	safe WHO level is 10ppm	-	
Phytate	0.35g	319.78+0.48mg/100g	tolerable level is 25 mg/100g	-	

Source: *:19, **/***:20

Percentage of a nutrient in s tan dard RDA = (Amount of nutrientstaken) / RDA S tab dard Amount x 100

Statistical Analysis

IBM SPSS Statistics version 20 analytical package was used for the analysis of the data. The variability of nutrient contents among cassava based recipes (treatments) among the test treatments were analyzed by using one way analysis of variance (ANOVA) and the difference between means was determined using the Least Significant Difference (LSD) at ($p<0.05$) statistical significance.

Results and Discussion

The mostly Consumed Cassava Staple Recipes

Four cassava recipes were identified namely; plain cassava recipe, coconut cassava recipe, groundnut cassava recipe and tomato cassava recipe. It was observed that plain cassava recipe was the most commonly used (97%) among the four recipes. It was further established that plain cassava recipe was preferred due to its affordability as cassava is the only sole ingredient apart from water and salt. Therefore, it is the cheapest recipe compared to all other recipes. The amount of cassava meal consumed by children per day ranged from 150 grams -750 grams per day and the average consumption was 439 grams per day.

Nutrition Composition of Plain Cassava Recipe

As indicated earlier, plain cassava recipe was the mostly consumed recipe hence it was worth evaluating the contribution of the selected nutrients to the RDA. The quantified nutrient contents were thus used to determine the contribution of the respective nutrient to the RDA among the under five children. Table 1 present the results of the nutrient content of the plain cassava recipe, RDA for an under five child as well as the average nutrient intake per day (which was calculated for each nutrient) quantified from plain cassava recipe.

The quantified nutrient contents for the plain cassava recipe (Table 1) indicates very low contribution to the average nutrient intake per day except for magnesium, copper and manganese. This observation supports the statement that cassava meal alone cannot cater for the body nutrients requirement.[9] This further justify the need for improved dietary diversity by inclusion in their diets the under consumed food groups. Dietary diversification can be achieved by incorporating locally available foods such as green vegetables, coconuts, fish, and poultry in their meal and increase the consumption frequencies of the nutritionally enriched cassava staple meal.[9] These results well indicate poor contribution of cassava meal to average nutrient intake per day for zinc, iron, potassium, calcium, protein, carbohydrate and fat.

Anti-Nutritional Factors

The result (Table 1) also presents the levels of ant-nutrients, phytate and cyanide in plain cassava meal. The anti-nutrient (phytate) content was far above the tolerable level of 25 mg/100g but cyanide was within the acceptable level. Phytate levels above the tolerable level have a nutritional implication due their ability to interact and form none-soluble complexes with calcium, zinc, iron and copper and flavonoids (which are a group of polyphenolic compounds that include tannins) chelate metals such as iron and zinc and decrease their absorption.[21] The complexing of phytate with vital nutritional elements and the probability of interfering with protolytic digestion have been advocated as responsible for

Table 2: Percentage of contribution of a nutrient into total RDA

Nutrient	RDA values f or u5 children	Amount of nutrients taken	% contribution by cassava meal to RDA	Statistical Significance (P <0.05)
Iron	10mg	1.94mg	19.4	0.59
Zinc	4mg	0.84mg	21	
Protein	24g	1.024g	4.26	
Fat	30g*	0.158g	0.527	

RDA: 19, *Adequate Intake: 20

anti-nutritional action. Phytate is negatively charged with phosphate compound that binds minerals and inhibits absorption.[22] It is also indicated that such toxic substances can be reduced during processing of cassava, for example through cooking, fermentation and soaking. Similarly, it was indicated that cooking and fermentation destroy anti-nutritional factors.[21] This implies that the levels of anti-nutritional factors are much higher in raw cassava and suggests that phytate could also be a causative factor to high occurrence of malnutrition in that area due to high cassava consumption rate.

Contribution of Selected Nutrients from Plain Cassava Recipe to the Total Rda

The percentage contribution of selected cassava nutrients to the RDA of the respective nutrient is presented in Table 2. The adequacy of nutrient of plain cassava recipe was computed based on the quantity of foodstuff eaten in a day and the computed nutrient intake was evaluated against the RDA of respective nutrient for respective age category.

RDA for Macronutrients

The RDAs for protein and fat were selected for evaluation, due to their importance on children's optimal growth and development. Carbohydrate deficiency is so rare among children, as it is so abundant in common diets. The results show that regardless of the high consumption rate, cassava provided an average of 4.26% only to the protein RDA which is an extremely low contribution. This imply its contribution to protein RDA is negligible in view of the amount of protein the body requires ($p=0.59$) and the amount of protein plain cassava meal supplies per day, that is, only 4.2%.

The findings of this study which indicate little contribution of cassava to protein RDA agree with those of other researcher[23] who observed that the amount of protein among familiar cassava cultivars is classically only 1%.[24] He further indicated that, people that eat great amounts of cassava could well be at risk for insufficient dietary protein ingested. It was argued based on observational study that was conducted in Kenya and Nigeria,[23] that eating cassava as a staple food puts children 2-5 years old at risk for inadequate protein intake. The other researcher[25] found insufficient protein intake in the diets of Nigerian and Kenyan children eating cassava as a main food. The other study[26] that involved 2-5 years children which was conducted in Ede-Oballa

Table 3: Individual Dietary Diversity Score for Children

Food Groups	% of individuals consuming / not consuming a particular food group			
	Yes	(%)	No	(%)
White potatoes, white yam, white cassava, or other foods made from roots	246	74.8	83	25.2
Pumpkin, carrot, squash, or sweet potato that are orange inside + *other locally available vitamin A rich*	19	5.8	310	94.2
Other fruits, including wild fruits and 100% fruit juice made from these	71	21.6	258	78.4
Meat, poultry, fresh or dried fish or shellfish/seafood	142	43.2	187	56.8
Dried beans, dried peas, lentils, nuts, seeds or foods made from these (e.g. hummus, peanut butter)	91	27.7	238	72.3
Milk, cheese, yogurt or other milk products	68	20.7	261	79.3
Eggs from chicken, duck, guinea fowl or any other egg	2	0.6	327	99.4
Oil, fats or butter added to food or used for cooking	169	51.4	160	48.6
Sum IDDS	808			
Average IIDS	2.5			
Target IIDS for the population	5.0			

Community indicated that the contribution of starchy root was only 1.72±0.2 g out of 16g of Food and Agriculture Organization/World Health Organization protein requirement which further supports the present findings.

Figure 1 shows the percentage score of each child for cassava contribution to protein RDA which ranged from 1.45% to 7.29 % among the children population depending on their consumption frequency of cassava. The results provide the average percentage contribution of 4.26% of cassava in children's RDA as presented in Table 2.

The link between growth and intake of protein, as established by earlier researcher[10] don't verify a causal relationship, in particular since the amount of micronutrient in the diets as well as other ecological factors are likely to be confounding factors. Nonetheless, the proof from observational human studies and animal intervention studies suggests that stunting occurs if a least amount of protein to energy ratio is not achieved.[10] From the dietary diversity and consumption pattern among children in Mtwara rural district as indicated in Table 3, protein can be obtained from food sources like meat/poultry/fish and beans/legumes food groups which are however poorly consumed. Therefore provision of nutrition education and counseling is important to enhance consumption of other food groups to increase dietary availability of protein.

It was important to evaluate the RDA for dietary fat due to its importance as a superior source of necessary fatty acids (e.g. omega 3 fats) and concentrated energy. Energy balance is vital to sustaining healthy body weight and guaranteeing best possible nutrient intakes. Fats and fatty acids are metabolized and used in the body, change cell membrane function, manage gene transcription and expression, and interact with one another. Fats specifically long chain poly unsaturated fatty acids has a role on newborn mental advancement, as well as a advantageous role in safeguarding long-term health and avoidance of specific chronic diseases.[27] The findings of this study show that cassava contributed only 0.527% to the fat RDA. Figure 2 indicates the percentage contribution of plain cassava meal to the fat RDA among children which ranged from 0.18% to 0.9%. The results clearly imply low contribution of plain cassava meal to the amount of fat required by the body for optimal growth and development. Previous intervention researches from developed countries propose that diets with lower % of energy from fat tend to be hypo caloric and are thus linked with short term weight loss.[27] This could imply that children who are underweight might have experienced a hypo caloric condition and might require diets enriched with fat to re-gain healthier weight. The results on dietary diversity (Table 3) indicate that only 51.4% households consume fat/ oils food group which implies the need for more emphasis to food diversification to meet the body's

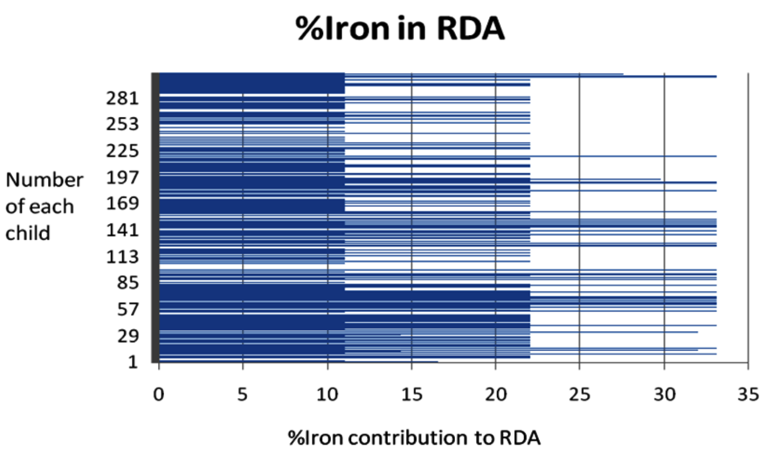

Fig. 3: Percentage contribution of plain cassava meal to Iron contribution into its RDA in each under five child.

requirements using the locally available food sources such as coconuts.

RDA for Micronutrients

Micronutrients are chemical elements including vitamins and minerals that are required in trace amounts for good health, normal growth and development of human and other organisms. Iron is an indispensable nutrient that is engaged in oxygen transport, energy metabolism, immune response, and plays a vital role in brain/cognitive development. The findings of the present study show that the average amount of iron and zinc that is consumed from plain cassava recipe is 1.94 g/day and 0.84 g/day respectively which contribute 19.4% and 21% respectively of the required RDA (Table 2). This is far below children RDA requirements for these potential minerals. This further suggests the need for food diversification and / or fortification in order to meet the RDA for both iron and zinc. Dietary diversity results (Table 3) indicate that sea foods and foods from animal sources as well as fruits and vegetables which are rich in iron and zinc are rarely consumed.

The percentage contribution of plain cassava to iron and zinc RDAs (Figures 3 and 4) for each child ranged from 6.62% to 33.08% and 7.16 to 35.81% for iron and zinc respectively. It is well documented that young children are vulnerable to the effects of iron deficiency (ID) because of rapid growth and development of their brain and other organs that occurs from birth to the age of three.[28] Low intake of iron can contribute to anemia which indicates the vulnerability of this age group to the same.

Iron scarcity (ID) is the most regular micronutrient shortage globally and young children are a particular risk group as infant becomes reliant on extra dietary iron and, due to rapid growth; iron demands per kilogram body weight are greater than during any other stage of life. The previous situation of iron deficiency rates shows 35% of under five children (6-59 months) had moderate anaemia and the anemic children were 59%,[29] and the recent study shows that 30% Tanzanian children have moderate anaemia and 58% are anemic.[6] This shows poor progress in reducing iron deficiency rate among children. Eating of foods such as meat, fruits, cereals and fortified formulas appear to protect against iron deficiency. A previous study[30] has proved the effective ways of achieving the daily needs of minerals, protein, and energy is through fortification of cassava products. This further suggests that in places where cassava is a staple food with limited food diversity food fortification could be a viable option. This is further supported by the existing literature31 which shows that minerals such as iron and zinc are obtained in low quantities in cereal and tuber based meal. The report further indicates that inclusion of legumes slightly boosts the iron contents of such meals. However, the bioavailability of this non-haem iron source is very low. Therefore it is impossible to meet

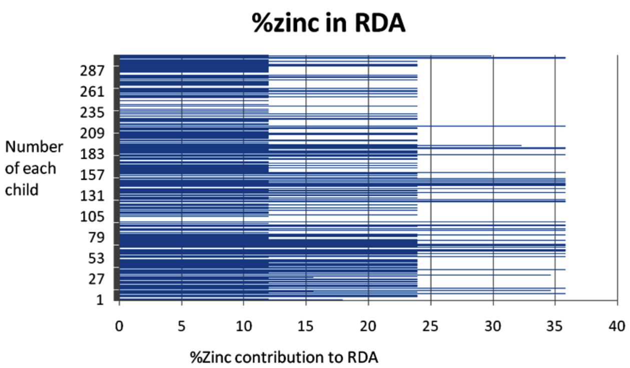

Fig. 4: Percentage contribution of plain cassava meal to Zinc RDA in each under five child

the recommended levels of iron in the staple based diet through a food based approach unless such foods like meat or fish is also included.

On the other hand, zinc scarcity has been indicated globally to cause substantial morbidity and mortality in developing countries because of little intake of animal protein and great intake of phytates.[21] The results of this study also show that the phyate contents in plain cassava recipe (PCR) is 319.78mg/100g which is far above the tolerable level of 25 mg/100g. This could thus have a nutritional implication as phytates could interact and form insoluble complexes with iron and zinc thus reducing their absorption.[21]

There is some indication that malnourished children put on weight more rapidly as they are offered zinc supplementation.[32] According to approximation by the International Zinc Nutrition Consultative Group (IZiNCG), 37.5% of the country's inhabitants is at risk of insufficient zinc intake,33 which spaces Tanzania in the 'high' risk group for zinc shortage. The documentation also indicate that zinc deficiency is a public health concern in which case high phytate levels could be one of the main contributing factors.[34] Inadequate zinc intake is recognized to impair the immune system and children with trivial nutritional status are at major risk of developing zinc exhaustion. Hence appropriate nutritional interventions in addressing micronutrient deficiencies are required to address the problem.

Individual Dietary Diversity for the under Five Children

Dietary diversity gives a clear picture of how many food groups are consumed in a particular area, and which ones are mostly consumed. Table 3 presents the Individual Dietary Diversity Score (IDDS) for Children under this study.

The average IDDS of 2.5 which was found in the present study (Table 3) further indicate poor dietary diversity among population members. It can be observed from the results (Table 3) that consumption of foods of animal origin (which are rich in iron and vitamin A) is very low.

Furthermore, the results indicate that the average IDDS that was obtained in the current study is far below the average target IDDS for the study population that stands at 5. This was computed based on 10 children who had the highest IDDS of 5, using the computational formula of determining the IDDS target for the target population. This was achieved by considering the average diversity of 33% of individuals with the highest individual IDDS. In this case 33% of 10 children give 3.3 children which approximates to 3 children. Therefore, the targeted population IDDS is 5 as indicated below:

$$IDDS = \frac{(5+5+5)}{3} = 5$$

The 5 IDDS score shows a meaningful target level of diversity for children in Mtwara rural district which has to be attained. This means has to be over and above the average IDDS of 2.5 that has been established in this study. Thus a 2.5 IDDS score obtained from this study implies the need for further improvements of the average food groups consumed by the children. The problem of dietary diversity seems to affect many regions in the country based on the findings of the previous study[35] which showed an average of less than 5 IDDS for many regions. This implies the need for countrywide nutrition interventions to combat the problem of malnutrition.

The poor dietary diversification observed in the present study suggest the need for developing strategies to encourage and make possible dietary diversification in order to achieve complementarity and prevent malnutrition.

Conclusions

The results of the present study indicated poor contribution of plain cassava recipe to the RDA for protein, fat, zinc and iron. The IDDS (of 2.5) was similarly far below the targeted population IDDS of 5 implying poor dietary diversity among population members. The anti nutritional factors in particular phytate was far above the tolerable level which is likely to chelate such minerals like zinc and iron and reduce their bio-availability. This could in turn expose the population to malnutrition especially young children. It is thus important to develop strategies which encourage and make easy for dietary diversification among community members in order to complement cassava based recipes with readily available foods rich in macro and micronutrients. This would enrich the diets with a diverse of nutrients and meet the nutritional requirements of children. The strategy could also consider dietary practices such as control of intake of inhibitors e.g. of iron absorption and increase intake of enhancers of absorption in a given meal.

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THE NUTRITIONAL AND ANTI-NUTRITIONAL COMPOSITION OF THE COMMON CASSAVA RECIPES IN MTWARA RURAL DISTRICT, TANZANIA

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Abstract: This study was conducted to determine the nutritional and anti-nutritional composition of the common cassava recipes in Mtwara Rural District. Cassava recipes and the consumption patterns were identified using 24 hours dietary recall and Food Frequency Questionnaire (FFQ). Proximate composition, anti-nutrient contents and mineral composition were also determined. Data were analyzed using IBM SPSS Statistics version 20 using descriptive statistics to describe the main features and summarize the data. ANOVA was used for mean comparison and the differences between means were separated using Duncan Multiple Range Taste. Four cassava recipes with their consumption frequencies were identified which included plain cassava recipe (96.9%), coconut cassava recipe (40.7%), tomato cassava recipe (6.7%) and groundnuts cassava recipe (0.6%). The nutrients (proximate and minerals) and anti-nutrients (cyanides and phytates) contents among recipes varied significantly ($p \leq 0.05$). Coconut cassava recipe was nutritionally the most superior recipe compared to other recipes. Cyanide contents in all the recipes were within the acceptable level of 10ppm but phytate contents were above the tolerable level of 25 mg/100 g in all four recipes, with the lowest phytate content being (78.73mg/100g) in CCR. Higher phytate levels suggest possibility of micronutrient deficiency especially minerals due to reduced bioavailability through interaction.

Keywords: cassava recipes, nutrients, anti-nutrients, consumption pattern.

1.0 Introduction

Cassava (Manihot esculenta Crantz) is a cheap and reliable source of food for more than 700 million people in the developing countries and is Africa’s second most important staple food after maize in terms of calories consumed. Around 70 percent of Africa's cassava output is harvested in Tanzania (Felix, 2004). It is an increasingly important crop in Tanzania and is the second most important food crop after maize in terms of production volume and per capita consumption, supporting the livelihood of 37% farmers in rural areas (Bennett *et al.,* 2012). Cassava root can be cooked, eaten fresh or processed into flour (Montagnac *et al.,* 2009). Preparation of cassava roots prior to consumption varies according to preferences. However, processing can affect the nutritional value of cassava roots through modification and losses in nutrients of high value. Analysis of the nutrient retention for each cassava edible

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product has been conducted in South Africa (Montagnac *et al.,* 2009) and indicated that raw and boiled cassava root kept the majority of high-value macro and micronutrients compared to processed cassava. However, no nutritional and anti-nutritional evaluation has been done for the different consumed cassava based recipes in areas where cassava is a staple food like Mtwara district, thus calling for the present research. According to Hambwe *et al.,* (2009) in their evaluation of the iron content of the selected East African indigenous vegetables formulated into different recipes, they indicated the importance of examining the nutrient content of the developed recipes when the effort is towards improving nutrition security which further supports the present study. The findings of the present study would thus form a foundation for optimizing the nutrient content of cassava based recipes through various formulations. This could in turn improve the nutritional value of cassava and address the issue of malnutrition. Furthermore, cassava roots have also raised concerns about the effects of anti-nutrients on human health. Common examples are phytates which form insoluble complexes with calcium, zinc, iron and copper and flavonoids which are a group of polyphenolic compounds that include tannins (Sarkiyayi and Agar 2010). These compounds chelate metals such as iron and zinc, and reduce their absorption. They also inhibit digestive enzymes and may precipitate proteins (Beecher, 2003). In view of all these, this study was therefore undertaken to determine the nutritional and anti-nutritional composition of the identified cassava recipes in Mtwara Rural District.

2.0 Methodology

2.1 Study area and study population

The current study was conducted in Mtwara Rural District which was purposively selected due to its high cassava production in Mtwara region (NBS 2007) and high malnutrition (stunting) rate of 45% (TFNC, 2010). The study employed a cross-sectional design in which data was collected only once. The study population constituted of the under five children and their mothers/caregivers who are responsible for preparing their foods. The sample size of the population was computed from the formula $n = t^2 x \, (1-p) / m^2$ as reported by Magnani, (1997) where n= required sample size, t=Confidence Interval level 95% (standard value 1.96), p=estimated malnutrition prevalence which is 31.65% (TFNC, 2014) and m=margin error at 5% (0.05). This gave a sample of 332 under five children whose parents / care givers were to be interviewed but only 329 mothers / caregivers participated in the study. Participants were made aware of the objective of the study and clarification was given regarding their involvement. Informed consent was obtained from each mother / caregiver who agreed to participate in the study.

2.2 Recipes identification

The common cassava recipes and methods for their preparations were identified through a dietary pattern assessment method using the 24hours dietary recall and food frequency questionnaire. The name and proportion of each ingredient used in preparation of cassava food were recorded in the 24 hours dietary recall in which mothers/caregivers responsible for food preparation and feeding children were interviewed. The questionnaires were administered to mothers/caregivers of the physically and mentally able under-five children who could describe properly the diet fed to their children daily.

2.3 Recipes preparation

Two households from among the households that constituted the study sample were selected for preparation of the identified recipes. The recipes/samples were prepared in duplicates by each household. The ingredients and other raw materials used for preparation of the various cassava based recipes described during the interview were obtained from a local market. After cooking, the recipes (meals) were left at room temperature 30◦C to cool down for about one hour then packed in duplicates in the freezer bags which were then stored in the freezer model WestPoint (Tropical, made in France) with the temperature set at -20ºC.

2.4 Laboratory analyses

During laboratory analysis the frozen samples were defrosted at room temperature 30◦C and were then pooled together and homogenized using an electric blender in a well cleaned and dried container and analysed as per the analytical method.

2.5 Analysis of Nutrients and Anti-nutrients content

The proximate analysis of moisture, ash content, fat and protein content was carried out using AOAC (1990) methods. Kjeldahl method was used for the analysis of protein and Soxhlet method for the determination of fat. Crude fiber was determined by Kirk and Sawyer (1991) method. The total carbohydrate (in percentage) was calculated by subtracting the sum of the percentage values of moisture, crude protein, ash and crude fat from 100% (McDonald *et al.*, 1973).Cassava recipes were analyzed for the minerals (iron, zinc, copper, potasium, calcium, magnesium and manganese) using the atomic absorption spectrophotometer model iCE3000series as described by Eslami *et al.* (2007). Phytate content of the samples was done as escribed by Davis (1981) and total cyanide content in the samples was analyzed using the alkaline titration method as stated in the AOAC (1990).

2.6 Statistical analysis

IBM SPSS Statistics version 20 was used for the analysis of data. Descriptive statistics was used to analyze the cassava recipes. The variability of nutrient contents among cassava based recipes / test treatments were analyzed by using ANOVA and the difference between means were separated by using the Least Significant Difference (LSD) at ($p \leq 0.05$).

3.0 Results

3.1 Cassava based recipes and consumption frequencies

The survey covered 329 mothers / caregivers with children aged 6-59 months out of 332 who were sampled for the study. This indicates a participation rate of 99.1%. Four most commonly consumed cassava recipes were identified which included plain cassava recipe (PCR), coconut cassava recipe (CCR), groundnuts cassava recipe (GCR) and tomato cassava recipe (TCR) (Table 1). Several other recipes were mentioned and described but only those four were identified as the most commonly consumed recipes. Of the four identified recipes it was indicated that PCR was the most commonly consumed cassava based recipe and GCR was the least consumed cassava based recipe.

Table 1: Types of cassava recipes and consumption frequencies among the respondents

Recipe	N (329)	%
CCR	134	40.7
PCR	319	96.96
GCR	7	0.02
TCR	22	6.7

CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe

3.2 Proximate composition of the cassava recipes

The proximate composition results for the four cassava recipes are presented in Table 2. The fat content indicated significant differences ($P < 0.05$) between CCR and the rest (TCR, PCR, GCR) but no significant differences ($P \geq 0.05$) were observed among TCR, PCR and GCR. The highest fat content was recorded in CCR ($3.67 \pm 0.20\%$) and the lowest in PCR ($0.18 \pm 0.13\%$). The protein content did not show significant variations among the four cassava recipes. The recorded protein content ranged from $0.06 \pm 0.00\%$ in TCR to $0.53 \pm 0.47\%$ in CCR. The minimum and maximum fibre content was $3.20 \pm 0.78\%$ and

1.87±0.05% for CCR and TCR respectively but the differences were however insignificant (p<0.05). The moisture content ranged from 67.28±0.18% to 73.55±0.27%. The highest moisture content was recorded for PCR and the lowest for CCR. Significant difference in moisture contents (P <0.05) was observed between PCR and the other recipes. However, no significant difference was recorded (P ≥ 0.05) between CCR, GCR and TCR. Carbohydrate content ranged from 21.69±0.67 to 24.4±0.39% with the lowest carbohydrate content found in PCR and the highest in CCR The variations were however insignificant (P < 0.05) between CCR, GCR and TCR but were significant between CCR and PCR.

Table 2: Proximate composition of cassava recipe

Proximate Composition	Cassava Recipes			
	CCR	PCR	GCR	TCR
% Protein	0.53 ± 0.47^{a}	0.07 ± 0.01^{a}	0.12 ± 0.00^{a}	0.06 ± 0.00^{a}
% Fat	3.67 ± 0.20^{a}	0.18 ± 0.13^{b}	0.39 ± 0.02^{b}	0.32 ± 0.04^{b}
% Fibre	3.20 ± 0.78^{a}	2.63 ± 0.55^{a}	3.06 ± 0.12^{a}	1.87 ± 0.05^{a}
% Moisture	67.28 ± 0.18^{b}	73.55 ± 0.27^{a}	71.64 ± 0.21^{a}	72.47 ± 0.39^{a}
% Ash	1.34 ± 0.01^{c}	1.87 ± 0.02^{a}	1.53 ± 0.03^{b}	1.23 ± 0.01^{c}
% Carbohydrates	24.4 ± 0.39^{a}	21.69 ± 0.67^{b}	23.25 ± 0.37^{ab}	24.05 ± 0.36^{ab}

- CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe
- Values are means of ± standard deviations of triplicate determinations. Values with different superscript letters in the same row are significantly different (P≤0.05)

3.3 Minerals Composition

The results for mineral contents are presented in Table 3. The calcium content ranged from 70.95+2.42 to 96.5±0.14 mg/kg, with the highest content found in CCR and the lowest in TCR. Significant variations in Ca (P < 0.05) were recorded between CCR and both GCR and TCR and between TCR and both PCR and GCR. Magnesium content varied between 243.77+7.48 and 309.62+0.02mg/kg. The highest content was recorded in GCR and lowest in PCR. Significant difference (P < 0.05) in magnesium content was observed between CCR and PCR and between PCR and GCR but no significant variation (P ≥ 0.005) were observed between CCR, GCR and TCR. On the other hand, potassium content ranged from 0.02+0.00 to 0.03+0.00 mg/kg, with the lowest amount recorded in PCR and the highest in CCR. The variation was significant (P < 0.05) between PCR and the rest (CCR, TCR and GCR). The highest zinc content was found in CCR (2.78+0.26mg/kg) and the lowest in PCR

(1.91+0.48mg/kg), however the variations were insignificant (P≥0.05) among the four recipes. In terms of copper, TCR had significantly high levels of copper (3.04+0.67mg/kg) compared to the other recipes. However, no significant variations (P≥0.05) were observed among CCR, PCR and GCR. The lowest copper content was recorded in GCR (1.52+0.16mg/kg). Iron content on the other hand varied between 4.41+1.12 and 7.46+0.25mg/kg with the highest iron content quantified in TCR and the lowest in PCR. Iron content varied significantly (P < 0.05) between CCR and TCR and between PCR and TCR but no significant differences were observed between CCR, PCR and GCR. Manganese content varied between 1.77+0.06 and 3.71+0.01mg/kg, with the highest content recorded in CCR and the lowest in TCR. Significant variations (P < 0.05) were found between CCR and the rest and between PCR and TCR but were insignificant (P≥0.05) between GCR and TCR.

Table 3: Mineral content of the cassava recipes

Minerals (mg/kg)	CCR	PCR	GCR	TCR
Ca	96.5±0.14[a]	91.24±5.74[ab]	84.23+2.62[b]	70.95+2.42[c]
Mg	288.24±2.37[ab]	243.77+7.48[c]	309.62+0.02[a]	261.59+10.84[bc]
K	0.03+0.00[a]	0.02+0.00[b]	0.03+0.00[a]	0.03+0.00[a]
Zn	2.78+0.26[a]	1.91+0.48[a]	1.99+0.18[a]	1.98+0.07[a]
Cu	1.63+0.00[b]	1.66+0.42[b]	1.52+0.16[b]	3.04+0.67[a]
Fe	6.78+0.82[cb]	4.41+1.12[c]	5.28+0.87[cb]	7.46+0.25[b]
Mn	3.71+0.01[a]	2.90+0.37[b]	2.24+0.01[cb]	1.77+0.06[cd]

- CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe
- Values are means of ± standard deviations of triplicate determinations. Values with different superscript letters in the same row are significantly different (P≤0.05)

3.4 Anti-nutritional factors

The results for anti-nutritional factors (cyanide and phytate) content are presented in Table 4. Cyanide contents ranged from (0.32µmol/g or 7.44ppm) to 0.43µmol/g(9.99ppm). The highest content was found in CCR and GCR (which had equal amounts) and the lowest cyanide content was recorded in PCR. Cyanide content varied insignificantly (P≥0.05) between CCR and GCR and between PCR and TCR but varied significantly (P < 0.05) between those two sets of recipes. Phytate contents varied significantly (P < 0.05) among all four recipes with GCR registering the highest content (712.18+16.0 mg/100g) and CCR the lowest phytate content (78.73+0.57 mg/100g).

Table 4: Anti-nutrients composition of cassava recipes

Anti-nutrients composition	CCR	PCR	GCR	TCR
Cyanide (µmol/g)	0.43+0.00^{a}	0.32+0.00^{b}	0.43+0.00^{a}	0.38+0.05^{ab}
Phytate (mg/100g)	78.73+0.57^{c}	319.78+0.48^{a}	712.18+16.00^{b}	677.10+3.31^{d}

- CCR-Coconut cassava recipe, PCR-Plain cassava recipe, GCR-Groundnuts cassava recipe, TCR-Tomato cassava recipe
- Values are means of ± standard deviations of triplicate determinations. Values with different superscript letters in the same row are significantly different (P≤0.05)

4.0 Discussion

The results have indicated that cassava based dishes were the most commonly consumed dishes in Mtwara rural district either alone or as cassava blends. Four cassava based recipes were identified which included CCR, GCR, TCR and PCR. Of the four recipes it was indicated that PCR was the most commonly used recipe at the frequency of about 97% and GCR was the least consumed recipe with a consumption frequency of 0.02%. Davidson *et al.* (2017) also indicated 92% of the study population to have consumed cassava-based dish within 24 hours prior to an interview in the study conducted in Nigeria. The reasons for the high consumption frequency of PCR and CCR in the present study were indicated to be affordability of the former (was the cheapest of all) and also the availability of coconut for CCR preparation. Coconut is one of the mostly cultivated perennial crops in the district. Despite PCR being the most consumed recipe the mostly liked recipe (Per personal comm.) was indicated to be CCR due to its delicious taste which was attributed to coconut as one of the ingredients. CCR is also the mostly consumed recipe in special occasions especially during fasting seasons, and is famously locally known as Futari (*Iftar*). According to Usmal *et al.* (2015) dietary fats have been shown to enhance the taste and acceptability of foods, slows gastric emptying and intestinal motility thereby prolonging satiety and facilitating the absorption of liquid soluble vitamins. This could as well explain the high preference of CCR due to considerable amounts of fats in coconut juice.

The highest significant amount of fat recorded in CCR could be attributed to coconut milk. The study conducted by Okorie *et al.* (2012) also observed higher fat content in coconut than in groundnuts. A similar observation was also documented by Ayoolo *et al.* (2012). On the other hand, Omosuli (2014) in his research on nutritional content of raw and boiled cassava indicated a reduction in fat content in boiled cassava compared to raw cassava. This reflects the effect of boiling on fat content. Similarly the lowest fat content was recorded in PCR in the present study. The fat contents in the present study which ranged from 0.18$\pm$0.13 to 3.67$\pm$0.20% compare well with that reported by Odebunmi *et al.* (2007) for cassava (0.18$\pm$0.03%).

Protein content did not show any significant variations between recipes. However, contrary to these results, Awad (2013) found higher protein content in pure groundnuts than in pure coconut and attributed the variation to the inclusion of groundnuts. Bankole *et al.* (2013) demonstrated increased protein content when cassava was fortified with groundnut flour. The inconsistencies with previous results could be attributed to several factors that influence the protein contents of groundnuts such as environmental conditions that affect protein viability during storage like temperature, moisture content, initial quality and mycoflora (Jyoti and Malik, 2013). Generally the protein content recorded in the present study (0.06$\pm$0.00 to 0.53$\pm$0.47%) was lower than those reported by Odebunmi *et al.* (2007) for cassava of 2.84$\pm$0.00%. According to Salvador *et al.* (2014) the nutritional content of cassava depends on specific plant part (roots or leaves), geographic location, variety, age of the plant and environmental conditions.

In terms of fibre, CCR had the highest contents though no significant variations were observed. High fibre content was also recognized by Usman *et al.* (2015) who recommended addition of coconut in breakfast cereals which served as a nutritious and healthy source of dietary fiber in the food products that were under study. Fibers are recognized for their physiological role of maintaining an internal distension for peristaltic movement of the intestine (Makori *et al.,* 2017) nevertheless they tend to reduce nutrient digestibility and increase mal-absorption of micronutrient. This could lead to growth retardation thus higher fiber contents are not advisable in infant foods. The fiber content for the recipes understudy which ranged from 1.87$\pm$0.05 to 3.20$\pm$0.78% was slightly higher than that reported by Odebunmi *et al.* (2007), 1.38$\pm$0.03% for cassava. This could well be due to the inclusion of other ingredients and / or due to factors explained by Salvador *et al.* (2014) as determinants of nutritional variations in cassava.

The moisture content indicated significant differences ($P < 0.05$) between PCR (which had the highest content) and the other recipes. The low moisture in other recipes could be attributed to significant electrolyte contents of the added ingredients. On the other hand, the moisture content reported in the current study (67.28±0.18 to 73.55±0.27%) compare well with that reported by Odebunmi *et al.* (2007) of 68.8±0.08%.

Carbohydrate contents also did not show significant difference (P < 0.05) between CCR, GCR and TCR but varied significantly between CCR and PCR. The higher carbohydrate content in CCR and its richness in fat contents imply a high calorific value of the recipe (CCR). Carbohydrate is also indicated to contribute to the taste, texture and appearance of foods and helps to make the diet more varied and enjoyable (EUFIC, 2012). This could as well assist to explain the higher consumers' preference of CCR to other recipes. On the other hand the carbohydrate content recorded in the present study (21.69±0.67 to 24.4±0.39%) was slightly lower than that reported by Odebunmi *et al.* (2007) (28.05±0.06%). Salvador *et al.* (2014) on the other hand linked the variations in nutritional content of cassava with specific plant part (roots or leaves), geographic location, variety, age of the plant and environmental conditions.

Minerals are important micronutrients in maintaining human health and have varied roles. Various minerals for the commonly consumed cassava recipes were also quantified. Significant variation in calcium content (P < 0.05) was recorded between CCR and both GCR and TCR and also between TCR and both PCR and GCR. The highest calcium content recorded in CCR is supported by the findings of Omotosho and Odeyemi (2012) whose research on coconut bio-nutrients indicated that calcium was significantly high in coconut milk. The literature data show that nuts are good source of calcium but coconut is richer in calcium than groundnuts as evidenced by the present study. The findings of Udeze *et al.* (2014) who measured the minerals content of beverage blended with coconut and groundnuts similarly showed that coconut was making the beverage richer in calcium. In the present study the calcium content which varied between 70.95+2.42 to 96.5±0.14 mg/kg was higher than that reported by Odebunmi *et al.* (2007) for dried cassava flour which had 1.11 mg/kg. The variation could be attributed to processing method, inclusion of other ingredients in the recipes or the factors described by Salvador *et al,* (2014) as determinants of nutrient variations. Calcium is responsible for bone formation in conjunction with phosphorus, magnesium, manganese, vitamin A, C and, chlorine and protein (Omosuli, 2014). This is why education on nutritional diversification is important to ensure a healthy and nutritionally secured community.

On the other hand the findings indicated higher amount of magnesium in GRC than in other recipes. The variation was significant (P < 0.05) between GCR and both PCR and TCR but varied insignificantly ($P \geq 0.05$) with that of CCR. The results agrees well with previous findings which indicated groundnuts were richer in magnesium content, that is, 0.176% (Settaluri *et al;* 2012) and 0.18% (Ayoola *et al.,* 2012) as compared to coconut that had less amount, 0.095% (FAO, 2017). In the present study magnesium contents which ranged from 243.77+7.48 to 309.62+0.02mg/kg was extremely higher than that reported by Odebunmi *et al.* (2007) of 12.54mg/kg for dried cassava. This variation could be attributed to the composition of the cassava based recipes, processing methods and other determining factors (Salvador *et al,* 2014).

Similarly, none significant ($P \geq 0.05$) variation in zinc contents was observed among the recipes. Omotosho and Odeyemi (2012) recorded high zinc contents in coconut milk meant for culinary use as was the case with the present study. On the other hand the significantly high ($P < 0.05$) copper content found in TCR is supported by Aydinalp *et al.* (2012) who also found higher copper in tomato than in other plant fruits. Odebunmi *et al.* (2007) reported 0 mg/kg zinc content in dried cassava contrary to the findings of the present study in which zinc content varied from 1.91+0.48 to 2.78+0.26mg/kg. Iron content varied significantly ($P < 0.05$) between CCR and TCR and between PCR and TCR but no significant differences were observed between CCR, PCR and GCR. Omosuli (2014) in his investigation of the nutritive composition of raw and boiled cassava, indicated that mineral contents of cassava tubers were not affected significantly by boiling except iron. This could as well explain the lowest iron contents recorded in PCR. On the other hand the higher content of iron in other cassava based recipes could be attributed to the inclusion of other ingredients which possibly enriched and / or counteracted the effect of boiling. The highest amount of iron was recorded in TCR. The findings of the present study generally indicate that plant products like coconut, groundnuts and tomatoes are valuable sources of minerals and other nutrients which could carter for the nutritional needs of the population at a minimal cost. Nevertheless iron content recorded in the present study (4.41+1.12 to 7.46mg/kg) was lower than that reported by Odebunmi *et al.* (2007) for dried cassava (18.8 mg/kg). This variation could as well be due to the composition of the cassava based recipes, processing methods and other determining factors (Salvador *et al,* 2014). On the other hand the richness of CCR in manganese content which varied significantly from the rest could be explained by the inclusion of coconut juice. Similarly the higher content of manganese recorded in the present study that varied between 1.77+0.06 and 3.71+0.01mg/kg compared to that reported by Odebunmi *et al.* (2007) for dried cassava (0.34mg/kg) could be associated with similar factors explained earlier.

The highest and equal amounts of cyanide were recorded in both CCR and GCR, nevertheless the levels of cyanide in all recipes were within the safe WHO level of 10ppm (Cardoso *et al;* 2005). These results however, contradict previous findings as fat content did not show any effect on cyanide levels. Olorunfemi and Afobhokhan (2012) indicated that treatment of cassava mash with vegetable oils resulted into 99.8% reduction in the total cyanogenic content at seven days of fermentation. They associated the reduction with increased temperature of grated cassava varieties which in turn led to the breakdown of cyanogenic glycosides and facilitated volatilisation after processing into *garri*. CCR and GCR were richer in fat content but also in cyanide content. This could probably be attributed to the acidic nature of the recipe due to fermentation and the time duration for storage of the recipes.

Phytate contents varied significantly among recipes with GCR (712.18 mg/100g) registering the highest contents and CCR the lowest phytate content (78.73mg/100g). Earlier studies (Mazahib *et al;* 2013) have shown higher contents of phytates in groundnuts than any other anti-nutrient which is in agreement with the present findings. It’s also indicated that such toxic substances can be reduced during processing of cassava, through cooking, fermentation and soaking. Sarkayayi and Agar (2010) indicated that cooking and fermentation destroy anti-nutritional factors. Modgil *et al.* (1993) examined the effect of oil treatments (Coconut, groundnut and mustard oil) on the levels of anti-nutritional factors in *Callosobruchus chinensis* (L.) infested stored pulses for 6 months at monthly intervals for anti-nutritional factors (phytic acid, trypsin inhibitor activity (TIA) and saponins). The results indicated changes in anti-nutritional factors from month two to six in which case the controls recorded progressively more anti-nutritional than oil treated samples. They also observed static levels of anti-nutrients in mustard and groundnut oil treated pulses during the same period, however, coconut oil treated pulse had increased anti-nutritional from end of month four onwards. They associated the storage period with the level of insect infestation which in turn influenced the anti-nutritional contents of pulses. Thus the results of the present study can also be attributed to the short storage duration and similarly the acidic nature of the medium. Phytate levels above the tolerable level of 25 mg/100g have nutritional implication. Phytates interact and form insoluble complexes with calcium, zinc, iron and copper and flavonoids (which are a group of polyphenolic compounds that include tannins) chelate metals such as iron and zinc and reduce their absorption (Sarkiyayi and Agar 2010). The complexing of phytate with nutritionally essential elements and the possibility of interference with protolytic digestion have been suggested as responsible for anti-nutritional activity. Phytate is negatively charged with phosphate compound that binds minerals and inhibits absorption (Abebe *et al;* 2014). The results of the present study generally indicate that CCR was richer in various micronutrients (Ca, Mg, K, Zn and Mn) and macronutrients (Protein, Fat and Fibre) compared to other recipes. The amount of cyanide (though within the safe levels), can however be further reduced by the preparation method like boiling of cassava roots (Salvador *et al;* 2014, pp. 29-38). On the other hand, although CCR had the lowest level of phytate was however above the tolerable level of 25 mg/100g. These findings suggest that CCR could make a better recipe from the nutritional point of view. Usman *et al;* (2015) similarly indicated a significant improvement of the nutritional quality of breakfast cereal when anti-nutrient compositions were less than the recommended safe level.

Conclusion

The study identified four commonly consumed cassava based recipes namely CCR, GCR, TCR and PCR. Proximate composition results showed that CCR had the best composition compared to the other cassava recipes whereas the poorest proximate composition was recorded in PCR. Similarly, in terms of mineral composition CCR had the highest Ca, Zn and Mn contents and TCR had the highest amount of Fe and Cu. GCR on the other hand had the highest Mg levels. The results generally suggest that though cassava is an important food crop but its nutritive value can well be improved by blending with other food crops rich in proteins and other nutrients that are deficient such as micronutrients. Data on anti-nutrients indicated that CCR and GCR had the highest and equal contents of cyanide and PCR had the lowest content. GCR on the other hand had the highest phytate content and CCR had the lowest phytate content. Though cyanide contents in all recipes were within the acceptable safe WHO level of 10ppm, phytate contents were above the tolerable level of 25 mg/100g which could thus affect the mineral contents of the recipes due to its interactivity nature. However, a clear distinctive and reflective view of the nutritional value of the recipes can be well gauged based on the evaluation of RDA.

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