THE POTENTIAL ROLE OF UNDERUTILIZED VEGETABLES IN IMPROVING FOOD AND NUTRITION SECURITY IN TANZANIA

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ABSTRACT

Underutilized indigenous vegetables from Morogoro and Kilimanjaro regions were investigated. Out of these, four underutilized vegetables (UVs); Sunga *(Launea cornuta)*, Kikundembala *(Vigna vexillata)*, Mokiki *(Momordica foetida)* and Inyiri (*Basella alba*) were identified, collected and studied. The overall objective was to identify and analyze safety and nutritional excellence of the identified UVs used as food and claimed to be remedy to the sick. Primary data was collected using a checklist, questionnaire and chemical analyses. A total of 120 individuals from 120 households in Kilimanjaro and Morogoro regions were interviewed. Over 75% preferred UVs to exotic species. It was further noted that with the widespread use of the exotic vegetable species among the modern generation, the UV's future demand was diminishing. The nutritional and medicinal claims of the selected UV's were also mentioned during interviews and chemical analyses data strongly supported the claims. Chemical analyses revealed vitamins A, B_1, B_2, B_3 and C contents ranged from 2.50 to 6.67, 18.94 to 182.95, 0.18 to 0.76, 0.09 to 0.43 and 46.52 to 198.08 mg/100g, respectively. Also, Ca, Fe, Mg and Zn contents ranged from 60.28 to 421.03, 4.28 to 21.05, 191.12 to 1151.91 and 4.28 to 21.10 mg/100, respectively. Moisture content, oxalates and phytates contents ranged from 78.59 to 95.49%, 1.28 to 3.15 and 1.64 to 6.18 mg/100g, respectively. The values were evidence that the UVs are rich sources of micronutrients. The findings from the study added credence to the selected UVs that they are crucial in daily human diet to curb hidden hunger. This calls for their domestication as a way of increasing their availability and a measure to improve food and nutrition security in Tanzania.

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DECLARATION

I, James Chacha, declare to the Senate of Sokoine University of Agriculture that this research paper is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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The above declaration is confirmed;

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This dissertation is dedicated to my family for the discipline, confidence and determination they instilled in me; to my dearest friend Zidah and to the German HORTINLEA Project.

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LIST OF ABBREVIATIONS AND SYMBOLS

AFO	Agricultural Field Officer
AIDS	Acquired Immunodeficiency Syndrome
ALVs	African Leafy Vegetables
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
DFTNCS	Department of Food Technology, Nutrition and Consumer Sciences
DSGS	Department of Soil and Geological Sciences
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FHHs	Female Headed Households
g;	grams
HIV	Human Immunodeficiency Virus
HORTINLEA	Horticultural Innovations and Learning for Improved Nutrition and Livelihood in East Africa
IPGRI	International Plant Genetic Resource Institute
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KII	Key Informant Interview
mg	milligrams
NBS	National Bureau of Statistics
p;	probability
RDA	Recommended Daily Allowance
SPSS	Statistical Package for Social Sciences
SUA	Sokoine University of Agriculture
TZS	Tanzania Shillings

URT	United Republic of Tanzania
UVs	Underutilized Vegetables
Vit	Vitamin
WEPs	Wild Edible Plants
WFO	Ward Field Officer
WHO	World Health Organization
ZALF	Leibniz Centre for Agricultural Landscape Research
β	beta

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Food security and nutrition security are different but related concepts. Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2009). FAO (2009) further identifies four food security dimensions/pillars including food availability, economic and physical access to food, food utilization as well as stability over time. Nutrition security is an adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times; achieved when secure access to food is coupled with a sanitary environment, adequate health services and knowledgeable nutrition care (FAO, 2013).

The term traditional food system includes all of the food species that are available to a particular culture from local natural resources and the accepted patterns for their use within culture. It also embraces an understanding of the socio-cultural meanings given to these foods, their acquisition, and their processing, the chemical composition of these foods, the way each food is used by age and gender groups within a selected culture; and the nutrition and health consequences of all these factors for those who consume these foods (Kuhnlein and Chan, 2000). The traditional knowledge of indigenous peoples about the diversity of world food resources must be preserved, and combined with basic scientific data. Economically, traditional foods are more affordable in comparison to the high costs of processed foods. According to Kuhnlein, and Chan (2000), it is not an easy task to achieve food and nutrition security. People are deficient in micronutrients like iron, zinc, and vitamin A. Children and women of reproductive age are especially vulnerable, given their particularly high nutrient requirements. Tanzania needs to address the issue of food insecurity, through the use of vegetables, fruits, grains and even edible insects (entomophagy). These have been proven to be cost effective and nutritious, paving way to the achievement of the global Sustainable Development Goal's (Osborn *et al*., 2015).

It is estimated that 2500 plant species have undergone domestication worldwide, with over 160 families contributing one or more crop species (Meyer *et al*., 2012). Gebauer *et al.* (2013) showed that, many species around the world are harvested from the wild and play a very important role in the nutrition of the rural poor. Traditionally agricultural research has been given little attention to underutilized or neglected crops. However, most contribute to food supply of a more balanced diet and are important in natural medicinal treatment (Gebauer *et al*., 2013). There exist vegetables that are domesticated as well as those which are wild. Even the domesticated were once considered wild, adding to the list of domesticated means increased benefits to the community.

1.2 Problem Statement and Justification

Agriculture is under pressure to produce greater quantities of food, feed and biofuel on limited land resources (Ebert, 2014). Current over-reliance on a handful of major staple crops has inherent agronomic, ecological, nutritional and economic risks and is probably unsustainable in the long run. According to Ebert (2014) many traditional vegetables are an essential source of vitamins, micronutrients and protein and, thus, a valuable component to attain nutritional security. Vegetables in general are of considerable commercial value and therefore an important source of household income (Ebert, 2014). Nutritional problems are common all over Tanzania. In every region there are traditional plants that are used as food and purported as medicine to cure people suffering or recovering from diseases. There is also indigenous knowledge that the natives have to explain the beliefs in using such plants. Unfortunately little has been conducted regarding the nutritional excellence of such plants and possible medicinal potentials and anti-nutritional factors they contain. In many regions, when patients are recovering from illnesses, they need a diverse nutritious recipe from indigenous foods for quick recovery. There is need to screen such plants and establish their chemical composition and determine, which nutrients, especially vitamins and minerals they contain that justify the claims by the locals. Some of these are claimed to contain a high content of minerals like iron and calcium (Kuhnlein, and Chan, 2000).

1.3 Objectives of the Study

1.3.1 Overall objective

To identify, collect and screen plants with nutritional and health claims from communities in Kilimanjaro and Morogoro regions.

1.3.2 Specific objectives

i. To identify underutilized edible vegetables claimed to have therapeutic and medicinal potential in Kilimanjaro and Morogoro regions
ii. To determine micronutrient and anti-nutrient/toxicants content of the identified underutilized edible vegetables
iii. To examine consumer habits and market demand along the value chain

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Food Insecurity Situation

Food insecurity and malnutrition affect much of the world's population (Godfray *et al.,* 2010). Approximately two billion people, representing every country on earth, are estimated to suffer from micronutrient deficiencies that make them more susceptible to disease, and that can be a significant obstacle to economic growth (FAO, 2012). Millions of people in many developing countries do not have enough food to meet their daily requirements and further more are deficient in one or more nutrients (FAO, 2012). Many of the interventions and policies designed to mitigate the potential negative impacts of climate change on food production are beginning to emphasize resilience; a combination of flexibility in the face of disturbance and capacity to adapt to change (Speranza, 2010). Recent climate change assessments have identified low levels of adaptive capacity as one of the main drivers of vulnerability in Africa, largely due to the prevalence of extreme poverty, extreme weather (primarily drought), low levels of yield-enhancing technology, and general lack of infrastructure (Müller *et al.,* 2011).

Globally, it has been estimated that 868 million people do not have access to adequate energy (FAO, 2012). About 239 million of the populations in sub-Saharan Africa are affected by chronic under-nutrition (Sasson, 2012). According to Ezzati *et al.* (2002), the low consumption of vegetables and fruits is among the top 10 risk factors for mortality. The diets of the people in both urban and rural areas are mainly cereal-based resulting in poor diets with increased prevalence of nutritional deficiency disorders (Kwapata and Maliro, 1995; Hotz and Gibson, 2007).

The daily diet in many African countries is dominated by starchy staples. Good nutrition is essential for survival, physical growth, mental development, performance and productivity, health and well-being. People with adequate nutrition are more productive and can create opportunities and gradually break the cycles of poverty and hunger (Rita *et al.*, 2012). Many species of indigenous African vegetables are not well known globally, even though vegetables and herbs are an important source of proteins, vitamins and essential amino acids. These lesser known vegetable plants when properly harnessed and utilised could be an antidote to malnutrition, which is an issue of major concern in Africa (Rita *et al.*, 2012).

2.2 Traditional Foods

Ogoye-Ndegwa and Aagaard-Hansen (2003) describe traditional foods as a large and heterogeneous group of raw and processed foods. The foods comprises of: wild indigenous flora and fauna obtained from uncultivated land and forest (for example leafy plants, roots, berries, small rodents and insects) and from aquatic environments (fish, frogs and snails); semi-domesticated indigenous plant species such as amaranth in Africa and culture of indigenous fish species in rice fields in Asia and the locally available staple foods processed using traditional processing technologies (Ogoye-Ndegwa and Aagaard-Hansen, 2003).

According to Kinyuru *et al.* (2012), the foods have some similar characteristics; besides being culturally acceptable, they are an integral part of local food habits, which can be collected for consumption or traded locally with no or low commercial value. Orech *et al.* (2007) reports that such foods when adapted to local conditions, they contribute to the diet in periods of seasonal scarcity; hence playing an important role against periodic famines (Kinyuru *et al.*, 2012).

2.2.1 Vegetables: a potential foodstuff for human survival

Micronutrient dietary deficiencies that lead to nutritional disorders such as anaemia, night blindness, and iodine deficiency disorders are still common in Tanzania (Kinabo and Msuya, 2002). To counter these nutritional problems, it is important that the rich sources of such nutrients are identified and promoted to be consumed in day to day diets of the people (Weinberger and Msuya, 2004). Given the fact that there are geographical and seasonal limitations in the availability of these vegetables; there is a need to put more effort in searching and identifying more species of edible vegetables that have great potentials for supplying micronutrients (Weinberger and Msuya, 2004). Mineral contents in vegetables are known to vary according to their availability in the soil at different collection sites and plant uptake (Ogle and Grivetti, 1985).

According to Funke (2011), vegetables are important contributors to human health and well-being. They are thought to have large amount of vitamins and minerals like folic acid, vitamin A and vitamin C; starch and cellulose. They supply high amount of water and mineral elements which contributes to the alkaline substance in the body; maintaining the acid-base balance of the body. Nevertheless, except in roots and tubers, vegetables are poor sources of calories.

Certain health challenges such as hypertension, diabetes and high cholesterol levels can be reasonably controlled by consuming the right kinds of foods. Vegetables make a major group of four kinds of foods regarded as healthy foods used in nutrition therapy. They may be considered as free foods which are harmless even when they form a large chunk of our daily diet. Furthermore, they are low in saturated fats, trans-fats and have substantial amounts of fibre, vitamins, mineral nutrients; potassium, magnesium and calcium (Ubwa *et al.*, 2014).

These wild ranges of leafy vegetables, roots, tubers, fruits and stems are harvested by rural communities because of their taste, cultural uses, as food supplements or to tide over food shortage (Mahapatra *et al.*, 2012). Often referred to as famine or hunger foods, wild plants have been acknowledged to be prospective in meeting household food and income security (Kebu and Fassil, 2006). Wild plants become extremely important during certain seasons of the year. Most of them are more available during the dry season when shortage of the commercial vegetables and food condiment runs short of supply (Ubwa *et al.*, 2014).

2.2.1.1 Underutilized vegetables (wild edible plants)

Wild vegetables in particular, play significant roles in the livelihood of many communities in the developing countries of the world as food and for medicinal purposes (Arowosegbe, 2013). However, many of these vegetables are underutilized because of inadequate scientific knowledge of their nutritional potentials (Awobajo *et al.*, 2010); as well as their medicinal uses (Jimoh *et al.*, 2010). However, these leafy vegetables are under-exploited because of inadequate scientific knowledge on their nutritive potentials (Acho *et al*., 2014). Many of such greens are still unexplored scientifically and grown wildly or sometimes in homestead gardens particularly in rural areas (Syeda *et al.*, 2013).

Many of the non-cultivated IVs are collected from the wild (Fleuret, 1979); although there have been efforts to domesticate some few (Weinberger and Msuya, 2004). The IVs are known to be inexpensive and easily accessible in Tanzania (Fleuret, 1979; Mnzava, 1993); but there is a general feeling that their use is declining (Mnzava, 1993; Lyimo *et al.*, 2003; Weinberger and Msuya, 2004). The attributed reasons for the decline include the inability of the species to compete with the cultivated vegetables, particularly the exotic ones, and their poor reputation as low-status food items, especially in urban areas (Weinberger and Msuya, 2004).

Wild Edible Plants (WEPs), defined by the Food and Agriculture Organization (FAO) as "plants that grow spontaneously in self-maintaining populations in natural or semi-natural ecosystems can exist independently of direct human action" (Heywood, 1999); have been identified as a particularly important way that households in rural Africa can reduce their sensitivity to environmental change while also adapting to less favourable conditions (Shumsky *et al*., 2014). Also, WEPs defined as plant species used as sources of food that are neither cultivated nor domesticated but available in their wild natural habitats like rangelands, have continued to be an important dietary component (Fashir *et al*., 2015).

They are also known to have vital contributions to human food stuff (Schippers, 2004). The consumption of WEPs, although often difficult to assess, is still significant at all levels (Bharucha and Pretty, 2010. WEPs play an important role in food production and maintaining ecosystem services, especially in Sub- Saharan Africa (Grivetti and Ogle, 2000; Bharucha and Pretty, 2010).

(i) Factors for reliance/resilience on WEPs/UVs

WEPs are known to make important contributions to food baskets and livelihoods in the smallholder and subsistence farming communities of sub-Saharan Africa (Shumsky *et al*., 2014). Reports reveal that reliance on WEPs are greater in households that report food insecurity, lack off-farm income, and have lower asset levels. Access to WEPs is also a major factor in consumption frequency, with smaller farm sizes and increased distance to harvest areas significantly correlated with lower levels of WEP use.

(ii) Key characteristics of WEPs

The key characteristics of WEPs are: locally available and their use is based on traditional ecological knowledge (Arenas and Scarpa, 2007); low-input, low-cost option for increasing nutrition and reducing need to spend limited cash resources (Jama *et al*., 2008). They contribute to livelihoods and are available during times of drought or conflict-driven famine (Muller and Almedom, 2008). WEPs are tolerant to water stress and are better than their domesticated relatives (Addis *et al.*, 2005). They possess an "innate resilience to rapid climate change, which is often lacking in exotic species" (Fentahun and Hager, 2009).

Considering the importance of WEPs to household food security, it is essential that the social-ecological systems that make gathering these natural resources possible be appropriately protected, managed, and valued to avoid overexploitation and degradation (Feyssa *et al.*, 2011). Better understanding of ethno-botanical knowledge and WEP users is necessary to inform agricultural development, natural resource management, and food security policies that could facilitate more sustainable access to these resources and even increase their positive impact on community resilience (Termote *et al.*, 2011; Mavengahama *et al.*, 2013). Studies have shown that inappropriate regulation of WEPs can take several forms, from unmitigated open access, which can result in unsustainable harvest levels and degradation (Stewart, 2003), to poorly targeted restrictions that exclude populations relying on WEPs as a major nutrition source (Falconer, 1990).

2.2.1.2 Green leafy vegetables

Green leafy vegetables; being the richest in carotene (depending on the intensity of green colouration), are fair sources of protein and good sources of vitamins and minerals (Funke, 2011). Some contain anti-nutrients as reported by Raheena (2007) and Salawu and Akinda (2005); like phytic acid, oxalates, pro-anthrocyanidin, tannin and dietary fibres that are claimed to interfere with nutrient absorption by reducing their bio-availability. Green leafy vegetables are the powerhouse of health promoting phytochemicals and can be used by the people of all ages and are useful to alleviate and combat many deficiency diseases (Saha *et al.*, 2015).

Green leafy vegetables act as a buffer and maintain the proper alkalinity of the blood by balancing acid producing foods like meats (Funke, 2011). They provide low-cost quality nutrition for large parts of the population in both rural and urban areas (Chweya and Eyzaguirre, 1999). In fact, they are good sources of micronutrients including iron and calcium as well as vitamins A, B C and E (Funke, 2011). For example amaranth, contains more of such nutrients compared to a typical exotic leafy vegetable like white cabbage (NFNC, 2007).

Besides, they have numerous health potentials; for instance amaranth vegetables are eaten and used for protection against respiratory disorders, defective vision, recurrent colds, retarded growth and functional sterility (Funke, 2011). These vegetables have been at times recommended by doctors for people with low red blood cell count because vitamin C promotes iron absorption from the small intestine (NFNC, 2007). According to World Health Organisation, in developing countries, every second pregnant woman and about 40% of preschool children are estimated to be anaemic (Funke, 2011).

2.2.1.3 Indigenous vegetables (IVs) versus exotic vegetables (EVs)

Several studies have shown that the nutritional composition of wild plants revealed higher micronutrients levels than those found in most exotic species (Nesamvuni *et al.,* 2001; Odhav *et al.*, 2007; Ndlovu and Afolayan, 2008). For example, IPGRI, (2003) reported high mineral contents of *Amaranthus spp,* which contains 57 times more vitamin A than cabbage, 13 times more iron and about 9 times more calcium. In a similar study, Ndlovu and Afolayan (2008), reported high contents of crude protein and magnesium in wild okra (*Corchorus olitorius*) when compared with cabbage (*Brassica aoleracea*).

The non-cultivated IVs are known to have similar or higher contents of nutrients compared to the well-known cultivated counterparts like Amaranth (Weinberger and Msuya, 2004). From the study, African spider flower (*Cleome gynandra*) and bitter lettuce (*Launaea cornuta*) had higher contents of iron (Fe) than the commonly cultivated and consumed amaranth and pumpkin leaves. Also, while African spider flower had iron (Fe) content of 49.95 mg per 100 g edible portion, amaranth leaves had only 37.05 mg/100g (Weinberger and Msuya, 2004). Several studies have indicated that leafy vegetables consumed in Africa contain higher level of micronutrient than those found in most exotic areas (Steyn *et al*., 2001).

2.3 Phytochemicals

Phytochemicals or phyto-constituents (from the Greek word phyto, meaning plant) are biologically active, naturally occurring chemical compounds found in plants, which provide health benefits for humans further than those attributed to macronutrients and micronutrients (Hasler and Blumberg, 1999). They protect plants from disease and damage and contribute to the plant’s colour, aroma and flavour; recently, it has been known that they have roles in the protection of human health, when their dietary intake is significant (Kulkarni *et al*., 2016).

Medicinal plants contain many chemical compounds which are the major source of therapeutic agents to cure human diseases (Saxena *et al*., 2013). Plants contain alkaloids, flavonoids, glycosides, tannins, saponins, phenolics and terpenoids (Costa *et al*., 1999).

Phytochemical levels vary from plant to plant depending upon the variety, processing, cooking and growing conditions (Rao, 2003). Phytochemicals are also available in supplementary forms, but evidence is lacking that they provide the same health benefits as dietary phytochemicals (Siddiqui *et al.*, 2010). These compounds are known as secondary plant metabolites and have biological properties such as antioxidant activity, antimicrobial effect, modulation of detoxification enzymes, stimulation of the immune system, decrease of platelet (Kulkarni *et al.*, 2016).

Phytochemicals from dietary and medicinal plants have been supposed as promising sources of potential anticancer agents with increasing anticancer evidences coupled with considerations of safety and efficacy (Shu *et al.*, 2010; Johnson *et al*., 2011). Dietary and medicinal plants are important sources of phytochemicals for the treatment of cancers (Newman *et al.*, 2000).

2.4 Traditional Medicine

The use of medicinal plants for treating illness is probably the oldest existing human healthcare practice (Kayombo, 2016). They act as first aid on the onset of the health problems even today in rural areas (Mahonge *et al.*, 2006). In developing countries, (Tanzania included), herbal remedies are used even in places where health facilities are available (Kayombo *et al*., 2012).

However, when the illness/disease does not respond to these herbal remedies, then the option of visiting a health facility comes up; but choice of this option is often affected by the distance to the health facility, availability of the bus fare, consultation fee (user charge), cost of laboratory investigation and money to buy drugs (Busia and Kasilo, 2010). Most of the people in rural areas do not have money for such charges and therefore turn to traditional health practitioners, who therefore are of much significance for health care in these communities (Chudi, 2010). The possible reasons for increasing use of herbal remedies are: inadequate decentralization of health services, isolation of some rural communities, and shortage of drugs and other medical supplies, higher user charges, long waiting period to see the medical personnel, lack of competent medical personnel, and abusive language from medical personnel and persistence regarding pathology-resistance of diseases to conventional medicine (Chudi, 2010).

2.5 Nutrients and Micronutrients Contribution

Traditional foods may contribute to a nutritionally balanced diet by supplying essential vitamins and minerals (FAO, 1979); providing macronutrients and micronutrients (Kinyuru *et al.,* 2010) and to reduce childhood malnutrition. It has been noted that these underground vegetables and spices are good source of micronutrients (Kumar and Kumar, 2016).

Wild vegetables are edible, mostly herbaceous plants growing in the wild, fallow fields or in cultivated farms as weeds. These weeds are sometimes pulled out or left undisturbed for subsequent use depending on whether that particular species is utilised as a vegetable or not; wild vegetables are edible portions of a plant which could be consumed totally or in bits as a side or main dish; they are sometimes eaten in raw forms or cooked along with starchy staples (Sowunmi, 2015). Wild vegetables are important dietary and therapeutic components which possess macro and micro nutrients (i.e., vitamins and minerals). These nutrients play significant roles in nutrition, food security and serve as supplements in reducing the risk of several diseases (Odhav *et al*., 2007).

Plants provide food and medicine besides protecting the environment and are very important for survival of peoples; an attribute of the carbohydrates and nutrients stored in the plants' organs (Kumar and Shiddamallayya, 2014). Wild vegetables are important in alleviating micronutrient deficiencies since they are the cheapest source of protein, fibres, vitamins, minerals and essential amino acids (Grivetti and Ogle, 2000; Lyimo *et al.*, 2003; Afolayan and Jimoh, 2009). These micro nutrients aid in promoting immunity against infections, good health status and providing food security for the people (Sowunmi, 2015).

2.5.1 *Launea cornuta*; use and nutritional potentials

Launaea cornuta commonly known as bitter lettuce or "*Mchunga/Sunga*" is a wild vegetable in the family Asteraceae (Faith and Matheka, 2016). It is indigenous to Kenya, Uganda, Malawi, Tanzania, Mozambique and Zimbabwe where it is mainly used as a vegetable (Jeffrey, 1966; Schippers, 2004). In Southern Africa, the leaves are commonly eaten as a vegetable and are added fresh to maize porridge or a relish prepared from them, mixed with other vegetables (Lim, 2012). It is rich in nutrients such as proteins, fat, calcium and iron carbohydrates, calcium, phosphorus, iron, ascorbic acid and crude fibre (Ndossi and Sreeramulu, 1991; Lyimo *et al*., 2003). *L. cornuta* is used as a wild vegetable in African communities as source for vitamin C (Misonge *et al*., 2015).

2.5.2 Parts consumed in vegetables

The edible portions include leaves, flowers, seeds, fruits, stems and roots (Asaolu *et al.*, 2012). According to Kinyuru *et al.* (2012), leaves are the most consumed parts of vegetables, for example *Amaranthus hybridus L.* consumed as a leafy vegetable. Also, some are consumed as a whole plant, for instance, the vegetable *Commelina africana* while others bear fruits whose seeds are consumed or the fruits consumed together with seeds. Kinyuru *et al.* (2012) shows that others are consumed as grain, for instance the grain species *Amaranthus cruentus L.*

2.6 Vegetables' Contribution to Health

People in various parts of Africa have since time immemorial used plant extracts as medicine (Karau *et al*., 2014). Many commercial drugs used in modern medicine are derived from plants following ethno-botanical and ethno-medical knowledge (Arokiyaraj *et al*., 2012). In the rural areas, reliance on traditional medicine is high; attributed to both economic and cultural factors (Aketch, 1992). Wild plants provide the medicines cheaply and readily available to the vast majority of the rural population, as is the case in many other developing countries in the world. Also, they are a source of some of the active ingredients in modern pharmaceuticals (Kumar and Shiddamallayya, 2014).

Besides having ecological, agronomical and cultural significances (Geissler *et al*., 2002); traditional foods also have medicinal values (Lindeberg *et al*., 2003). For thousands of years, different cultures in the globe have been using plants for medicinal purposes (Murira *et al*., 2014); 80% of the population depending on plant-based remedies for primary healthcare (Evans, 2001). Innumerable flora and fauna used as food by human beings are bestowed in the natural environment. Leafy vegetables in the form of a leaf, flower, stem, seed, shoot or rhizome, fruit, bark or any other part of a plant (Syeda, 2013); are an indispensable component of the diet as well as in the provision of health protective factors (Syeda, 2013). However, despite their potentials, traditional foods are generally uncultivated and underutilized (Abukutsa-Onyango, 2003; Kiambi and Atta-Krah, 2003).

The use of herbal medicine is increasingly finding more relevance today, especially with the recognition that the world is facing more challenges in the treatment of some medical conditions such as diabetes and cancer (Kigen *et al*., 2013). Plants used for traditional medicine contain a wide range of substances that can be used to treat chronic as well as infectious diseases (Nimri *et al*., 1999). Plants possess medicinal and drug activities; thus indigenous knowledge must be combined with new knowledge to identify the compounds of medicinal plants and their advantages and disadvantages.

The bulk of the fibrous framework of leaves provide the necessary roughages in the diet that satisfies one's appetite, also stimulate intestinal functions in reducing the incidence of disorders like chronic constipation, diverticular diseases, hemorrhoids and various cancer of the gastrointestinal tract (Myers, 2007). The beneficial effects of crude fibre from vegetables in minimizing the incidence of diabetes mellitus, obesity, coronary artery diseases and colon cancer are well documented (Myers, 2007). Kinyuru *et al*. (2012) reports underutilized vegetables as a good source of energy, besides increasing blood and prevention of stomach pains, bloating as well as constipation.

Grain amaranth contributes to the nutritional needs of vulnerable individuals due to its high protein content, superior protein quality, high content of essential fatty acids and micronutrients (Tagwira *et al*., 2006). Amaranth has been associated with aiding recovery of severely acutely malnourished children and an increase in the body mass index of people formerly wasted by HIV/AIDS (Tagwira *et al.,* 2006). In lactating women, amaranth (*Amaranthus sp*.) has been claimed to increase breast milk (Kinyuru *et al*., 2012).

Orech *et al*. (2005), reports that some of the vegetables contain possible agents that can cause toxicities when consumed in large quantities or over a long period of time. Nevertheless, their consumption can be made safe through the use of traditional preparation and cooking methods. Complex carbohydrates derived from plant sources help in lowering the risk of cardio-vascular diseases and diabetes mellitus.

Syeda (2013) reported that IVs are good sources of vitamins and minerals; vitamin C, iron, calcium and potassium as examples. Adequate calcium intake is crucial for the formation and retention of a healthy skeleton (Power *et al*., 1999); thus can be used therapeutically for treating bone weakness (Purkayastha *et al*., 2006); Potassium serves as an important diuretic (Sondhi and Janani, 1995) and ascorbic acid as an anti-oxidant.

2.6.1 Vegetable parts used for medicine preparations

Among different plant parts used for the preparation of medicine include roots, leaves, fruits, stem, barks, seeds and the flowers; in some instances the whole plant is used; besides aerial parts and latex produced by the plants (Kumar and Kumar, 2016).

2.6.2 Methods of medicine preparations

According to Kumar and Kumar (2016), plant parts can be used as decoction; juice extracted from the plant parts; plant parts applied as paste (prepared by pounding or crushing the plant parts in a stone made mortar and pestle); infusion; extraction; powder made from dried material and tonic. Majority of the remedies are prepared in the form of decoction from freshly collected plant parts. Water has been mostly used to prepare the medicine.

2.6.3 Modes of medicine application

The mode of use of the vegetables for medicinal purposes differs with respect to features of a particular vegetable. For example, *Amaranthus albus L.* (family Amaranthaceae); whole or ground seeds or dried leaf powder can be soaked in water for infusion, and then drunk as one glass 2–3 times daily, for 2 weeks or until recovery (Stanley *et al*., 2011). Its roots can be used to treat stomach ache (Maundu *et al*., 2005).

Also, *Launaea cornuta* (family Asteraceae); shoots or as a whole plant can be macerated in water and infusion drunk, one glass 2–3 times daily, for 2 weeks (Karau *et al*., 2014). Fresh roots are chewed to cure swollen testicles and roots may be pounded and soaked in water or boiled and the decoction drunk for treatment of typhoid (Muriira *et al*., 2014). For measles, the whole plant is boiled and the warm water used for washing the infected body (Muriira *et al*., 2014). Pounded leaves are soaked in water and given to chickens to treat chicken fever or coccidiosis and the dried root powder is applied to treat warts (Karau *et al*., 2014).

Furthermore, *Aloe secundiflora* (family Xanthorrhoeaceae); its fleshy young stem juice is applied on painful area 3–4 times a day to reduce pain and to promote rapid healing of injured tissues; aloe gel is macerated in hot water and taken orally 1 glass 2 times daily for 2 weeks (Stanley *et al.,* 2011). It possesses an antimalarial activity (Oketch-rabah *et al.,* 1999; Nguta *et al.,* 2010); its leave exudates containing phenolic compounds, mainly anthrones, chromones and phenylpyrones (Rebecca *et al*., 2003); which helps in the fight against rheumatism, malaria, headache, pneumonia and chest pains (Karau *et al*., 2014; Maundu *et al*., 2005).

2.7 Distribution, Seasonality and Availability of IVs

According to Shumsky *et al.* (2014), indigenous vegetables are widespread in many African countries, from Ethiopia, Djibouti, and Sudan Westwards to Nigeria and southwards to Zimbabwe and Mozambique. According to Kinyuru *et al.* (2012), during both short and long rainy seasons the vegetables grow abundantly and are easily obtainable in large quantities from the local environment; with species such as *Corchorus trilocularis* and *Launaea cornuta* considered as invasive weeds in cultivated fields; thus uprooted and burnt or fed to domesticated animals (Kinyuru *et al*., 2012). These are abundant all the year round, forming an important food resource during periods of drought or poor harvests; most particularly important in the driest regions, the regions that are most vulnerable to drought (Orech *et al.*, 2007).

Some UVs are self-sustaining, for example *Asystasia mysorensis* and *Gynandropsis gynandra*; once planted they persist in the field through self-seeding. Unfortunately, some of the vegetable species have continued to become rare, for example, *G. gynandra*, which if found, it only prefers fertile loamy and clay soil around abandoned homes, home gardens, farmlands or cattle pastures (Kinyuru *et al.*, 2012).

2.8 Roles and Responsibilities Regarding the IVs

In a study done by Kinyuru *et al*. (2012), it was reported that foods, the vegetables inclusive, are traditionally prepared by mothers; that they are believed to be acquainted with good cooking skills as well as capable of maintaining hygiene. Fathers were claimed to lack skills and knowledge on good preparation of food. According to Fashir *et al.* (2015), WEPs are less popular among young people, while old and middle aged people still retain wide knowledge and collect them; usually due to poverty and hunger as they do not have money to trade in other alternatives. Rural women also use their indigenous knowledge to improve their livelihoods and to meet their basic needs. Further studies show that women are the major deposits of wild plant local knowledge (Pieroni *et al.*, 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area Description

3.1.1 Kilosa district

3.1.1.1 Location

Kilosa district has a total area of 14 918 km2. It is located in the north-western part of Morogoro region, lying between latitudes 5055’ and 7053’ S and longitudes 36030’ and 37030’ E. It is within an altitude of 200 to 700 m above the sea level. The district borders Mvomero district to the east, Kilombero and Kilolo districts to the south, Kiteto (Manyara region) and Kilindi (Tanga region) to the north; and Mpwapwa district (Dodoma region) to the west. It is divided into 9 divisions, with 36 wards, 164 villages and 1010 hamlets (NBS, 2012).

3.1.1.2 Population and economic activities

According to NBS (2012), Kilosa district has a population of 438 175 people where 218 378 are males and 219 797 are females, with an average of 4.2 people per family. Agriculture (including crop farming and livestock keeping), is the main economic activity.

3.1.1.3 Climate

Rainfall distribution is bimodal, with short rains starting from October to December while the long rains between January and May. The highest parts of the district get annual rainfall of 1000-1600 mm whereas the central and southern parts an average of 800 to 1400 mm. Temperature varies between 15ºC to 32ºC with mean annual temperature of 25ºC (URT, 2015).

3.1.2 Mvomero district

3.1.2.1 Location

Mvomero district is found between latitudes 05° 80' and 07° 40' S and between longitudes 37°20' and 38° 05' E. The District has a total area of 7325 km2. The district is bordered by Handeni district to the north, Bagamoyo district to the east, to the south Morogoro Municipal and Morogoro district to the south and Kilosa district to the west. It is divided into 4 divisions, 23 wards, 115 villages and 577 hamlets (NBS, 2012).

3.1.2.2 Population and economic activities

Mvomero district has total population of 312 109 people of whom 154 843 are male and 157 266 are female with an average of 4.3 people per family (NBS, 2012). The district economy depends mainly on agriculture. The economic activities are production of maize, beans, cassava, rice, fruits and sunflower, where by others are livestock keepers (URT, 2005).

3.1.2.3 Climate

Mvomero district has temperature range from 18℃ to 30℃, with annual rainfall from 600 mm to 1000 mm. The area experiences bi-modal rainfall pattern where long rains are from March to the end of May while short rains occur from October to December. The dry seasons are from June to August and January to March (URT, 2015).

3.1.3 Rombo district

3.1.3.1 Location

Rombo district lies in the northern part of Kilimanjaro region, between latitudes 2º50’ and 3º23’ S and longitude 37º15’ and 37º41’ E. It covers an area of 1442 square kilometres. It is bordered to the north and east by Kenya, to the west by the Hai district and to the south by the Moshi Rural district. The district contains a large portion of Mount Kilimanjaro (URT, 2015).

3.1.3.2 Population and economic activities

According to the 2012 Tanzania National Census, the population of Rombo district was 260 963 people whereby 124 528 were males and 136 435 were females and the average household size being 4.4. The natives depend on subsistence and small scale farming; livestock keeping and some depend on retail business (NBS, 2012).

3.1.3.3 Climate

Rombo district has volcanic soils, with the rainfall pattern being bimodal; short rains from November to December and long rains from March to May. Rainfall ranges from 1000 mm to 2000 mm on average and varies with elevation while temperature ranges from 18^o to 28^{o}C.

3.1.4 Hai district

3.1.4.1 Location

Hai district, located on the western part of Kilimanjaro region; is bordered to the south and west by Arusha region, to the west by the Siha district, and to the east by Moshi Urban district, Moshi Rural district and Rombo district. The western breach part of Mount Kilimanjaro is located in the districts. Mnadani ward is among the wards found in Hai district. The district lies between 2^{o}50’S and 3^{o}29’S and longitude 30^{o}30’E and 37^{o}10’E and covers an area of 13 000 km^2 (URT, 2015).

3.1.4.2 Population and economic activities

According to the 2012 census, the population of Hai district was 210 533 whereby 102 457 were males and 108 076 were females with an average household size of 4.2 (NBS, 2012).

3.1.4.3 Climate

Hai district experiences two main rain seasons; the long rain season which begins in March and ends in June and the short rain season that starts in November and ends in December. The area has soils that are mainly alluvial and volcanic in nature and experiences a temperature of 20ºC and an average annual rainfall of 700 mm. Most people earn their living through farming, livestock keeping and trading.

3.2 Research Design

Cross-sectional survey was used; data were collected at the selected points (2 regions) in time selected to represent a larger population (Tanzania) as recommended by Saunders *et al.* (2007) Also, experimental laboratory work was carried out to determine the nutrients and anti-nutrients present in the vegetables.

A cross-sectional research design was employed in this study since it permits collection of data in a particular place at once and enables descriptive study for the determination of relationship between the independent and dependent variables. The preferable design is most efficient on data collection in terms of time and financial resource constraints (Saunders *et al.*, 2007).

3.3 Sample Size

Two districts from each region were selected based on the extent of participating in agricultural activities; crop farming and livestock keeping respectively. These were Mvomero and Kilosa districts from Morogoro region; Hai and Rombo districts from Kilimanjaro region. From each district, a single ward was selected due to budgetary limitations of the research. Simple random sampling was used to select a total of 30 individuals from each ward; basing on their period of stay in the area, knowledge, experience and acquaintance with the IVs. Thus, a total of 60 respondents from each region were included in the interviews, making it a total of 120 respondents. Bailey (1994) wrote that if a sample is to be subdivided, the smallest sub-sample should be at least 30 cases. Thus, the sample size used for the study was considered sufficient.

3.4 Data Collection Methods

3.4.1 Equipment

Erlenmeyer flask (125ml); 10 ml falcon conical centrifuge tubes; 100 ml volumetric flasks, 250 ml volumetric flask; UV-Visible spectrophotometer (X-ma Spectrophotometer, Human Corporation, UK); 100 ml volumetric flask No. 42 Whatman filter papers; atomic flame emission spectrophotomter (AA-6200 Shimadzu Corp, Kyooto Japan); glass crucible; desiccators; beakers and conical flasks were used.

3.4.2 Materials and reagents

Vegetable samples included *Launea cornuta*, *Vigna vexillata*, *Momordica foetida* and *Basella alba*; Chemicals included: 3% trichloroacetic (TCA) acid solution; 0.04M ferric chloride; 1.5N NaOH; hot 3.2N nitric acid solution; distilled water; 70ml and 20ml of 1.5N potassium thiocyanate; 4.33mg/ml $Fe(NO_3)_3$; water bath; 0.1000 g thiamine HCl; serially deionized water; 0.1M $Fe(NO_3)_3.9H_2O$; 0.1 M $K_3[Fe(CN)6]$; 1g of standard (EC

No 201-507-1, Sigma); 0.1 N HCI; 1.0N Sodium Hydroxide; glacial acetic acid; 4% $KMnO_4$; 3% H_2O_2; 1N sulphuric acid; ammonium sulphate; 2N NH_4OH; 10% sulphuric acid; cyanobromide solution; 2,6-dichorophenol indophenol; cold acetone; petroleum ether (BP 40-60^oC) layer; activated anhydrous sodium sulphate; standard β-carotene; dry petroleum ether; methyl red indicator; NH_4OH solution; 10% $CaCl_2$ solution; 0.05M (potassium permanganate) $KMnO_4$ solution.

3.4.3 Quantitative primary data collection methods

3.4.3.1 Moisture content determination

Moisture content determination was done using the oven drying method as per AOAC method 920.151 (AOAC, 1990). Five grams of a food sample was weighed into a previously dried and weighed glass crucible. The crucible and its content were placed in a thermostatically controlled oven at 105ºC for 18 h. The contents were cooled in desiccators and then weighed. The loss in weight was recorded as moisture content and it was expressed as a percentage of the total weight of sample used; using the formula:

$$\% \text{ moisture} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100 \quad \ldots\ldots 1$$

Whereby: w_1= weight of empty crucible (g)

W_2=weight of container + sample before drying (g)

W_3= weight of container + sample after drying (g)

3.4.3.2 Dry Matter determination

Dry matter was calculated based on moisture content using the formula:

% Dry Matter = 100 % - % moisture ……………….……………………………………2

3.4.3.3 Minerals determination

Mineral contents were determined using atomic flame emission spectrophotometer (AA-6200 Shimadzu Corp, Kyoto Japan) as per the AOAC procedures (AOAC, 1990). The ash content was used for analysis of the minerals according to the AOAC (1990) procedures. The ash was dissolved in 20 ml of 1 N HCl and heated for 5 minutes at 80-90ºC. The solute was then transferred quantitatively to a 100ml volumetric flask and made to level with distilled water. Ca, Mg, Fe and Zn were determined using atomic flame emission spectrophotometer (AA-6200 Shimadzu Corp, Kyoto Japan) with air acetylene flame at 722 nm. Each sample was analysed in duplicate. Quantification was accomplished by comparison with standard curves (Appendix 4) drawn using standard solution of known concentration at 0 to 4 ppm and was expressed using the formula:

Mineral content (mg/100g) = ((R*EV*DF)/(1000ml * SW)) *(100)…………………….3

R = Reading in parts per million

EV = Volume of sample made (ml)/Extraction volume

D.F = Dilution factor

1000 = Conversion factor to mg/100g

S W= Sample weight

3.4.3.4 Vitamins determination

(i) Vitamin A (beta- carotene) determination

Beta- Carotene was determined using standard AOAC Method 2005.07 (AOAC, 2005). Ten millilitres of water were warmed in a water bath to 40ºC. Samples were extracted with 150ml cold acetone and poured into 30ml petroleum ether (BP 40-60ºC) layer, washed with distilled water until free from any acetone. The clear extracted carotenoids were then passed through the activated anhydrous sodium sulphate, collected into volumetric flask. Absorbances were read at 450nm using UV-Visible spectrophotometer. Beta carotene standard solution was prepared by dissolving 1.0 mg of standard β-carotene into 100ml (10.0mg/ml) dry petroleum ether. The stock solution was then diluted serially to obtain the standard range (0 – 10 mg/ml) beta carotene. Absorbances were read at 450nm. Samples concentrations were calculated using the obtained linear regression equation (Appendix 5).

(ii) Vitamin B_1 determination

Vitamin B_1 was determined by spectrophotometry as per AOAC method 942.23 (AOAC, 2005). Homogenized sample (2 g) was accurately weighed into erlenmeyer flask and 20 ml of distilled water were added. The contents were placed in a boiling water bath for 20 minutes and cooled. The contents were then transferred to 100 ml volumetric flask and diluted to 100 ml mark with distilled water then filtered using Whatman No 42 filter paper. Standard stock solutions (1 mg/ml) of thiamine HCl (vitamin B_1) were prepared by dissolving 0.1 g thiamine HCl in deionized water and diluting to the mark in a100 ml volumetric flask. Working solutions (0 – 1 mg/ml) were prepared by diluting the standard solution serially in deionized water. 1 ml of sample extract and diluted standard were taken into 100ml volumetric flask, 0.19 ml of 0.1M $Fe(NO_3)_3.9H_2O$ added and shaken. 0.6 ml of 0.1M $K_3[Fe(CN)_6]$ and diluted to mark with distilled water and left to stand for 20 minutes in the water bath at 40°C and absorbance measured at 747 nm using UV-visible spectrophotometer (X-ma Spectrophotometer, Human Corporation, UK). Thiamine content in the samples was then calculated using the linear regression equation of the standard plot.

(iii) Vitamin B_2 determination

Vitamin B_2 was determined by fluorometry using AOAC Method 970.65 (AOAC, 2005). Vegetable sample (1g) and 1 g of standard (EC No 201-507-1, Sigma) were weighed into the erlenmeyer flask. Then, 60 ml of 0.1 N HCI were added into the contents of the flasks and mixed well so that the solids dispersed in the liquid. The mixture was heated in autoclave for 30 min at 121-123^{o}C and cooled. Mixing was done regularly to ensure no lumping of solids occurred. The mixture was adjusted to pH 5.0-6.0 with dilute HCI. Amounts of deionized water were added such that total volume of liquid reached 80 ml, followed by addition of 1.0 ml of 1.0 N HCI. The mixture was refluxed for 1 hour and cooled followed by adjusting the pH to 6.0-6.5 with 1.0 N sodium hydroxide. The extract was swirled constantly during the addition of alkali to prevent local areas of high pH. Thereafter, 1 N HCl was added immediately until no further precipitation occurred (pH around 4.5), then transferred quantitatively into a 100 ml amber volumetric flask and made up to the mark. The solution was then filtered. 1N HCl was added to a 50 ml aliquot of the filtrate drop-wise until no precipitation of dissolved protein occurred. 1 N sodium hydroxide was added with constant shaking to pH 6.8. The aliquot was then diluted to 100 ml with water. One milliltre of glacial acetic acid was added, followed by 0.5 ml of 4 % $KMnO_4$ and 0.5 ml of 3% H_2O_2. Absorbance was read at 440 nm and riboflavin calculated using the formula;

$$\text{Riboflavin (mg/100 g)} = \frac{(A - C) \times 20 \times 100}{(B - A) \times W \times 1000} \qquad \ldots\ldots 4$$

where;

A = Fluorescence reading of test sample

B = Fluorescence reading of standard

C = Fluorescence reading of blank

W = Sample weight (g)

(iv) Vitamin B_3 determination

Vitamin B_3 was determined by colorimetric method as described by Deutsch (1984). A sample (5 g) was weighed into 150 ml Erlenmeyer flask. Then, 20 ml 1 N sulphuric acid and 20 ml water were added. The mixture was mixed well and heated for 1 hour in a boiling water bath. Cooling was followed by pH adjustment to exactly 4.5 with 10 N NaOH and 9 N H_2SO_4. The mixture was diluted to 100ml (V_1) with water and filter. 17 g Ammonium Sulphate added into 50ml (V_2) of the filtered extract in a 100 ml volumetric flask and diluted to the mark (V_3) with water and shaken vigorously. This was filtered and mixed well. 1.0 ml of aliquot (V_4) and 1ml of working standard solution were taken into 100 ml volumetric flask. Distilled water (5.0ml), 0.5 ml of 2 N NH_4OH and 2.0 ml of 10 % sulphanic acid were added followed by 0.5 ml cyanobromide solution and 0.5ml of 0.5N HCl. Absorbances were read at 450 nm and niacin concentrations calculated using the following equation;

$$\text{Niacin (mg/100g)} = \frac{\text{test O.D. x C x } V_3 \text{ x } V_1 \text{ x } 100}{\text{std O.D. } V_4\ V_2 \text{ W } 1000} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

where;

C = µg niacin standard in reaction tube (3.0 µg)

W = weight, in g, of food taken for analysis

V_1 = volume attained after diluting NaOH and H_2SO_4

V_2 = volume of filtered extract

V_3 = volume attained after diluting filtered extract with water

V_4 = volume of aliquot

O.D.= Optical Density

(v) Vitamin C determination

Vitamin C content was determined using 2,6-dichorophenol indophenol method as per AOAC Method 967.21 (2005); where 5 g of the sample were weighed accurately and mixed with acid washed sand and TCA solution. The mixture was quantitatively transferred into 100 ml volumetric flask by using TCA to the mark and mixed well. The sample solution (1 ml) was titrated by 2,6-dichorophenol indophenol solution until light/rose pink colour appeared. Vitamin C content was calculated using the following formula;

$$\text{Vitamin C content (mg/100g)} = \frac{(A-B) \times C \times 100}{10 \times S \times 100} \quad \ldots\ldots 6$$

where;

A= volume (ml) of the 2,6-dichorophenol indophenol used for sample

B= volume (ml) of the 2,6-dichorophenol indophenol used for blank

C= mass in mg of ascorbic acid equivalent to 0.1 ml of standard 2,6-dichorophenol indophenol

S= weight of the sample (g) taken

3.4.3.5 Anti-nutrients determination

(i) Oxalates determination

Oxalate content was determined basing on AOAC method (AOAC, 1990). The oxalate content was determined by heating 1.0 g of powdered sample in distilled water and 0.3 M HCl. The cold filtrate was treated with 2 to 3 drops of Methyl Red indicator and NH_4OH solution before heating the mixture to 1000C. After cooling, the filtrate was heated further before the addition $10cm^3$ of 10% $CaCl_2$ solution and allowed to stand overnight. After filtration, the precipitate formed was washed to remove traces of Ca^{2+} before dissolving in H_2SO_4 solution. The solution formed was brought near boiling by heating before titrating with 0.05M (potassium permanganate) $KMnO_4$ solution. Oxalate content was calculated using the formula:

$$\text{Oxalate in mg/kg} = \frac{(A - B) \times M \times Mwt \times 100}{Swt \times 1000 \times A} \quad \ldots\ldots 7$$

where;

A = Amount (g) of $KMnO_4$ used for sample

B = Amount (g) of $KMnO_4$ used for blank

M = Molarity of $KMnO_4$ (0.05)

Mwt= Mass (g) of $KMnO_4$ equivalent to 0.05M

Swt = Amount of sample taken (g) for analyses

(ii) Phytates determination

Phytate content of the samples was determined as described by Davis (1981) where 0.1g of finely ground (40 mesh) sample was taken into 125ml Erlenmeyer flask. 10ml of 3% Trichloroacetic (TCA) acid solution added and left to stand for 45 minutes with occasional swirling. The suspension was transferred into 10ml falcon conical centrifuge tubes and 4ml of 0.04M ferric chloride in 3% TCA added. The contents were heated in a boiling water bath for 45 minute followed by centrifugation for 15 minutes at 3000rpm. The supernatant was discarded and residues washed twice with 10ml 0f 3% TCA in boiling water bath for 10 minutes. The acid was washed out with distilled water and 3ml of 1.5N NaOH added and vortex mixed for 1 minute. The mixture was centrifuged again at 3000rpm for 15 minutes, supernatant discarded and precipitates dissolved with 40 ml of hot 3.2 N Nitric acid solution into 100ml volumetric flask and distilled water added to approximately 70 ml. 20 ml of 1.5 N potassium thiocyanate was added and volume completed to 100 ml volume with distilled water and absorbencies at 480 nm read within

1 minute using UV-Visible spectrophotometer (X-ma Spectrophotometer, Human Corporation, UK). Standard stock solution was prepared by taking 4.33 mg/ml $Fe(NO_3)_3$ into 100ml volumetric flask; and 2.5 ml of this stock solution taken into 250 ml volumetric flask to make the working solution with the concentration of 0.0433 mg/ml $Fe(NO_3)_3$. Serial dilution made to concentrations of 0, 0.0011, 0.0022, 0.0043, 0.0065 and 0.0087 mg/ml $Fe(NO_3)_3$ by taking 0, 2.5, 5, 10 and 20 ml of the working standard solution followed by coloration and absorbencies were read at 480 nm. Standard plot of concentration against standard absorbance plot and linear regression equation (Appendix 6) obtained and concentration of phytates was computed.

3.4.4 Qualitative primary data collection methods

3.4.4.1 Focus Group Discussions (FGDs)

FGDs, based on the checklist on Appendix 1 were conducted in the wards, whereby each FGD involved 5 to 7 people. Selection of participants for FGDs was based on the depth of their knowledge on indigenous vegetables; whereby to obtain a detailed set of information, they were divided into separate groups of male and female FGDs. Also, older people were included in the groups since, besides utilizing the vegetables themselves; they were considered as valuable deposits of factual ancient information on the potentials of the IVs. Village leaders assisted in identifying such individuals.

3.4.4.2 Participant observation

This was also necessary to supplement the information from the respondents, especially to obtain the real situation of the habitats of the IVs as well as their key features. Also, after the discussions and the interviews at the village level, two participants well acquainted with the vegetables were sought for showing the plants as well as take photos for identification.

3.4.4.3 Key Informant Interviews (KIIs)

Key informants were consulted based on checklist to provide responses to the administered questions (Appendix 1), besides authenticating some of the information obtained from the FGDs. They were purposely selected through their various leadership positions in respective districts. These were village agricultural officers, ward agricultural officers and the district agricultural officers. Also, few notable respondents were also interviewed as key informants based on their long stay (35 years) in the regions as well as being well informed with the UVs due to their old age.

The main aim of the discussions and interviews were to find out the reasons for consuming the vegetables and whether they had any medicinal/health potentials. The information obtained included names of plant(s) and part(s) used as medicine, dosage and means of administration, habitat, seasonality/ availability, processing methods and storage methods among others.

3.4.5 Secondary data

Publications related to the study provided a lot of helpful secondary information. These included journals, scientific papers and reports. These scientific references alongside the native's knowledge facilitated a quick identification of the vegetables aforementioned.

3.5 Statistical Data Analysis

Data were entered and processed using Excel sheets and SPSS software version 16.0. Descriptive statistics such as frequencies and percentages were computed. Also, for laboratory data, One-Way ANOVA was done with post hoc analysis and results expressed as means ± standard deviation.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Names of Underutilized Vegetables Screened

From the focus group discussions conducted in Morogoro and Kilimanjaro regions, underutilised vegetables' names were provided by the respondents as detailed in Table 1. For this study, two vegetables were chosen from each region; that is, one UV per district. These were: Sunga (*Launea cornuta*) and Kikundembala (*Vigna vexillata*) from Mvomero and Kilosa districts, Morogoro, region respectively and Mokiki (*Momordica foetida*) and Inyirii (*Basella alba*) from Rombo and Hai districts, Kilimanjaro, region respectively.

Criteria for selection of the vegetables included preference of use over the others, availability of the vegetable in the region and those that were believed to have both nutritional and medicinal potentials

Table 1: List of vegetables reported by respondents in Morogoro and Kilimanjaro regions

Local name	**Scientific name**	**Edible portion**	**Data source (ward)**
Sunga/Chunga/Mchunga	*Launea cornuta*	Leaf	Melela; Chanzuru
Kikunde mbala	*Vigna vexillata*	Leaf	Chanzuru
Mlenda mgunda	*Corchorus olitorius*	Leaf; Stem	Melela; Chanzuru
Mbwimbwiza	Unidentified	Leaf	Chanzuru
Mchicha pori	*Amaranthus spp*	Leaf; Stem	Melela; Chanzuru
Songolomaridadi	Unidentified	Leaf	Chanzuru
Mnafu pori (bwasi)	*Solanum incanum*	Leaf	Melela; Chanzuru
Kigegedu/Chamgegedu/Chainizi pori	Unidentified	Leaf	Melela
Kidingililu	Unidentified	Flower	Melela
Mhilile	Unidentified	Leaf	Melela; Chanzuru
Mlenda mwage	*Sesbania spp.*	Leaf	Chanzuru
Mgange	Unidentified	Leaf	Chanzuru
Mangwi	Unidentified	Leaf	Chanzuru
Mlenda mwidu	*Corchorus spp.*	Leaf	Chanzuru
Mwanamdewa	Unidentified	Leaf	Chanzuru
Matembele pori	*Ipomeas spp.*	Leaf	Melela; Chanzuru
Nyakatwanga	Unidentified	Leaf	Chanzuru
Kikongwa	Unidentified	Leaf	Chanzuru
Orobwe	Unidentified	Leaf	Chanzuru
Msimwe	Unidentified	Leaf	Chanzuru
Koroga	Unidentified	Leaf	Chanzuru
Esikisilanjoi	Unidentified	Leaf	Melela
Nyaweza	Unidentified	Leaf	Chanzuru
Mokiki	*Momordica foetida*	Leaf	Rombo
Ibangasa	Unidentified	Leaf	Rombo; Hai
Ngolowo	Unidentified	Leaf	Rombo; Hai
Kisamvu	*Manihot grazioli*	Leaf	Rombo
Makamaka	*Bidens pilosa*	Leaf	Rombo
Majani ya kunde	*Vigna spp.*	Leaf	Rombo
Mnafu	*Solanu nigrum*	Leaf	Rombo; Hai
Mashona nguo	*Bidens pilosa*	Leaf	Rombo
Sunga/Kiruarua	*Launea cornuta*	Leaf	Rombo; Hai
Mchicha pori	*Amaranthus spp*	Leaf	Rombo; Hai
Nyanya pori (Nukuria)	*Solanum betaceum*	Leaf	Rombo
Mgagani	*Cleome gynandra*	Leaf	Rombo; Hai
Masuti (Majani ya maboga)	*Cucurbita maxima*	Leaf	Rombo
Tungusha	*Solanum betaceum*	Leaf /fruit	Rombo
Mtasi	Unidentified	Leaf	Rombo
Inyiri,	*Basella alba*	Leaf	Hai
Kimashira	Unidentified	Leaf	Hai
Mchunga,	*Launea cornuta*	Leaf	Hai
Mashona nguo; Chagga: Makamaka)	*Bidens pilosa*	Leaf	Hai
Mlenda pori	*Corchorus spp.*	Leaf	Hai
Kunde pori	*Vigna vexillata*	Leaf	Hai

Source: Field Survey (2017)

4.2 Descriptions of the Selected UVs

4.2.1 Sunga (bitter lettuce, *Launea cornuta*)

4.2.1.1 Morphological description

As supported by Muriira *et al*. (2014), *L. cornuta* leaves form a rosette at the base, alternate on the stem, sessile, up to 25 cm long by 3 cm wide, entire or with two to three pairs of lobes acute-pointed near the base (Plate 1).

Plate 1: Sunga (*L. cornuta*)
Source: Field survey (2017)

The vegetable was reported to be wild and grows on its own, at times bearing flowers that are usually yellow or whitish in colour. The results are in line with Misonge *et al*. (2015) who reported that *L. cornuta* is wild and grow on its own. It was also reported that when properly dried, the leaves can last for 6-12 months.

L. cornuta commonly known as wild or bitter lettuce or "mchunga/sunga" is a wild vegetable in the family Asteraceae /Compositae (Faith and Matheka, 2016; Misonge *et. al*., 2015); one of the eight families of the order campanulales (Misonge *et al*., 2015). This is the largest among flowering plants, containing about 960 genera and some 13,000 species (Evans, 2001). *L. cornuta* is an upright perennial herb with hollow stems up to 1.5 m high and creeping rhizomes (Lim, 2012; Misonge *et al*., 2015). It has long and narrow leaves, which contain white fluids; and as also supported by Fashir e*t al*. (2015), the leaves taste very bitter when cooked.

The vegetable is native to African countries of Cameroon, Central African Republic, Ethiopia, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Somalia, Sudan, Tanzania, Uganda, Zaire, Zambia, and Zimbabwe where it is mainly used as a vegetable (Jeffrey, 1966; Karau *et al*., 2014; Schippers, 2004).

4.2.1.2 Acquisition

Leaves form the edible part of the *L. cornuta* plant. The major method of acquisition involves plucking, especially the tender ones. Others prefer uprooting the whole plant, an easy and fast way of acquisition, but a rather troublesome method as one will be required again to detach the leaves from the stems at home.

4.2.1.3 Processing

L. cornuta is usually subjected to various treatments before consuming. This includes washing, boiling and drying. The first step involves washing, to remove soil and dirt that might have remained attached to the plant after plucking or uprooting. The second step involves boiling. This can be carried out up to three times, the main reason being to reduce bitterness, a fact that is also supported by Fashir *et al*. (2015), that the vegetable has a very bitter taste. Bitterness attribute is associated with the milky juice it produces in its leaves (Misonge *et al.*, 2015). The process is accompanied with spillage of the water obtained from boiling. After several times of boiling and spilling of the water used in boiling, the leaves can be cooked in any form depending on the needs of the consumer. Nevertheless, the bitterness of the vegetable does not completely disappear even after the repeated boiling and spillage of the water, making it necessary to add spices for improvement of taste and palatability.

4.2.1.4 Methods of storage

The vegetable is stored in a dried form. This is usually preceded with washing to remove sand and dirt then followed by boiling and filtration to remove the bitter water. What follows next is sun drying, which to a small extent results to losses of the leaves' greenish colour. The dried form of the vegetable; usually kept in a vessel for instance a pot, can last for a week. When one needs to use it, the desired amount is taken and boiled/cooked following the normal cooking procedures.

4.2.1.5 Seasonality and occurrence

According to Misonge *et al.* (2015), *L. cornuta* can become a dominant weed in a range of semiarid subtropical ecologies; on roadsides and bush vegetation. The conditions favouring growth of the vegetable include a mixture of loam and sand soil, with moderate temperature and rainfall. Misonge *et al.* (2015) also reported that this vegetable grows well on alluvial soils.

Due to climate change effects and variability, though drought-resistant (Muriira *et al.*, 2014); the vegetable is not abundantly available throughout the year, thus people find it hard to put their hopes on it as a source of livelihood. During such periods of water scarcity, it is mostly found in the lowlands, in places that have water during the dry seasons; near rivers and cultivated areas, including irrigated areas (Misonge *et al*., 2015). The vegetable can be obtained in abundance during the rainy season most specifically in May.

4.2.1.6 Utilization of the vegetable

(i) Nutritional potentials

Nutritionally, *L. cornuta* was claimed to be a rich source for vitamins, though they were not able to point out the exact vitamin. Also, the respondents claimed that the vegetable provide strength (energy). Moreover, the vegetable was claimed to increase appetite, as supported by Muriira *et al.* (2014); this being attributed to its bitterness and the fact that an individual usually feels hungry after consuming it. As supported by Ndossi and Sreeramulu (1991), Lyimo *et al.* (2003) and Misonge *et al.* (2015), the vegetable was also reported to be a rich source of minerals and vitamins; for instance calcium and iron.

The interview reports were supported by laboratory analyses, which showed the presence of considerable amounts of the micronutrients calcium, iron, magnesium, zinc, vitamins A, B_1, B_2, B_3 and C to be 60.29, 6.04, 301.56, 6.05, 3.84, 25.22, 0.24, 0.1 and 120.88 mg/100g, respectively. In Southern Africa, the leaves are commonly eaten as a vegetable and are added fresh to maize porridge or a relish prepared from them, mixed with other vegetables (Lim, 2012).

(ii) Medicinal potentials

Medicinally, the vegetable was reported to provide cure for a number of diseases including malaria and typhoid. The curing attribute is mainly attributed to the bitter juice/sap contained in the vegetable.

The claims find support in various findings, which show its medicinal potentials. It has been reported to provide remedy against malaria (Musila *et al.,* 2013), joint pains (Wambugu *et al*., 2011), coughs, typhoid, fever reliever, swollen testicles/hernia, measles (Hiene and Heine, 1988, Muriira *et al.,* 2014), diabetes as it has been reported to be anti-diabetic (Kareru *et al*., 2007, Muriira *et al*., 2014), chicken pox (Karau *et al*., 2014) and ear pains/aches (Hiene and Heine, 1988; Misonge *et al.,* 2015). It has been used to treat gonorrhoea, syphilis, sore throats, coughs, nasal-pharyngeal infections, pain in the spleen, ear aches, hookworm eradication as well as fever (Hiene and Heine, 1988).

4.2.1.7 Cultural applications

Culturally, the respondents claimed that there is a belief that those who consume natural foodstuffs are not attacked easily by diseases. Besides that, they claimed that in their cultures, something bitter must be part of the diets. There were no any consequences associated with the use of the vegetables as food or for medicinal purposes.

4.2.1.9 Socio-cultural aspects

Women are the ones who are responsible for harvesting, processing, and preparations of food as well as storage. Participants claimed that it is a norm in the society that women are the ones in charge of kitchen and food preparation chores. Also, decisions for buying foods, the UVs inclusive are made by the mother. Men are usually providers of cash but mothers are the ones who decide what to do with the money. Sometimes, men decide what kind of vegetable to be bought when they have missed it. Also, when men bring vegetables home, it is because they were at the farm that they bring the vegetable along with them. The situation is different with female headed households (FHHs) where all the decisions in the family rest upon the mother.

4.2.2 Kikundembala (wild cowpea, *Vigna vexillata*)

4.2.2.1 Description

The morphology of the leaves is not any different from that of the legumes cowpeas (*V. unguiculata*), the greatest difference seem to be utilisation, whereby *V. vexillata* is underutilised as well as wild in nature compared to the cowpeas, which are domesticated and highly utilised (Plate 2).

Plate 2 (a): Kikundembala (*V. vexillata*) leaves   Plate 2 (b): *V. vexillata* seeds

Source: Field survey, 2017

V. vexillata has a tap root system which grows so deep; making it hard to uproot. Sprent *et al*. (2009) reported that the vegetable was observed to have a special characteristic of spreading, covering a large surface.

Vigna is a genus of the important legume tribe Phaseoleae; which also contains soybeans and the so-called common bean, *Phaseolus vulgaris L* (Sprent *et al.,* 2009). It belongs to the family Fabaceae (Van Wyk, 2011; Kumar and Shiddamallayya, 2014). All species are herbaceous, both annual and perennial and some are climbing (Sprent *et al.*, 2009). Commonly referred to as the 'wild mung bean' or'wild cowpea', *V. vexillata* is native of Africa, Asia and Central America (Kumar and Shiddamallayya, 2014). The species is morphologically variable and widely distributed across Tanzania to South Africa (Garba and Pasquet, 1998) and from Yunnan in China to South-East Asia and northern Australia (Lawn and Watkinson, 2002).

4.2.2.2 Acquisition

The edible parts of the vegetables are obtained through plucking. Usually, the tender leaves are the ones that are picked as they are the most suitable for food.

4.2.2.3 Processing

Drying and boiling are the major methods of processing the vegetable. The two processes are usually associated with storage. Moreover, boiling goes hand in hand with cooking, using the same procedures as on other vegetables, whereby oil and other spices can be added.

4.2.2.4 Methods of storage

The vegetable is stored in a dried form. This is preceded by boiling; then finally keeping the product in a vessel, mostly properly dried pots are used. The respondents claimed that in the dried form, the vegetable can last even for a year provided that the keeping conditions are favourable; cool and dry environment.

4.2.2.5 Seasonality and occurrence

V. vexillata grows well in sand soils; usually on its own (wild), in grassy areas, after harvesting of other staples like maize or rice. It is available throughout the year; even during periods of drought as it tolerates harsh growing conditions. The vegetable can be found in abundance during March. According to Sprent *et al*. (2009), *V. vexillata* is, both annual and perennial and grows in well-drained, low-fertility soils.

4.2.2.6 Utilization of the vegetable

(i) Nutritional potentials

Nutritionally, *V. vexillata* is claimed to provide vitamins. The claims were supported by the lab analysis conducted in the current study which revealed *B. alba* as a rich source of vitamins, whereby the vitamin contents specifically vitamins A, B_1, B_2, B_3 and C were found to be 2.57, 18.94, 0.18, 0.09 and 136.71 mg/100g, respectively. On the other hand, the mineral contents specifically calcium, iron, magnesium and zinc were found to be 85.28, 4.28, 191.12 and 4.28mg/100g, respectively. This finds support in a study done by Kumar and Kumar (2016) whereby it was observed that the vegetable is a good source of micronutrients among them iron (Fe) and zinc (Zn). The vegetable was also claimed to increase strength (provides energy); a fact that is also reported by Yesodharan and Sujana (2007) that *V. vexillata* suppress hunger.

According to Van Wyk (2011), the leaves are eaten fresh or they may be cooked and eaten with porridge as a relish. The leaves may also be briefly cooked and then sun-dried and stored for later use or for trading on local markets (Van Wyk, 2011).

(ii) Medicinal potentials

Medicinally, it is believed to cure eye problems and increases blood (attributed to the iron components of the leaves). Also, its roots are believed to cure hernia, whereby the roots are boiled and its water drank. Moreover, pains due to menstrual flow can be relieved using the vegetable. The healing virtue is attributed to the claim that no insecticides or pesticides are applied on the vegetable; the respondents even attempted to refer to it as "pure, clean and safe."

4.2.2.7 Cultural potentials

Culturally, people believe that those who consume natural foodstuffs are not attacked easily by diseases, they are the most healthy and powerful people in the society. There have not been any consequences associated with consuming the vegetable. The respondents associated this to the fact that, in its production, no chemicals or synthetic fertilizers are used. Nevertheless, some of the respondents said that the root of *V. vexillata* is poisonous, a claim that was refuted by women FGD respondents, with a clarification that the root is not poisonous but bitter; only a healing virtue.

4.2.2.8 Socio-cultural aspects

In various responsibilities pertaining to the vegetable, for instance, harvesting, processing, and preparations as well as storage, all family members are involved, though in a greater percentage, the fact still remained that women are the ones who are mostly in charge.

4.2.3 Mokiki (bitter cucumber, *Momordica foetida*)

4.2.3.1 Description

M. foetida grows by spreading/climbing other plants, vegetation or even sticks using its tendrils. Widely known to be a seed-bearing leafy vegetable, *M. foetida* has soft, broad and spoon-shaped leaves (Plate 3).

Plate 3 (a): Kikundembala (*M. foetida)* leaves **Plate 3 (b): *M. foetida* seeds**

Source: Field Survey, 2017

Its leaves when plucked from the mother plant give a strong and very unpleasant smell (stench); surprisingly the stench disappears on cooking! Other findings on the vegetable has shown *Momordica* genus to contain about 80 species (Bharathi *et al*., 2011; Raj *et al.*, 1993). *M. foetida* is a medicinal plant that belongs to the family of Cucurbitaceae (Molehin and Adefegha, 2014). The plant has both male and female flowers (Jeffrey, 1990; Oleyede and Aluo, 2012); and has been shown to possess insecticidal properties (Baerts and Lehmann, 2002).

M. foetida; a dioecious, perennial climbing herb with tendrils; rooting at nodes and with dark green, flecked stem and simple leaves; is occasionally cultivated in the native areas for leaves (Froelich *et al*., 2007). Originally from the Indo-Malayan region, it is currently found to grow in India, Bangladesh, Sri-Lanka, Myanmar, China, Japan, South East Asia, South America, tropical and subtropical regions of Africa, Asia and Australia (Madalaa *et al*., 2016).

Commonly known as bitter gourds, bitter melon and bitter cucumber, plants from the *M.* genus, Curcubitaceae are consumed as vegetable and are characterized by a bitter taste owing to the presence of phytochemicals such as alkaloids and cucurbitacins (Chen *et al.*, 2005; Nagarani *et al*., 2014; Madalaa *et al*., 2016). In East and Central Africa, *M. foetida* is reported to relieve a number of diseases including hypertension, diabetes mellitus, fever and malaria (Hakizamungu *et al*., 1992).

4.2.3.2 Acquisition

The leaves of this underutilized vegetable are obtained through plucking. Tender leaves are ones that are usually picked as they are claimed to be the ones that are suitable and with the desired components. This is supported by Olaniyi (1975) that leaves of *M. foetida* are ones which are collected from the wild and eaten after boiling; a common practice in Gabon, Sudan, Uganda, Tanzania and Malawi.

4.2.3.3 Processing

M. foetida can be prepared in several ways. As supported by Olaniyi (1975); two major processing methods used include cooking/boiling or frying. A prominent greenish dish referred to as the ‘Moviro food’ can also be prepared using *M. foetida*. The food is prepared through plucking leaves of the vegetable, frying or cooking them then ground before squeezing to obtain the greenish liquid from the procedure. The liquid obtained is stirred before mixing with cooked bananas and milk. The whole mixture ("Moviro" food) turns green due to the effect of *M. foetida*. The dish is claimed to be very delicious and well known for increasing strength (energy provision) and quick recovery from illness.

4.2.3.4 Methods of storage

The Rombo inhabitants do not have a custom of storing vegetables for future use. This is due to the reason that they are used to the exotic species which they buy on daily basis depending on one's use. Moreover, from the discussions, it was reported that since the UV's are found naturally growing in farms, the locals do not see if there is need of preserving something which they know can be found with ease.

4.2.3.5 Seasonality and occurrence

M. foetida was reported to be available the whole year round. However, it was reported that it is found in abundance during the rainy season. The underutilized vegetable was also reported to be usually growing under shades, for instance bananas, being supported much by the clay soils found in Kilimanjaro. Moreover, as supported by Hakizamungu *et al*. (1992), the vegetable also grows in swampy areas; and like other climbers, *M. foetida* needs a support of other vegetation/trees to grow and spread using its tendrils.

4.2.3.6 Utilization of the vegetable

(i) Nutritional potentials

It was reported that the leaves of the plant can be prepared and eaten alongside any other vegetable and or food. Nutritionally, *M. foetida* was claimed to increase strength (provide energy) as well as appetite. It was also reported that the UV increases blood. Laboratory analysis revealed the presence of mineral contents specifically calcium, iron, magnesium and zinc which were found to be 421.03, 21.05, 1151 and 21.1 mg/100g, respectively. Also, vitamin contents specifically vitamins A, B_1, B_2, B_3 and C were found to be 5.5, 58.34, 0.76, 0.12 and 46.52 mg/100g, respectively. The presence of vitamins is thought to contribute to the appetite-increase-role of the UV.

Also, it has been shown that *M. foetida* possesses antioxidant potentials (Oloyede and Aluko, 2012), in accordance with other studies which reported that green leafy vegetables and medicinal plants exhibited higher levels of flavonoid (Sultan and Anwar, 2009). The antioxidant property is due to the presence of phenols and polyphenolic compounds such as flavonoids that are widely found in food products derived from plant sources (Molehin and Adefegha, 2014).

(ii) Medicinal potentials

M. foetida was claimed to have a number of medicinal potentials. These included relieving cough/flu; whereby its leaves are chewed raw; or the leaves are plucked, wrapped in banana leaves and put on fire to be heated for a while; thereafter it is removed and chewed. A mixture of “Ngolowo”, “Mokiki” and “Ibangasa” constitutes a liquid which is used as medicine against smallpox. The mode of treatment involves drinking of the mixture by the sick child who is then covered by a blanket for a sleep. A lot of sweating takes place, a procedure believed to indicate that the medicine is carrying out its functions. Also, it was reported that the UV helps in relieving diarrhoea, malaria as well as in removing toxins from the body.

As supported by other scientific reports, Momordica species, for instance *M. charantia* has been used in Chinese folk medicine for the treatment of different chronic diseases. Also, antimalarial activity for *Momordica balsamina* and other species of Momordica genus, have been reported (Clarkson *et al.*, 2004; Kaou *et al.*, 2008). The species are currently used as medication for sugar diabetes and chronic hypertension diseases in some parts of South Africa (Madalaa *et al.,* 2016). They are known to contain large quantities of polyphenolic compounds, for instance flavonoids, that are known to possess several therapeutic activities (Kubola and Siriamornpun, 2008; Zhu *et al.,* 2012). Drinking of aqueous leaf extracts of the plant to treat malaria has been reported in East and Central Africa (Hakizamungu *et al.*, 1992; Waako *et al*., 2005).

According to other reports, *M. foetida* extracts are also used for the treatment of hypertension, peptic ulcers, diabetes mellitus, and as a purgative (Hakizamungu *et al*., 1992; Froelich *et al.*, 2007). According to Van de Venter *et al.* (2008), *Momordica foetida* have scientifically demonstrated hypoglycaemic activity. *M. foetida* is also traditionally used in Mozambique to treat vomiting believed to be associated with fever (Bandeira *et al*., 2001).

Further reports have shown that indigenous plants including *M. foetida* used in ethno-veterinary medicine are useful in the treatment of helminthiasis (Akhtar and Riffat, 1984). The anthelmintic property is dependent on numerous substances found in them including alkaloids, sugars, saponins, aromatic oils and resins. Foetidin, is a root extract that is among the phytochemicals that have been obtained and demonstrated hypoglycaemic activity in diabetic models (Marquis *et al.,* 1977; Waako *et al.,* 2005 and Marquis *et al*., 1977). Furthermore, Oryema (1997) reported that substances like steroids, coumarins, tannins, and triterpoids, alkaloids, glycosides, enzymes, anthraquinones, tannins, gums, fixed oils, fats, waxes, volatile oils, proteins and carbohydrates all have medicinal or pharmaceutical value.

For medicinal purposes, *M. foetida* can be prepared by decoction whereby plant parts of a single plant species are boiled in water. Moreover, hot and cold infusions are prepared by soaking the plant parts in hot and cold water, respectively (Ketera and Mutiso, 2012).

4.2.3.7 Cultural applications

Culturally, it was reported that M. foetida provides stability to the body. Thus, people from the district believe that those who consume natural foodstuffs are not attacked easily by diseases.

4.2.3.8 Socio-cultural aspects

It was reported that mothers are the ones involved in preparations and cooking issues, since they are the 'chief' cooks in the home. However, in the absence of the mothers, it was claimed that anyone else may carry on with the preparations of UVs with the exception of children. Children are strictly prohibited to take part in such activities as they can cause damage to the vegetable including total uprooting of the plant instead of the normal plucking of leaves.

4.2.4 Inyiri (malabar spinach, *Basella alba*)

4.2.4.1 Morphological description

Naturally and wild-growing, it was learnt from the focus group discussions and participant field observation that *B. alba* spreads on ground surface and on other vegetation as a climber plant. It was also known that the vegetable does not bear seeds; that its stem cuttings are the ones which are planted. *B. alba* has broad ovate or heart shaped leaves (Plate 4); and when cooked, it behaves like slippery 'Mlenda mgunda' *(Corchorus olitorius*)**.**

Plate 4: Inyiri (*B. alba*)
Source: Field Survey (2017)

B. alba is an extremely heat tolerant (Grubben and Denton, 2004), fast growing perennial vine which belongs to the family Basellaceae (Rathee *et al*., 2010). It is commonly known as Malabar spinach, Indian spinach, Ceylon spinach, vine spinach (Roy *et al*., 2010; Prajapati *et al*., 2014); climbing spinach (Sen *et al*., 2010); East-Indian spinach, Chinese spinach (Bamidele *et al*., 2010); and cyclone spinach (Nirmala *et al*., 2011). Besides being a leafy vegetable with a climbing growth habit, it is a succulent, branched, smooth, twining herbaceous vine, which grows into several meters in length (Deshmukh and Gaikwad, 2014).

B. alba has purplish or green succulent stems; and tender leaves that are fresh, ovate or heart-shaped (Prajapati *et al*., 2014; Suguna *et al*., 2015). It has nodes and internodes; and can be cultivated from either seed or cutting. It has a bland and mucilaginous taste, with no odour (Kumar *et al*., 2013).

They are of three common types: *B. alba* with green stem and oval to almost round leaves; *B. rubra* with red stems and green, oval to round leaves; and a third type being a hybrid of the two (Singh *et al*., 2016). Though abundant in Malaysia, Philippines, tropical Africa, the Caribbean and tropical South America (Palada and Crossman, 1999); *B. alba* is native to tropical Southern Asia, and believed to have originated from India or Indonesia (Saroj *et al*., 2012).

4.2.4.2 Acquisition

The leaves (usually tender ones) are obtained through plucking.

4.2.4.3 Processing

As food, *B. alba's* leaves are plucked, washed, cut and then cooked just like other vegetables using tomatoes, onions or any other condiments. The vegetable can be mixed with bananas, yoghurt and maize that have been boiled and husks removed to form a special kind of traditional foodstuff/meal referred to as "Kitalolo"; which is eaten just as it is, with no other accompaniment and is claimed to provide a lot of energy.

As medicine, the leaves and stems of the vegetable are boiled and their water drunk. Also, its roots can be boiled and the liquid obtained drank as treatment for constipation. According to Mahr (2014), young leaves can be eaten raw mixed in green salad, and steamed or boiled to be used like cooked spinach; with some people preferring addition of small amounts of vinegar to the cooked leaves to overcome the somewhat slimy texture and improve palatability.

4.2.4.4 Methods of storage

The Hai natives do not at all store vegetables including *B. alba*, due to the reason that, just like other underutilized vegetables, *B. alba* is plenty even though it is not used by many people. Those who use it as an accompaniment for food do so when they feel like they have missed it, just plucking it from the farms; only to satisfy their tastes. It was reported that most of the inhabitants are used to buy the exotics, which are bought from vendors on daily routine.

4.2.4.5 Seasonality and occurrence

B. alba grows well in areas that have optimum amount of water; or alongside other vegetation and plants like bananas. This is due to the fact that they need other plants to use as support for climbing as they grow to maturity. The UV is favoured much by clay soil. According to Sase *et al*. (2013), *B. alba is* propagated by cuttings or seeds whereby the leaves are usually removed before planting materials; usually slanting or horizontal trellises. *B. alba*; a fast-growing and soft stemmed plant, can grow as a twining vine to several meters in length as an annual (longer as a perennial), but generally remain smaller in most gardens (Mahr, 2014).

4.2.4.6 Utilization of the vegetable

(i) Nutritional potentials

B. alba was nutritionally claimed to be a good source of vitamins and minerals especially zinc. Zinc was specifically mentioned and claimed due to the soil type and colour of the area that the vegetable grows, claimed by one of the key informants to be rich in zinc. The claims were supported by the lab analysis conducted which revealed *B. alba* as a rich source of minerals and vitamins. The mineral contents specifically calcium, iron, magnesium and zinc were found to be 134.11, 13.4, 524.5and 13.4 mg/100g, respectively.

Also, the vitamin contents specifically vitamins A, B_1, B_2, B_3 and C were 6.67, 182.95, 0.54, 0.43 and 198.08 mg/100g, respectively.

The findings are supported by literature as it has been known that *B. alba* leaves are fleshly eaten as food. They are believed to contain vitamin A, vitamin C, riboflavin, niacin and thiamine; besides vitamin B9 (folic acid), K and E (Werner and Thomas, 2006; Sase *et al.*, 2013). The vegetable has also been reported to contain calcium, magnesium, iron and several vital antioxidants (Grubben and Denton, 2004). Furthermore, the vegetable is reported to be a good source of calcium, magnesium and iron (Kumar *et al.*, 2013).

(ii) Medicinal potentials

Medicinally, the vegetable was claimed to increase blood and appetite; prevent constipation; and relieve ulcerative pains. The UV was also mentioned to prevent constipation in animals, for instance dogs. The claims are in line with the laboratory chemical results; for instance *B. alba* is rich iron contents (13.4 mg/100g); indicating that its use can help fight anaemia comparable to what respondents reported as increase of blood. Also, Kumar *et al*. (2013) supports that *B. alba* leaves are used for the treatment of anaemia and other diseases including hypertension and malaria in Nigeria and Cameroonian folk medicine respectively. Also, in Asian countries, the stem and leaf of *B. alba* have been used as traditional medicine to treat dysentery, skin diseases, hemorrhages, anemia, constipation, gonorrhea, and cancer (Yasmin *et al*., 2009).

Furthermore, literature cites *B. alba* as traditionally being used to treat sexual asthenia and infertility in man in the West Cameroon region. This could be due to its capacity to stimulate not only androgens production, but also estrogens; maintaining the androgen-estrogen balance necessary for normal male reproductive function (Nantia *et al*., 2011).

Also, *B. alba* is used in many parts of the world for its medicinal use as laxative, anti-inflammatory, rubefacient, soothing as well as its cooling effects when applied to burns and scalds. It is also used for haemorrhages, skin diseases, ulcers and as laxative in children and pregnant women (Haneefa *et al*., 2012; Kumar *et al*., 2013).

Decoction of leaves is used for the mild laxative effect it shows; pulped leaves are applied to boils and ulcers to hasten suppuration; while leaf-juice mixed with butter is soothing and cooling when applied to burns and scalds. The plant is febrifuge, its juice a safe aperient for pregnant women; and its decoction has been used to alleviate labour. The leaf juice is also a demulcent, mostly used in cases of dysentery (Kumar *et al*., 2013). *B. alba* has been used for the treatment of anemia in women, coughs, cold and cold related infections (Rahmatullah *et al*., 2010). The mucilaginous liquid obtained from the leaves and tender stalks of plants is a popular remedy for headaches (Jadhav *et al*., 2011). According to Phadungkit *et al*. (2012), *B. alba* contains phytochemicals for instance steroids and phenolic compound, this might be for the medicinal potential it is reported to exhibit.

4.2.4.7 Cultural applications

The Kilimanjaro natives believe that those who consume natural foodstuffs are not attacked easily by diseases.

4.2.4.8 Socio-cultural aspects

Women are the ones in charge with most household and kitchen chores. This was claimed to be Mnadani people's (mostly Chagga) tradition/custom. In the community, women are the ones who take care of food preparations and all other related kitchen stuffs. Men may help, just in case of absence of the females at home.

4.2.4.9 Seasonality and occurrence

B. alba was reported to be found in plenty during the rainy seasons, but always available near wet areas; for instance irrigation points where other exotic vegetables (cabbages, spinach), bananas, maize and other crops are grown. In the araea (Mnadani ward, Hai district), water for irrigation is obtained from a river coming from Mt. Kilimanjaro whose water is tapped and spread through the villages using well dug and designed paths for water passage as an irrigation system. The vegetable is thus available throughout the year, even during dry spells, only that it is not as plenty as in the rainy season. As per the FGDs, various forms of environmental degradation result to a slow but sure wiping away of IVs due to destruction of natural vegetation.

From Palada and Crossman (1999), *B. alba* easily adapts to a variety of soils and climates and is thus considered as one of the best tropical spinach throughout the tropical world. It is reported to be one of the wild leafy vegetables, which is rare in its natural habitat (Wambugu and Muthamia, 2009). Nowadays it is an important leafy vegetable grown for its nutritive value throughout the temperate regions as an annual and the tropics as a perennial (Bamidele *et al.*, 2010).

4.3 Chemical Analyses

4.3.1 Moisture contents of the selected UVs

The percentage moisture content values recorded varied from 95% in *Momordica foetid*a to 78% in *Vigna vexillata*, with statistical significant differences ($p<0.05$) in the values recorded among the four UVs analyzed (Table 2).

Table 2: Moisture contents of the selected UVs

Sample	Moisture content (%)
Momordica foetida	95±0.00[c]
Vigna vexillata	78±1.41[a]
Launea cornuta	84±1.41[b]
Basella alba	92.5±0.71[c]

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

The results obtained in this study are in line with other reports, which showed that leafy vegetables have moisture contents ranging from 72 to 93% (Udo *et al.*, 2013). Furthermore, researches have reported *Basella alba* to have a moisture content ranging from 88 to 93% (Sreeramulu *et al.*, 1983; Sheela *et al.*, 2004, Saha *et al.*, 2015) and *Launea cornuta* 85 (Sreeramulu *et al.*, 1983).

According to Adepoju and Oyewole (2008), high moisture content of vegetables is an indicator of freshness, perishability and the role they play in aiding food digestion. The higher moisture contents recorded in this study are thought to be attributed to two major factors: firstly, the nature of the crops (species differences); for instance the higher value (95±0%) recorded in *Momordica foetida* contributed to being high in moisture content. Secondly, the harvest period; whereby the UVs samples for laboratory chemical analysis were collected during the rainy season, the period when the field work for this study was underway.

4.3.2 Mineral composition of the UVs

Quantitative analysis results revealed the UVs are rich sources of minerals, which is evident from the results presented in Table 3.

Table 3: Mineral composition of selected UVs (dry weight basis)

Sample	Ca (mg/100g)	Fe (mg/100g)	Mg (mg/100g)	Zn (mg/100g)
M. foetida	421.03±3.61^{c}	21.05±1.77^{c}	1151.91±49.47^{c}	21.1±1.84^{c}
V. vexillata	85.28±4.67^{ab}	4.28±0.23^{a}	191.12±19.64^{a}	4.28±0.23^{a}
L. cornuta	60.29±4.26^{a}	6.04±0.43^{a}	301.56±21.31^{a}	6.05±0.42^{a}
B. alba	134.11±17.16^{b}	13.4±1.70^{b}	524.5±121.08^{b}	13.4±1.70^{b}

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

The results (Table 3) showed that the highest calcium content (421.03±36.15 mg/100g) was recorded for *Momordica foetida* and the lowest content (60.29±4.57 mg/100g) for *Launea cornuta*. Also, it was found out that the highest level of iron content (21.05±1.79 mg/100g) was recorded for *Momordica foetida* while the lowest (4.28±0.23 mg/100g) was found in *Vigna vexillata*. The results supported what the natives reported during the FGDs, that UVs increase blood, an indication that they are good sources of iron, hence important in fighting anaemia. Moreover, *Momordica foetida* showed an exceptional and significantly high amount of magnesium (1151.91±49.47 mg/100g) (Table 3). The UVs were also rich sources of zinc with appreciable values ranging from 4.28±0.23 to 21.1±1.84 mg/100g.

As reported by Ndossi and Sreeramulu (1991); *Launea cornuta's* iron content was 7.2 mg/100g and calcium content was found to be 214 mg/100g. Also, in a study by Lyimo *et al*. (2003), it was reported that in *Launea cornuta*, the amounts of iron recorded was 27 mg/100g and calcium 256.2 mg/100g; and that *Basella alba* had iron content of 4.0 mg/100g and calcium content of 250 mg/100g. Moreover, in a similar study by Sheela *et al*. (2004); iron content in *Basella alba* was 5.45 mg/100g while calcium was 187 mg/100g. Singh *et al*. (2016) further reported *Basella alba*'s iron content to fall between 1.2 and 3.1 mg/100g and calcium content between 16 and 128.0 mg/100g. Furthermore, according to Saha *et al*. (2015) different values of zinc, iron, magnesium and calcium were recorded in *Basella alba* as 3.5, 90.8, 16.2 and 62 mg/100g, respectively. As it can be seen, some of the values obtained from this study on mineral composition are in line with those from the literature cited. However, the wide variability in some of the parameters are thought to be due to several factors including differences in localities, agro-climatic conditions, nature or species differences and stage of growth.

Nevertheless, from the findings in this study, UVs were shown to be rich sources of minerals with high ash contents. This is supported by Arowosegbe *et al*. (2015), that ash content is an indication of the level of inorganic elements such as calcium, magnesium and zinc in vegetables. *Momordica foetida* was found to have an exceptionally high level of magnesium (1151.91mg/100g).

Calcium is crucial in human diet as it promotes strength for bones and teeth (Amagloh and Nayarko, 2012). It also plays an important role in blood clotting, muscles contraction, neurological functions and in enzymatic metabolic processes (Senga *et al*., 2013). Magnesium is important in calcium metabolism in bones, preventing circulatory diseases, regulating blood pressure and insulin release (Alinnor and Oze, 2011). Moreover, Shankar and Prasad (1998) reported that zinc plays an important role in cellular and humoral immunity.

4.3.3 Vitamins composition of the UVs

Nutritionally, supporting reports by the respondents during interviews, chemical analyses showed the UVs are rich sources various kinds of vitamins. From Table 4, highest values of vitamin C (198.08 mg/100g) were recorded for *B. alba* and the lowest values (46.52 mg/100g) for *M. foetida*.

Table 4: Vitamins composition of selected UVs (dry weight basis)

Sample	Vit. A (mg/100g)	Vit. B1 (mg/100g)	Vit. B2 (mg/100g)	Vit. B3 (mg/100g)	Vit. C (mg/100g)
M. foetida	5.5 ± 0.77^{b}	58.34 ± 2.67^{a}	0.76 ± 0.06^{c}	0.12 ± 0.02^{a}	46.52 ± 3.70^{a}
V. vexillata	2.5 ± 0.40^{a}	18.94 ± 0.69^{a}	0.18 ± 0.01^{a}	0.09 ± 0^{a}	136.71±35.84b
L. cornuta	3.84 ± 0.50^{a}	25.22 ± 0.60^{a}	0.24 ± 0.02^{a}	0.1 ± 0.02^{a}	120.88 ± 11.26^{a}b
B. alba	6.67 ± 0.30^{b}	182.95 ± 47.76^{b}	0.54 ± 0.12^{b}	0.43 ± 0.06^{b}	198.08 ± 47.46^{b}

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

Also, *B. alba* was the richest source of vitamin B_1 (182.95 mg/100g) showing a statistically significant difference ($p<0.05$) among the four UVs analyzed. Moreover, there was no statistically significant difference ($p \geq 0.05$) in the contents of vitamin A recorded in *B. alba* (6.67 mg/100g) and *M. foetida* (5.5 mg/100g) compared to the lesser amounts in *V. vexillata* (2.5 mg/100g) and *L. cornuta* (3.84 mg/100g). Moderate amounts of vitamin B_2 and B_3 were recorded, with *M. foetida* being, the richest source of vitamin B_2 (0.76 mg/100g). The lowest amount of the vitamin (0.18 mg/100g) was recorded in *V. vexillata*. The UVs had the lowest amounts of vitamin B_3, with *B. alba* having an appreciably high amount (0.43 mg/100g) that was statistically significantly different ($p<0.05$) from the rest of the UVs analyzed.

Similar studies have reported varying proportions of vitamins composition in leafy vegetables. For instance, in *B. alba*, vitamin C content has been recorded as 15mg/100g (Sheela *et al*., 2004); 20.6 mg/100g (Steyn, 2001); 29-166 mg/100g (Singh *et al.*, 2016); 98.7 mg/100g (Lyimo *et al., 2003);* and 76.6 mg/100g (Sreeramulu *et al.,* 1983). In the same vegetable, β-carotene content was recorded as 5.4 mg/100g (Steyn, 2001), thiamine 0.04 mg/100g; riboflavin 0.12 mg/100g; and niacin 0.5 mg/100g (Singh *et al.*, 2016). In *L. cornuta*, vitamin C was 18.7 mg/100g (Ndossi and Sreeramulu, 1991); 15.9 mg/100g (Lyimo *et al.*, 2003) and 24.4 mg/100g (Sreeramulu *et al.*, 1983). However, the variations among the figures obtained in these findings as well as among the cited literature might be due to several reasons including nature of the plant species, soil types of the locations they were obtained and period of plant collection for analysis.

The results from the current study depict the selected UVs as good sources of vitamins, thus raising a need to domesticate them to ensure a successful fight against hidden hunger. For instance, according to Olayinka *et al.* (2012), ascorbic acid has been reported to play a crucial role in the synthesis of collagen, maintaining a healthy life style and preventing many diseases.

4.3.4 Anti-nutrients/toxicants composition of the UVs

The concentration of the anti-nutrients analysed revealed little amounts of oxalates recorded compared to the moderate levels of the phytates (Table 5).

Table 5: Anti-nutrients/toxicants composition of selected UVs (dry weight basis)

Sample	Oxalate (mg/100g)	Phytate (mg/100g)
M. foetida	2.74 ± 0.75^{a}	6.18 ± 0.04^{c}
V. vexillata	1.28 ± 0.71^{a}	1.64 ± 0.06^{a}
L. cornuta	3.15 ± 0.81^{a}	1.74 ± 0.05^{a}
B. alba	1.34 ± 0.13^{a}	4.31 ± 0.52^{b}

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

The oxalate contents ranged from (3.15 mg/100g) in *L. cornuta* to the least amounts (1.28 mg/100g) in *V. vexillata* (Table 4); with no statistical significant difference ($p<0.05$) in the Oxalic acid contents among the four UVs analysed.

Phytates concentration recorded were highest (6.18 mg/100g) in *M. foetida* and least (1.64 mg/100g) in *V. vexillata*. The phytic acid contents in *M. foetida* and *B. alba* were statistically significantly different ($p<0.05$) to the contents recorded in *L. cornuta* and

V. vexillata, which showed lower values with no statistical significance difference ($p \geq 0.05$) between them. The low values of anti-nutrients obtained from this study point to the bioavailability of other nutrients and indicate that the vegetables are less toxic and therefore safe to use.

Researchers have reported widely variable values of anti-nutrients in leafy vegetables. For instance in *B. alba*, Sheela *et al*. (2004) reported 60 to 84 mg/100g oxalic acid; while Saha *et al*. (2015) reported 2.86 mg/100g and 183.00 mg/100g oxalic acid and phytic acid respectively. Also, Agiang *et al*. (2016) observed phytates to be in a small range of 5.23-7.30 mg/100g.

According to Igile *et al*. (2013), at levels of about 6%, anti-nutrients have been reported to be deleterious in their effects. For instance, a diet with phytates in the range of 1-6% for a long period tends to decrease the bioavailability of mineral elements. Also, oxalate is capable of binding to calcium ions, forming calcium-oxalate crystals and rendering it bio-unavailable (Nkafamiya *et al*., 2010). The crystals may also form precipitates around the renal tubules, causing renal stones (Ladeji *et al*., 2004).

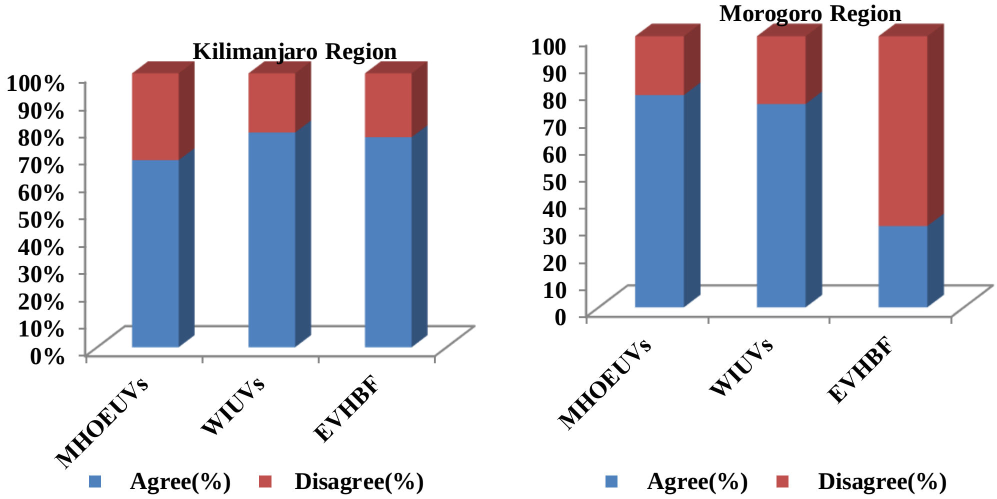
Phytic acid besides being associated with some nutrition-related diseases such as rickets and osteomalacia, it is known to be a very potent chelator; forming protein and mineral-phytic acid complexes thereby decreasing protein and mineral bioavailability (Erdman, 1979).

4.4 Consumer Habits

4.4.1 Interests and preferences of the UVs

From the FGDs, it was reported that most of the individuals who used the UVs had an interest with the vegetables. Most of them were accustomed to UVs since the eras of their great grandparents who were also explained to be major consumers of the vegetables on a daily basis, to the extent of staying physically fit, un-attacked by the common maladies that befell most people in the present-day generation. They explained that the UVs had a nice taste, besides being, medicinally; a reliable "immunity booster." The claims find support in the laboratory chemical analyses which revealed the UVs as good sources of minerals and vitamins; which are thought to contribute to their nutritional and medicinal potentials.

Lack of interest and inability to tolerate absurd tastes, for instance the bitterness in *L. cornuta* and the foul smell of *M. foetida* has been among the reasons provided as to why some individuals do not consume underutilised vegetables. It was found that over 70% of the respondents often ate UVs in their households and over 75% were interested in their consumption (Fig. 1); implying that majority of the people in the study areas were interested in and utilised the UVs.



MHOEUVs: Members of the household often eat UVs
WIUVs: We are interested with the UVs
EVHBF: Exotic vegetables have better features/benefits

Figure 1: Interests and preferences of the UVs

Source: Field survey, 2017

It was also reported that the UVs were usually used alongside other vegetables to neutralise their taste, as some were claimed to be unpalatable due to weird tastes like the bitter taste in *L. cornuta*. However, according to various reports, the decline in their production and consumption in many rural communities in Africa is believed to be due to the introduction of exotic vegetable varieties (Maundu *et al*., 2005; Weinberger and Msuya, 2004).

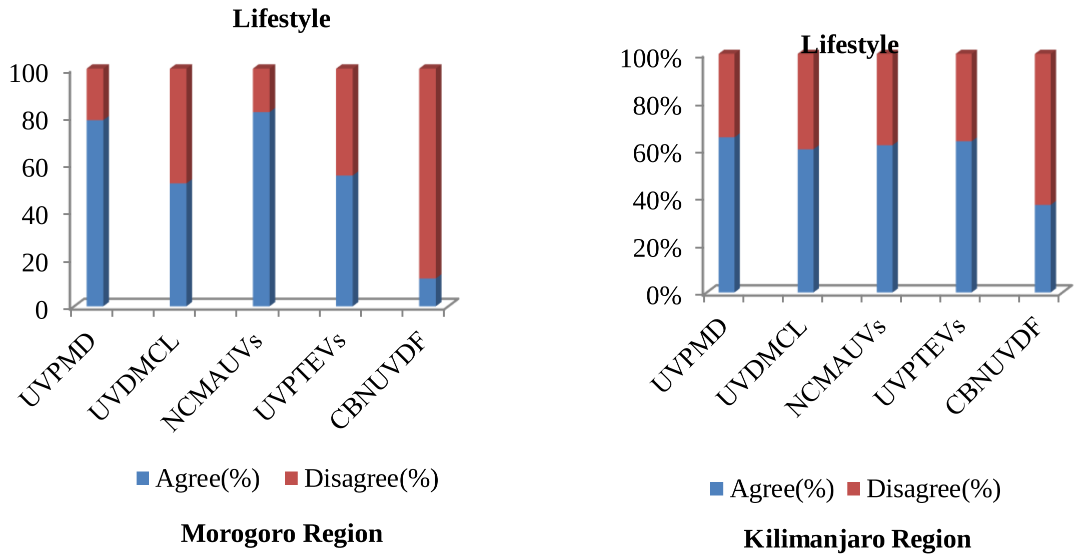
Most consumers were however claimed to come from the elderly group of people as they were the ones who had been using the UVs since time immemorial not only as food but also in folklore medicine. They claimed that the modern generations did not at all know anything about the potentials of the UVs as part of diet and as medicine; and how they are responsible for general body stability of the ancient people.

Among the reasons pointed out by the respondents as to why they used the UVs include: (i) cutting short budget expenditure on exotic species due to their affordability; (ii) do not use organic fertilizer; (iii) potential not only as food but also as medicine; (iv) appetizers as their taste is good compared to the exotic species; (v) as accompaniments with any kind of food, including cooked rice, bananas and stiff porridge (ugali).

4.4.2 Lifestyle/image of consumers concerning UVs

Those who considered the UVs as part of their diets had a positive image on the UVs, they did not consider them as a poor man's diet or a primitive foodstuff. Instead, they had a strong preference for the vegetables such that some pointed out that they could not afford a meal without such vegetables. Some went to the extent of mocking people in the current generation, that they were weak and sickling, just because they consumed foods that did not add anything to boost their immunity system. It was claimed that the UVs are pure and safe, because they did not involve any organic fertilisers or pesticides during their growing period. Nevertheless, in most cases, the rest of the people considered UVs as out of fashion and associated them with low-class people; also as food and source of income for the poor and unemployed households (Mnzava, 1993).

Preference of African leafy egetables (ALVs) species depends on the gender, age of consumers, cultural background and geographical location. Most of the respondents (25%) claimed that UVs are considered as the poor man's diet and those who consume them as primitive and old-fashioned. Most of the mid-aged people have also fallen into that trap of misconceptions; many of whom are the educated and people from the well-off families, most of these (20%) claiming that underutilised vegetables do not match their lifestyles or image (Fig. 2).



UVPMD: UVs are considered as a 'poor man's diet'; **UVDMCL**: UVs do not match consumers' lifestyle/image; **NCMAUVs**: Non-consumers have misconceptions about UVs; **UVPTEVs**: UVs are preferred to exotic vegetables; **CBNUVDF**: Consumers have a basic need that UVs do not fulfil

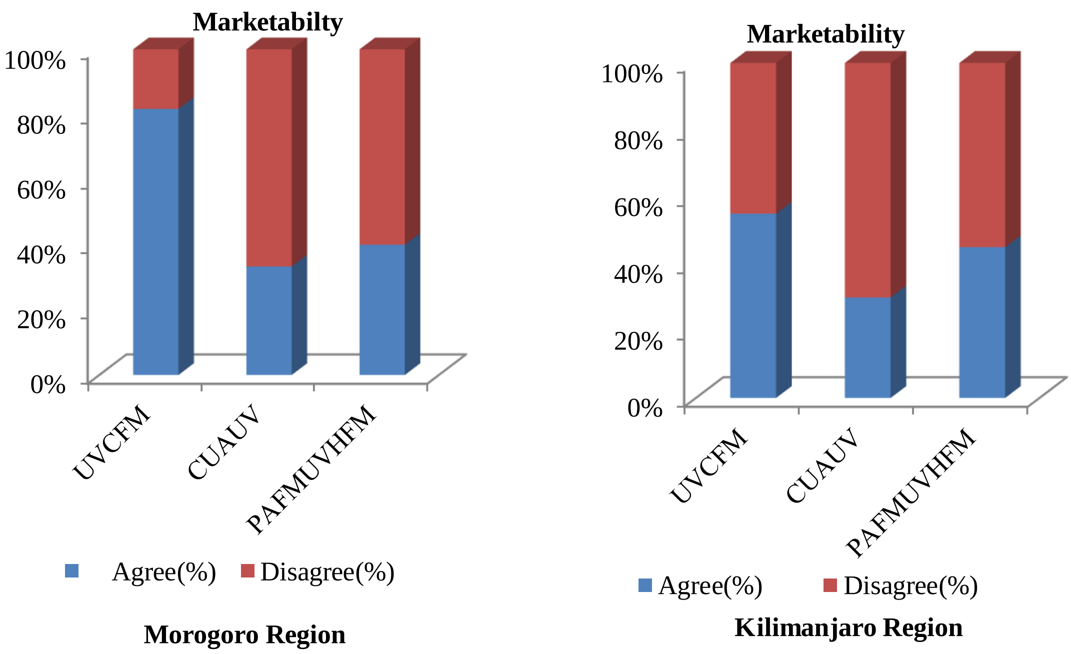
Figure 2: Lifestyle/image towards the UVs
Source: Field survey, 2017

Nevertheless, few among the youth and the high class people consume the UVs. They regard them as an additional variety of stew in their diets. Moreover, children do not prefer the UVs, they use the UVs just because their parents do so, while others find themselves 'victims' for remedial purposes, especially when they are sick from diseases that the UVs are claimed to provide relief. Few individuals also do not prefer the UVs, due to personal reasons and misconceptions, for instance there was a claim that some people have developed fears towards *V. vexillata*; with the claim that its roots are poisonous and can be fatal.

4.5 Market Demand

4.5.1 Marketability

Fig. 3 shows that over 70% of the respondents from both regions were aware of the availability of underutilised vegetables; that they can be found even in the markets. Poor availability in the farms was shown to be an illogical reason for unavailability of UVs in the market.



UVCFM: Underutilized vegetables can be found in the market; **CUAUV**: Consumers are unaware of the availability of underutilized vegetables; **PAFMUVHFM**: Poor availability in the farms makes UVs hard to find in the market

Figure 3: Marketability of the UVs

Source: Field survey, 2017

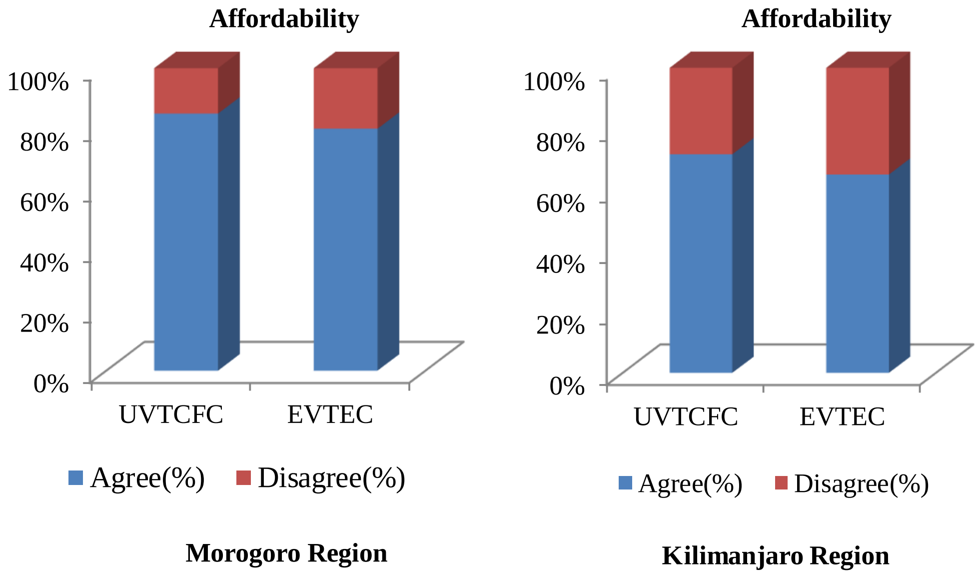
In Morogoro region, the markets for UVs were Morogoro town market, Mawenzi market, Kimamba and Kilosa markets while in Kilimanjaro they included Kalali, Mula, Kibororoni, Manyeni and Mbuyuni from Hai district.

Also, churches were considered as markets whereby the poor and lower class people took the UVs as their tithe and offering; whereby the UV's were in turn bought by people in church, especially those who found trouble accessing them, especially for their medicinal potential. Moreover, some individuals obtained them from vendors who walked to and from the villages selling them to the natives. The density of the target market was small and poor, those who buy the vegetables being people who were used to the vegetables and those who had at least some knowledge concerning them.

Similar to other vegetables, the IVs are highly perishable with a very short shelf life; deteriorating very quickly in quality and flavour after harvesting thus making the extent of post-harvest losses huge if the crop is handled poorly. The ability to maintain freshness of the UVs obtained from the farms is a challenging task; and as supported by Janet and Richard (2000), it is one of the major setbacks of farmers who would wish to expand their marketing opportunities and ability to compete in the marketplace. According to Schippers (2002), this creates problems in the marketing chain with producers, traders or consumers.

4.5.2 Affordability of the UVs

Over 75% of the respondents agreed that the UVs were cheap and very affordable compared to the exotic species, which were too expensive (Fig. 4).



UVTCFC; Underutilized vegetables are too cheap for consumers; EVTEC; Exotic vegetables are too expensive for some consumers

Figure 4: Affordability of the UVs

Source: Field survey, 2017

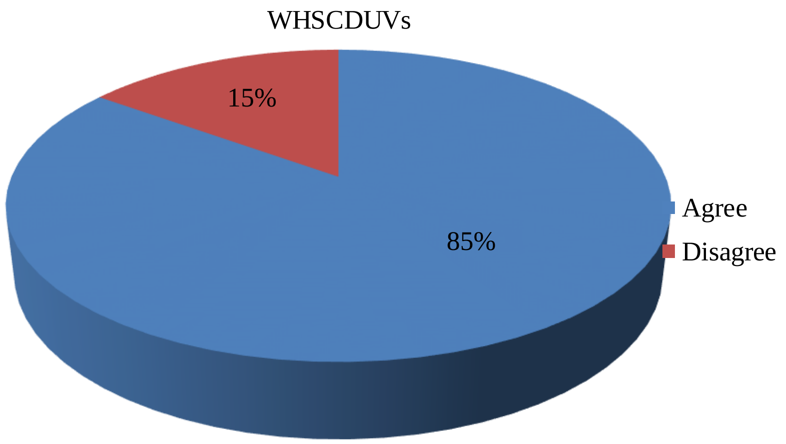
This was in line with Shackleton and Shackleton (2004) and Shumsky *et al.* (2014) who reported that in poorer households and in rural areas, wild edible plants can help to reduce spending of limited cash resources on energy, shelter, food and medical needs. Also, according to Jama *et al.* (2008), the UVs can be gathered without monetary cost and do not require expensive inputs, machinery or processing. Usually, a bunch costs from 100 to 500 TZS, with respect to the season and availability; whether plenty or scarce. Contrary to the exotic vegetables, a bunch of UVs is so huge that a household of three can use for a day or two. It was reported that an average of 2 out of 15 people purchase and consume the UV's once per week. The UVs market density is low, a fact attributed to modernity which has carried away most of the present-generation people to the point of neglecting the use of UVs and other traditional vegetables that were being used by the past generations.

Most of those who purchased the UVs did so twice to thrice per week, depending on the season because there were some UVs which did not tolerate the dry periods, thus unavailable during the periods. Some individuals never purchased the UVs at all but obtained them from the farms, where they usually grew on their own. It was also reported that very few people did not use the UVs at all, most of them being the ones that encountered them too much to the level of ignoring them. However, Fentahun and Hager (2009) reported that besides their contribution to household food security, the IVs are an important coping mechanism during periods of food insecurity brought on by drought, political unrest and unstable commodity markets, due to the availability of different species over the calendar year.

4.6 Current and Future UVs Needs

It was shown that currently, there is a great need of indigenous vegetables that are nutritious and health-promoting. The respondents claimed that they had been using the IVs and they will continue using them. They argued that, in most cases, the need depends on the status of the livelihood of an individual at a given moment, those that are starving and poor being the most needful of such vegetables during food shortage and drought periods.

Nevertheless, 85% (Fig. 5) of the respondents agreed that there had been a decrease in the demand of the UVs in the past 1-5 years. They described the decrease as unfortunate, whereby the modern generation, most specifically the youth were said to be accustomed consumers of exotic vegetables, contrary to the elderly (people of ancient times) who valued the wild vegetables. Households which seemed to have a continued interest in the UVs were considered primitive and old-fashioned.



WHSCDUVs; We have seen changes in the demand (decreasing) for UVs over the past 1-5 years

Figure 5: Current and future demand of the UVs

Source: Field survey, 2017

Also, due to increased unavailability attributed to drastic climate changes, the demand of the vegetables seemed to decrease in the present times. Moreover, due to westernisation of the minds of many individuals, even in the rural areas, developing preference to exotic species of vegetables over the traditional ones had been the trend. The demand of the UVs seems to fall, making a great alarm that if strong efforts are not put forward to domesticate them, then the future generation will be at stake of benefiting from such potential vegetables.

The findings of this study are in line with those of Maundu *et al*. (2005) that the introduction of exotic vegetable varieties has led to decreased demand of the UVs in many rural communities in Africa. Thus, due to the huge change in the mind-set of the present day youth who are the future generation, it is likely that in future the UVs will have a decreased demand.

4.7 Knowledge Dissemination

The key informants included the district, ward and village agricultural officers. These stated that they had been extending advisory services to the farmers, and concerning vegetables, they admitted that their services targeted exotic species and not the UVs. They agreed to the fact that knowledge on UVs is very important too, and that it is high time to start providing it to the famers for well-informed utilization. Muriira *et al*. (2014) supports the fact by explaining that the effective use of the herbs and other forms of IVs depends on extensive and thorough knowledge of their chemical compositions, safety and efficacy.

Among the services offered by the officers included: the proper use of natural fertilizers like farmyard and compost manure, use of pesticides, use of insecticides, line spacing; weeding; the purchase and use of certified seeds; the purchase and use of improved seed varieties as well as fertilizer and its proper application. Others included the use of natural insecticides (for example the neem tree whose leaves are ground, then the exudate is filtered and kept for 7 days thereafter sprayed on the seeds to kill pests; and “mfori” a cow’s urine kept for seven days and mixed with a little soap); as well as encouraging the use of chemicals, which are not too tough (for example selecron and desis for killing cutworms). Trainings were offered through farmer field schools while extension services were offered through frequent visits by the officers.

According to Shumsky *et al.* (2014), informal policy also affects the collection and use of UV’s and can be important in ensuring successful regulation. Also, as supported by Kinyuru *et al.* (2012), knowledge retention by the rural people on the potential benefits of the UVs has shown the significance of the foods for subsistence as well as cultural heritage. Most locals were knowledgeable about traditional foods; a trend which has however been slowly changing, fewer people being able to identify, cook or even consume them (Abukutsa-Onyango 2003, Kinyuru *et al*., 2012).

4.8 Challenges/reasons as to why Farmers/people do not Use UVs

Among the challenges given concerning the utilization and sustainability of use of the IVs include: low productivity, lack of markets, inputs too expensive; troublesome pests that do not die easily like the whitefly and the demand is too low as those who use them are mostly those ancient people. Others include livestock feeding on IVs making them a scarce commodity, lack of seeds in the farm input shops for productivity and lack of improvement for sustainability. Also, education status among individuals has been cited as among the reasons as to why the UVs are ignored or not used at all.

In the dissemination and access of new knowledge and practice on farming, challenges include: poor infrastructure, education status, poverty, lack of government support and policies, lack of transport means to reach the farmers easily, negative attitude of some villagers towards the extension officers when visited, some are unwelcoming, poor response to meetings when announced, unavailability of some villagers during meetings, especially the pastoral community who are busy with movements in search for water and pasture for their livestock. Poor policy design, lack of enforcement and community misunderstandings can result in harvest declines (Falconer, 1990). According to Shackleton and Shackleton (2004), although wild edible plants are an important dietary resource in rural areas, their contribution to food security is often under-appreciated by policy makers, leading to formal policies on access, extraction and sale that can lack understanding of local conditions.

Moreover, some people are just negative towards new knowledge (individual's perception and attitude); as some provide excuses, pointing fingers to "costs" whenever introduced to new technologies. Also, most farmers do not believe whatever the information they are provided with; they want to see results first.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

There is a wide variety of UVs in Morogoro and Kilimanjaro regions. UVs are a potential source of micronutrients namely vitamins and minerals; nevertheless, just like other plants, they contain varying levels of anti-nutrients especially phytates and oxalates. Consumption of the UVs will definitely benefit the communities in relation to reducing hidden hunger, thus ensuring food and nutritional security in Tanzania apart from the fads and myths that surrounding them. However, the UVs are currently showing decreased demand due to introduction of exotic species of vegetables; the main cause being easiness in preparation, palatability and negative image upon consumers.

5.2 Recommendations

i. There is an urgent need for promotion of consumption of UVs because of their nutritional excellence.

ii. There is need to study the effect of preparation and cooking of UVs to ascertain the safety in their consumption from the anti-nutrients standpoint

iii. There is need for community sensitization on increased consumption of UVs to counter and change their negative image and attitudes towards the vegetables

iv. There is a need to develop and acquire seeds of the selected UVs for domestication so as to ensure a wider adoption on a sustainable basis.

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APPENDICES

Appendix 1: FGD/KII Checklist (over 36 years of age)

FGD/KII checklist to identify, collect and screen plants with health and medicinal claims from communities in Kilimanjaro, Morogoro and Mara regions

Gender of the group:…………………………………..

Name of location: …………Village………………Ward…………….District……….....

Number of participants : ……………….

Date of FGD/KII: ………………………

Start time: ………………………………

Finish time:………………………………

1. What are the most eaten underexploited/traditional vegetables in this community?

	Vegetable (local name)	**Swahili name**	**Latin/Scientific name(by researcher)**
I			
Ii			
Iii			
Iv			
V			
Vi			
Vii			

3. What are the major methods of acquisition of the vegetables mentioned in Qn. 2 above?

	Vegetable (local name)	**Methods of acquisition**
I		
Ii		
Iii		
Iv		
V		
Vi		
Vii		

4. What are the major methods of processing of the vegetables mentioned in Qn. 2 above?

	Vegetable (local name)	**Methods of processing**
I		
Ii		
Iii		
Iv		
V		
Vi		
Vii		

5. What are the major methods of storage of the vegetables mentioned in Qn. 2 above?

	Vegetable (local name)	**Methods of storage**
I		
Ii		
Iii		
Iv		
V		
Vi		
Vii		

6. The occurrence of the vegetables mentioned in Qn 2 (the conditions favoring their occurrence)…………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

7. Utilization of the vegetables mentioned in Qn 2

i. Nutritional uses/potentials/claims……………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………

ii. Medicinal uses/potentials/claims…………………………………………

iii. Cultural uses/potentials/claims……………………………………

iv. Other uses/potentials/claims……………………………………

8. Are there any consequences of using such vegetables?

i. Health(nutritional) consequences………………………………
ii. Medicinal consequences……………………………………………………
iii. Cultural consequences………………………………………………
iv. Other consequences………………………………………………

9. Socio-cultural aspects

Who in the family are responsible for:

i. Harvesting ……………………………………………………………
ii. Processing …………………………………………………………
iii. Preparations for food …………………………………………………
iv. Storage ………………………………
v. Making decisions for buying………………………………………………..
vi. Other activities(**mention them**)……………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………

10. Seasonality/availability

i. Seasons on availed (months of the year in which they occur in plenty)……………………………………………………………………………
…………………………………………………………………………………
ii. Periods of scarcity and vulnerability to food security…………………………………………………………………………
…………………………………………………………………………

11. **Psychographic Questions**

- Opinions on UV……………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………
- Motives concerning UV(kinachowavutia)…………………………………………………………
…………………………………………………………………………………

- Lifestyle/image of consumers concerning UVs……………………………………………………………………………… ………………………………………………………………………………………

12. **Other questions**:

3. What's the price of UVs in the markets? (in and off season)…………………
4. Where do you go when you are looking for UVs (markets)?.. ....
5. What's the density of the target market (for sellers)?.. ....
6. How often do you purchase UVs?...
7. What are your current and future underutilized vegetables' needs?.. ....

13. Knowledge dissemination

a. Do you offer advisory services for farmers on underutilized vegetables? (Mention the services)………………………………………………………………… ……………………………………………………………………………… ……………………………………………………………………………..
b. Challenges/reasons as to why farmers/people do not use UVs………………………………………………………………………… ……………………………………………………………………………… ………………………………………………………………………………
c. In your view, what are hindrances in the dissemination and access of new knowledge and practice on farming?.. ....

Appendix 2: **Questionnaire**

a. CONSUMER HABITS

11. How much do you agree or disagree with the following statements?

(1. Strongly disagree, 2.Strongly agree, 3.Agree, 4. Disagree)

a. Members of our household often eat underutilized vegetables……….
b. Underutilized vegetables are inexpensive…………………………….
c. Underutilized vegetables are affordable…………………………..
d. We usually buy lots of underutilized vegetables…………………………
e. We don't have time to prepare underutilized vegetables……………….
f. Underutilized vegetables are a 'poor man's diet'…………………….....
g. We usually keep stored underutilized vegetables at home………………
h. Non-consumers have misconceptions about the underutilized vegetables…………..
i. Underutilized vegetables are preferred to exotic vegetables…...................................
j. We are interested/like with the UVs………………………………..

b. MARKET DEMAND

12. How much do you agree or disagree with the following statements?

(1. Strongly disagree, 2.Strongly agree, 3.Agree, 4. Disagree)

a. Underutilized vegetables can be found in the market…………………
b. Consumers have a basic need that underutilized vegetables do not fulfil……………..
c. Underutilized vegetables do not match consumers' lifestyles or image………………
d. Exotic vegetables have better features or benefits…………………………………....

e. Underutilized vegetables are too cheap for consumers……………………………….

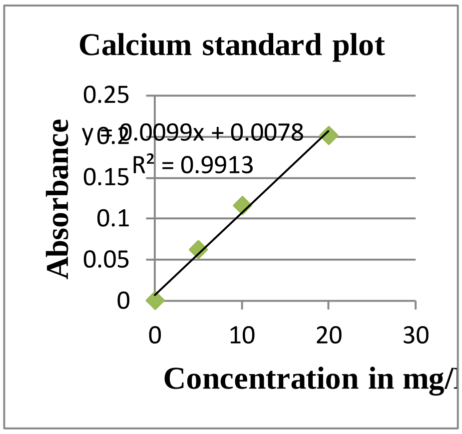
f. Exotic vegetables are too expensive for some consumers………………….…………

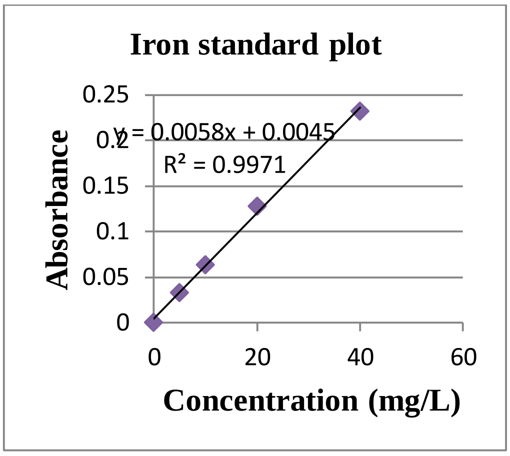
g. Consumers are unaware of the availability of underutilized vegetables………………

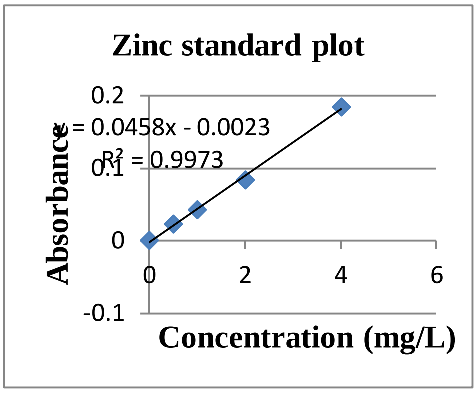
h. Poor availability in the farms makes UVs hard to find in the market…………………

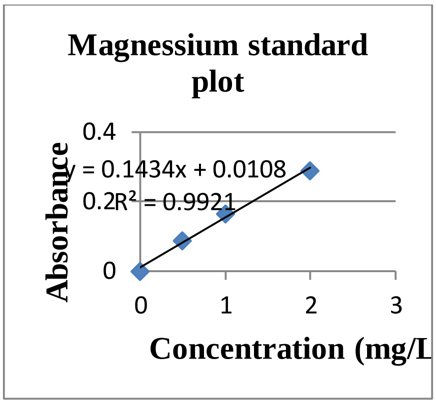
i. We have seen changes in the demand (decreasing or increasing) for UVs over the past 1-5 years……………....

Appendix 3: Standard curves for minerals Ca, Fe, Zn and Fe

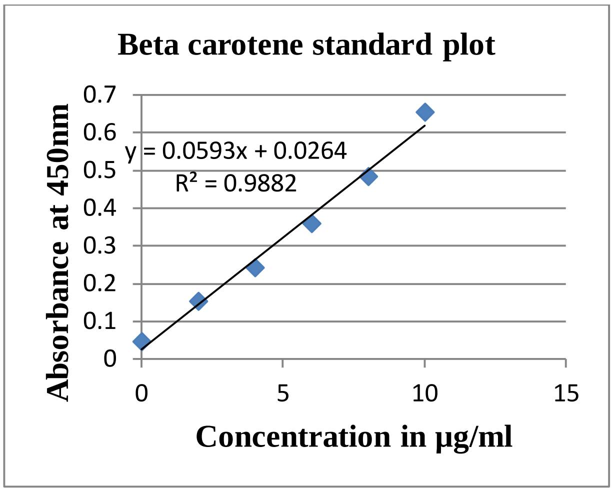








Appendix 4: Standard curve for vitamin A



Appendix 5: Standard curve for phytates