MEDICINAL PLANTS OF CHUKA COMMUNITY IN THARAKA NITHI COUNTY, KENYA AND SOME OF THEIR SELECTED ESSENTIAL ELEMENTS

By

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DECLARATION

I hereby declare that this is my original work and has not been presented for the award of a degree in any other university.

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DEDICATION

This thesis is dedicated to the Almighty God for providing good health and life during the period of the study. It is also dedicated to my dear wife Violet and our sweet children; Abida, Favour and Edgardavids.

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ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
ATP	Adenosine Triphosphate
BLD	Below Detection Limit
DNA	Deoxyribonucleic Acid
ED-XRF	Energy Dispersive X-ray Fluorescence
FAAS	Flame Atomic Absorption Spectroscopy
FAES	Flame Atomic Emission Spectroscopy
HIV	Human Immunodeficiency Virus
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
IDF	International Diabetes Federation
NHP	Natural Health Product
NAS	National Academy of Science
NRC	National Research Council
NIDDK	National Institute of Diabetes, Digestive and Kidney Disease
TB	Tuberculosis
UL	Tolerable Upper Intake Level
UNEP	United Nations Environmental Programme
UNICEF	United Nations Children’s Funds
WHO	World Health Organization

ABSTRACT

Medicinal plants are essential components of primary health care, especially for rural communities indeveloping countries. The medicinal plants contain essentialelements that are beneficial therapeutically. For example zinc plays a vital role in wound healing, nervous system, reproductive system and immune system. Chromium helps in metabolism and management of type-2 diabetes. Sodium is the chief extracellular ion and helps to maintain the body's fluid balance while potassium is the body's principal intracellular electrolyte, important in maintaining the fluid volume inside cells. Magnesium assists in the operation of more than 300 enzymes. It is also needed for the release and use of energy from energy-yielding nutrients. Iron is required for the making of new cells of amino acids, hormones and neurotransmitter. Calcium is an integral part of bone structure and the bone calcium. Medicinal plants are also known to contain secondary metabolites such as alkaloids, saponins, tannins, flavanoids and steroids among others. However, reports about levels of essential elements in medicinal plants and specifically on the medicinal plants used by the Chuka community are scarce. This study therefore undertook togather information on the knowledge and use of medicinal plants for treating various ailments as well as essential elements in the medicinal plant.The information obtained was used to collect and identify the common medicinal plants with the help of a Plant Taxonomist. Specimens of the same were deposited at East African Herbarium at the National Museums of Kenya. The levels of Zn, Fe, Cr, Mg, Ca, Na, Cu and K in 19 common medicinal plants used by Chuka community were determined using flame atomic absorption spectroscopy (FAAS) and flame atomic emission spectroscopy (FAES). The results obtained were analyzed using statistical package for the social sciences (SPSS). The study showed that 146 medicinal plants are used in the treatment of human beings and animals, with majority (97.9%) being used on the former. Analysis of variance (ANOVA) showed that levels of selected essential elements were significantly different from one plant to plant ($p \leq 0.05$ at 95% confidence level). The levels of K ranged from 1.50mg/Kg in stem bark of *Mangifera indica* to 455.00mg/Kg in leaves of *Aloe secundiflora*. The levels of Cu were 0.38 mg/Kg in *Iboza riparia*while*Euclea divinorum* registered levels below detection limit. The levels of Mgranged from 6.12 mg/Kg in *Dovyalis abyssinica*to 164.00 mg/Kg in *Aloe secundiflora*. Levels of Zn ranged from 0.35 mg/Kg in *Eucalyptus saligna* to 4.29 mg/Kg in*Aloe secundiflora,* while levels of Crranged from 0.47 mg/Kg in leaves of *Senna didymobotrya* to 1.61 mg/Kg in stem bark of the same plant. Iron levels ranged from 0.74 mg/Kg in *Bauhiniatomentosa* to 20.40 mg/Kg in *Eucleadivinorum*. Levels of Na ranged between 2.69 mg/Kg in *Bauhinia tomentosa* and 8.45 mg/Kg in *Aloe secundiflora*. The leaves of *Aloesecundiflora* had the highest levels of essential elements studied while the stem barkof*Dovyalis abyssinica* had the lowest levels. There was a negative correlation and positive correlations between certain metal pair interactions with high positive correlations between Mg-Na and Mg-Ca interactions ($r = 0.823$ and 0.887 respectively). The findings of this study will be used in developing sustainable use of medicinal plants. The information will be used to sensitize the community on use of medicinal plants.

CHAPTER ONE

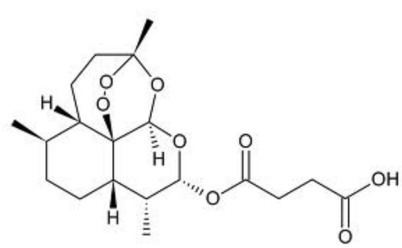
1.0 INTRODUCTION

1.1 Background information

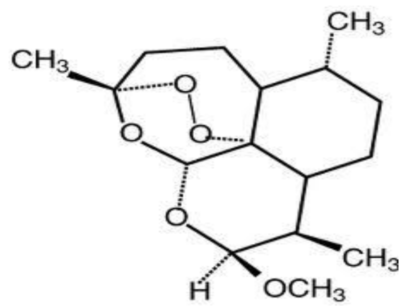
Traditional medicine has been in use since time immemorial (Dery *et al.,* 1999) and has remained a pillar component in health care systems of resource poor communities in developing countries.These countries are faced with high levels of poverty, high cost of living as a result of inflation and diseases such as Human Immunodeficiency Virus (HIV), Acquired Immune Deficiency Syndrome (AIDS), malaria, cancer, diabetes and tuberculosis (TB).Many people especially those in developing countries rely mainly on traditional medicine for their primary healthcare (Cunningham, 1993; Black and Cox, 1996; Mworia, 2000). The World Health Organization (WHO) estimated that 80% of the current population in the world uses medicinal plants for some aspect of primary healthcare (Choudhry *et al.,* 2004).

It is thought that some medicinal plants contain elements of vital importance for human metabolism, disease prevention and healing (Obianjunwa *et al.,* 2004). International Diabetes Federation (IDF) estimates that 194 million people worldwide suffer from diabetes and is expected to rise to almost 333 million by the year 2025 (NIDDK, 2005). However, population-based surveys of 75 communities in 32 countries show that diabetes is rare in communities in developing countries where traditional lifestyle has been preserved (Wild *et al.,* 2000). Cancer is a growing concern in developed and developing countries, with the number of cases increasing day by day. More than 7 million people are dying from cancer annually and 11 million new cases expected to rise from 11 million in 2002 to more than 16 million annually by 2020 (WHO, 2002). According to the American National Cancer Institute, about a third of all types of cancer is linked to diet and that the right choice of food can prevent majority of cancer cases. In fact, fewer cases of diet related diseases have been cited among communities relying on traditional diets (UNEP, 1995). For instance, a mixture of vitamin C and copper has lethal effects on cancer (Bakhru, 2006).

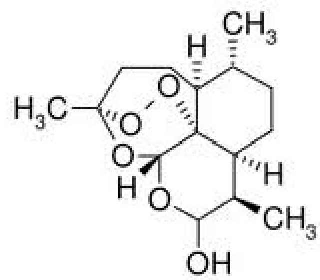
Malaria, a major parasitic disease in the world, especially in Africa, is responsible for 2-3 millions deaths every year and 500 million new cases, mostly among children under five years and pregnant women (WHO, 2008). Various synthetic analogues of quinine have been developed for malaria (Rukunga and Simons, 2006). Over a past decade, the discovery of artemisinin from *Artemisia annua*L.has boosted research on plants in the search for new antimalarial compounds(WHO, 2001a) with a new group of antimalarials - the artemisinin compounds, especially artesunate, artemether and dihydroartemisinin - which produce a very rapid therapeutic response and are active against multidrug-resistant *Plasmodium falciparum* malaria. Below are structures of artesunate, artemether and dihydroartemisinin as shown in Figure 1.1.



Artesunate



Artemether



Dihydroartemisinin

Figure 1.1: Structures of artesunate, artemether and dihydroartemisinin

It is reported that more than 3.5 billion people rely on plants for the treatment of both human and livestock diseases (FAO, 1997). The use of herbal medicines however, is on the increase even in developed countries because of the belief that herbal remedies are safe because of their natural originand have little or no side effects (Jacobsson *et al.*, 2009). According to World Health Organization (WHO), traditional healers such as herbalists, midwives and spiritual healers constitute the main source of assistance for at least 80% of rural population with health problems in developing countries (WHO, 2001b).

The worsening economic situation of the Sub-Sahara African countries has made it difficult to expand modern health services hence effective low-cost delivery medical system is urgently needed (Khalid and El Kamali, 1996). In Peru, it has been found that about 84% of the local people prefer traditional medicinal plants for their health care needs in comparison to modern pharmaceutical products. Some of the reasons given include the fact that they are of natural origin and no risks or harm is experienced when used (Bussmann *et al.*, 2007). In Africa, many communities use plants for treatment of many diseases (Environmental Centre International, 2003). In Ethiopia, nearly 80% of the population still relies on plants to prevent and cure various health problems (Dawit and Ahadu, 1993). In Kenya, about 90% of the population has used medicinal plants at least once for various health conditions (Chirchir *et al.*, 2006).

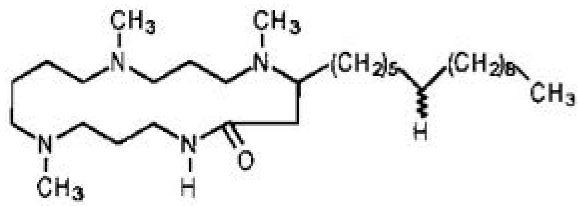
Comprehensive ethnobotanical information and healing methods among the local communities in Kenya is not completed. However, several authors have recorded indigenous information of medicinal plants (Kaendi, 1997).The Chuka area is endowed with rich biodiversity, ranging from many indigenous trees and medicinal plants. This is as a result of the undulating topography and moderate rainfall that sustain the growth of forest cover and medicinal plants in the lower region.

Medicinal plants used in indigenous medicine, in crude forms contain both organic and inorganic constituents. The efficacy of medicinal plants for curative purposes is often accounted for in terms of their organic constituents like vitamins, glycosidesand essential oils among others. However, it is thought that some medicinal plants contain elements of vital importance for human metabolism, disease prevention and curative ability (Obianjunwa *et al.,* 2004; Rajurkar and Damame, 1997). More than 40 elements have been considered essential to life systems for the survival of both mammals and plants. An element is said to be essential when reduction of its exposure below a certain limit results consistently in a reduction in a physiologically important function, or when the element is an integral part of an organic structure performing a vital function in that organism (Armah *et al.,* 2001). For the element to be pharmacologically effective or essential, it may need to be combining or chelated with some ligand, in order to be physiologically absorbed to prevent or cure impairment caused by deficiency of the element (Linder, 1991). For example, iron is a component of haemoglobin and other compounds used in respiration. Inorganic elements are widespread in soil in different proportions due to geo-climatic conditions and environmental pollution as a result of anthropogenic activities (Järup, 2003; Ahmed and Chaudhary, 2009).

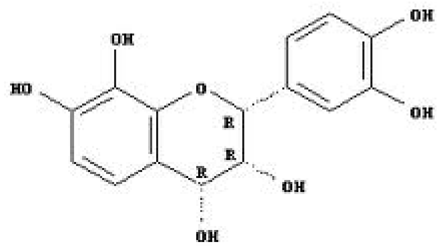
The composition of elements in terms of their contents in medicinal plants is very important and need to be screened for their quality control (Arceusz *et al.,* 2010) hence the recommended estimate of dietary intake of these minerals by a person is important. High levels may be toxic or interfere with absorption of other essential elements. Low levels may lead to deficiency of the elements in the body. Apparently, more than 2 billion people worldwide are deficient in one or more of the essential trace elements and suffer from cancer, anaemia and diabetes (FAO, 1995). Iron deficiency is one of the most prevalent and most serious nutrient deficiencies threatening human population in the world, affecting approximately two billion people (de Benoist *et al.,* 2008).In Ethiopia the Food and Agricultural Organization estimate showed that prevalence of iron deficiency is 85% among children and 58% among pregnant women while in Kenya similar survey estimated 60 and 70% respectively (Deckelbaum *et al.*, 2006; Liu *et al.*, 2004).

As far as ethnobotanical studies are concerned, the documentation of medicinal plants prioritised by the local people, as well as their understanding of possible biodiversity loss and strategies of conservation are under-explored (Bisht *et al.*, 2006). In the Meru community, the dependence on medicinal plants for management of diseases has not been exhaustively documented (Njuguna and Shin-Ichiro, 2008). The community uses the medicinal plants for treatment of various ailments including headache, stomachaches, and antidotes for snakebites among others. For example, the seed-flour of *Afromomum sanguineum* (K. Schum.) K. Schum. “minyua”and castor seed oil are used for treatment of worms and constipation respectively (Njuguna and Shin-Ichiro, 2008).

Decoction of stem bark of *Albizia amara* is taken three times a day as anemetic to induce vomiting and to treatmalaria while leaves are used in treatment of wounds (Dharani and Yenesew, 2010) and its seedscontain spermine alkaloidsreferred to as budmunchiamines. Some flavonoids such as melacacidinhave been isolated from the heartwood. Budmunchiamines such as budmunchiamine K from other *Albizia* species have also beenshown to exhibit antiplasmodial activities(Dharani and Yenesew, 2010).Figures 1.2 show structures of budmunchiamine K and melacacidin.



Budmunchiamine K



Melacacidin

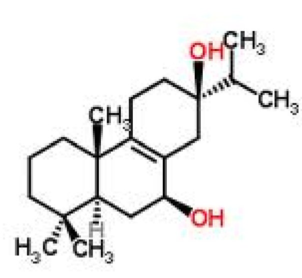
Figure 1.2: Structures of budmunchiamineK and melacacidin

Analysis of essential elements in medicinal plants has not been given a lot of consideration; hence need to study the medicinal plants from the Chuka community. With the rising cost of living in the country, cost of synthetic drugs has escalated making the cost of modern medication beyond the common man. An alternative source of medication for the people of Chuka and Kenyans as a whole will be a big asset.

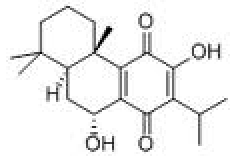
1.2 Statement of the problem

Given the increased use of traditional medicines, possibilities that would ensure their successful integration into a public health framework should be explored. There has been an increase in diseases and conditions such as diabetes, high blood pressure, heart diseases, obesity and cancers. Local medical experts warn that such diseases will soon overtake diseases such as malaria and AIDS as the leading killers of young Kenyans (FAO, 1995). Child mortality has been on the increase with a large number of children dying from diseases like diarrhoea, pneumonia, malaria and other infections (Kabi, 2004).This is compounded by the fact that health services are expensive especially to the poor Kenyans who are the majority (Meme, 1998). Most people have resorted to the use of traditional medicine and especially in the Chuka community.

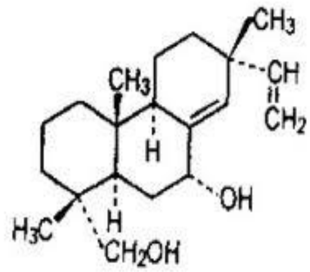
In recent years, secondary plant metabolites (phytochemicals), previously with unknown pharmacological activities, have been extensively investigated as a source of medicinal agents (Krishnaraju *et al.*, 2005). These phytochemicals include alkaloids, saponins, tannins, flavonoids, steroids, cardiac glycosides among others. For instance, the major chemical constituents of *Iboza riparia* are diterpenes for example ibozol, 7 α-hydroxyroyleanone, 8 (14), 15-sandaracopimaradiene-7α, 18-diol; α-pyrones which include umuravumbolide and tetradenolide. Some of them have shown adequate antibacterial efficacy (Balandrin *et al.,* 1985). The structures of ibozol, 7 α-hydroxyroyleanone, 8 (14), and 15-sandaracopimaradiene-7α, 18-diol and α-pyrone are shown in Figure 1.3.



(a) Ibozol



(b) 7 α-hydroxyroyleanone



(c) 15-sandaracopimaradiene-7 α, 18-diol

Figure 1.3: Structures of ibozol, 7 α-hydroxyroyleanone and 15-sandaracopimaradiene-7 α, 18-diol

Other than the phytochemicals, medicinal plants also contain mineral elements which are of vital importance for human metabolism, disease prevention and healing (Obianjunwa *et al.,* 2004). Essential elements such as Zn, Fe, Cr, Na, K, Ca, Cu and Mg are known to rejuvenate the body therapeutically and to boost immunity. For example zinc could reduce respiratory infections such as pneumonia by up to 45 % and malaria cases by 35 % (Fox, 1998) while iron is required for the making of new cells of amino acids, of hormones and of neurotransmitter, growth, reproduction, healing and immune function (Whitney and Hamilton, 1987; Van der Strate*et al.,* 2001).An enhanced immune system will in turn increase body resistance to various viral and bacterial infections as well as cancerous growths that flourish or die depending on the operation of immune system (Bakhru, 2006).

A lot of workhas been reported on the organic composition of the traditional medicine (Roja and Rao, 2000). Moreover, a lot has also been reported on the medicinal plants of Chuka community (Rukunga and Simons, 2006) but with little evidence on the essential inorganic elements in medicinal plants. Medicinal plants can be a good source of biologically important elements, which may play a part in the observed therapeutic properties of these plants.

1.3 Justification

Medicinal plants play a major role in the health care sector of developing nations for the management of diseases. They have macronutrients and micronutrients which have curative and preventive role in combatingdiseases thus important for the proper functioning of vital organs in the body. Elements such as zinc, iron, chromium, sodium, potassium, calcium, copper and magnesium are preserves of good health and boost body immunity. These metals are widespread in soil as a result of geo-climatic conditions and environmental pollution. Therefore, their assimilation and accumulation in plants is obvious. They are found in plants in varying quantities depending on the soil in which they are grown and plant species.

Phytochemical and bioactivity studies have been done on medicinal plants and associated with the curative properties of these plants. The mineral elements in these medicinal plants could also be contributing to their curative functions. This study therefore sought to determine the medicinal plants used by the Chuka community and selected mineral elements present in them.

1.4 Hypothesis

A significant number of members of Chuka community are aware of medicinal plants and that the medicinal plants from Chuka contain essential elements.

1.5 Objectives

1.5.1 General objective

To determine the medicinal plants used by the Chuka community andlevels of some selected essential elements in them.

1.5.2 Specific objectives

The specific objectives of this study were:-

i) To determine commonly usedmedicinal plants by Chuka community.

ii) To determine levels of calcium, chromium, copper, iron, magnesium, potassium, sodium and zinc in the most usedmedicinal plants by Chuka community.

1.6 Significance of the study

The information obtained on the assessment of Chuka community's awareness will help in documentation of the medicinal plantsand ailments they treat. The results of this study will be important in formulation of mineral supplements from natural products and packaging which will be of help to pharmaceutical firms. The study is to establish levels of, Na, K, Mg, Ca, Fe, Cu,Zn and Cr in common medicinal plants of Chuka community. The information gathered will be used to sensitize people on the role of traditional medicine from Chuka community and the levels of selected essential elements in them. The concern about the quantitative estimation of various essential element concentrations is important for determining the effectiveness of the medicinal plants in treating various diseases and also to understand their pharmacological action. The finding will also be used as a baseline study for other researchers working on medicinal plants.

1.7 Scope and limitations of the study

The study involved questionnaires administered to 117 respondents to collect information on the Chuka community's awareness and use of medicinal plants. The study was also designed to determine the levels of Zn, Fe, Cr and Mg in parts of commonly usedmedicinal plants from Chuka, using flame atomic absorption spectroscopy(FAAS) while Na, K and Ca were analyzed using flame atomic emission spectroscopy(FAES). Nineteen medicinal plants were sampled and analyzed based on the frequency of use by the local community, their general availability in the area, time available and resources. Only parts of the plants that are used for medication, that is stem barks, leaves or roots were analyzed for the selected essential elements. Soil condition and seasonal variations were not considered in this study. Non-essential elements such as lead, mercury and silver in the commonly used traditional medicinal plants by this community were not considered.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Traditional medicine

Since ancient times plants have been indispensable sources of both preventive and curative traditional medicine preparations for human beings and livestock. Traditional medicine refers to any ancient, culturally based healthcare practice different from scientific medicine and it is commonly regarded as indigenous, unorthodox, alternative or folk and largely orally transmitted practice used by communities with different cultures (Cotton, 1996). The World Health Organization (WHO) also defined traditional medicine as health practices, approaches, knowledge and beliefs incorporating plant, animal and mineral based medicines, spiritual therapies, manual techniques and exercises applied to treat, diagnose and prevent illnesses or maintain well being (WHO, 2003).

It is estimated that there are 250,000 to 500,000 species of plants on Earth (Borris, 1996). A relatively small percentage (1 to 10%) of these is used as foods by both humans and other animal species. More than 50,000 are used for medicinal purposes (Tilahun and Mirutse, 2007). According to Azaizeh *et al.*(2003), as many as 80% of the world's population relies on traditional medicine for their primary health care.

2.2 Use of medicinal plants of the world

The use of plants as treatment of diseases and food dates beyond recorded history perhaps as old as the history of mankind. Old civilizations in China, India, Egypt and Greece had a rich knowledge of its utility and expertise in using many types of plants. Historical accounts of traditionally used medicinal plants depict that different medicinal plants were in use as early as 5000 to 4000 BC in China, and 1600 BC by Syrians, Babylonians, Hebrews and Egyptians (Ermias *et al.,* 2008; Dery *et al.,* 1999). Much of an indigenous knowledge system, from the earliest times, is also found linked with the use of traditional medicine in different countries (Farnsworth, 1994). Even in the Western world, the use of herbal medicines is steadily growing with approximately 40% of the population reporting use of medicinal plants to treat medical illness (Lanfranco, 1999;Demma *et al.,*2009).

In India, medicinal plants appear to be considerably used throughout the country. In Nagaland, India, medicinal plants are used for the treatment of pains, mucous secretion, wounds of injured animals, constipation, gastric troubles, dizziness, sore tongue in children and fungal infections. These plants have also been used as anthelmintic, antipruritic and as antidote in food poisoning (Jamir *et al.,* 1999).Ermias *et al.*(2008) reported that 181 (78.70 %) of medicinal plants were used as human medicine, 27 (11.74 %) as livestock medicine and the remaining 22 (9.57 %) were used for treating both human and livestock ailments.

2.3 Use of medicinal plants in Africa.

Traditional remedies are part of the cultural and religious life of African people. The seemingly wide use of traditional medicine is attributed to its accessibility and affordability (Steenkamp, 2003). In Africa, up to 80% of the population uses traditional medicine for primary health care. For instance, in Ghana, Mali, Nigeria and Zambia, the first line of treatment for 60% of children with high fever resulting from malaria is the use of herbal medicines at home (Kassaye *et al.*, 2006).

In Ethiopia, traditional remedies represent not only part of the struggle of the people to fulfill their essential drug needs but also, they are integral components of the cultural beliefs and attitudes (Abebe, 1996). Plant remedies are still the most important and sometimes the only source of therapeutics for nearly 80% of the population (Abebe, 2001). Some of the common uses of the medicinal plants sold in markets include fumigation, vermifuge, pain relief and treating skin infections. Antimicrobial and wound healing plants are among some of the major medicinal plants that are commonly available in markets in Ethiopia (Tadeg *et al.*, 2005).

In Kenya for example, 90% of the population has used medicinal plants at least once for various health conditions (Chirchir *et al.*, 2006). In Central Kenya, 75 plant species from 34 families are used to cure 59 ailments in traditional medicine (Njoroge *et al.*, 2004). In the Bondo District, Siaya County of Kenya, medicinal plants are traditionally used by rural mothers of the local community for the treatment of false teeth, mouth infections, labour pains, constipation, swelling, worms and congested nose in children (Geissler *et al.*, 2002).In Dar es Salaam, Morogoro and Tanga regions of Tanzania, medicinal plants are locally used by traditional healers for the treatment of candida infections, including oral candidiasis, vaginal candidiasis, oesophageal candidiasis and skin fungal infections (Runyoro *et al.*, 2006). In the Bulamogi County, Kamuli District of Uganda, medicinal plants are used by local farmers to treat cattle (*Bos indicus*) ailments like East Coast

Fever (ECF), abdominal worms, cataract, itching skin, wounds, measles, diarrhea and cough (Cunningham, 1996).

In West Africa, Kadiogo Province of Burkina Faso, medicinal plants are used in the management of the following oral health concerns; acute necrotizing gingivitis, loose teeth, dental abscesses,sores in the mouth, on the tongue and lips (Tapsoba and Deschamps, 2006) while in Cameroon's Mbalmayo region and in the Dja Bioshere Reserve and its adjacent areas in East and South provinces, medicinal plants are traditionally used in the treatment of stomach ailments believed to come from witchcraft, magic practice or vampirism, lumbago, roundworms, hernia, hookworms (Noumi and Yomi, 2001). In Benin, medicinal plants are traditionally used to treat malaria (Weniger *et al.*, 2004).

2.4 Plants as sources of nutritional supplements

Ethnopharmacology and natural product drug discovery remains a significant hope in the improving the poor livelihoods of rural communities. Many modern pharmaceuticals have their origin in ethnomedicine and ethnoveterinary medicine, which rely upon a local pharmacopoeia (Tamboura *et al.*, 2000). The ethnopharmacology knowledge is a holistic system approach that can serve as an innovative and powerful discovery engines for newer, safer and affordable medicines (Patwardhan, 2005). For instance, women working in industries are increasingly using fertility-enhancing plants to combat among other things, the negative effects of industrial pollutants on fertility (Lans, 2007). The drugs of today's modern society are products of research and development by major pharmaceutical companies but among the most important raw materials researched and developed are naturally occurring materials obtained from plants.

Medicinal plant roots are used in preparation of traditional medicine among traditional medicinal practitioners. This is because roots normally have a high partitioning for the photosynthates or exudates (Balick and Cox, 1996) which act as toxins for protection against devourers and most of these are of medicinal value to the human body. This is also the reason for using the bark. The use of roots is dangerous to the existence of individual plants as compared to the leaves or branches. The utilization of the roots calls for conservation measures on the medicinal plants since the use of roots do not allow for sustainable utilization as the plants in question are depleted by continual use. Collection of leaves for medicinal preparations could be regarded as sustainable since some leaves are left over on the parent plant. It has been reported that leaves are the most collected plant parts for medicinal purposes (Neli *et al.,* 2012; Gidey, 2010; Okoli *et al.*, 2007).

The presence and/or quantities of bioactive compounds in medicinal plants are influenced by several factors that include among others seasonal variations, environmental changes, plant-part used, intra-species variations and plant age (Weenen *et al.,* 1990). Interactions of these bioactive compounds and mineral elements in the medicinal plants could be working synergistically in determining the quality of a particular drug to treat an ailment.

Medicinal plants come into preparation of various drugs singly or in combination and are used as the principal source of raw material for the other medicines (Mohanta *et al.*, 2003). Many of the plants species used for this purpose have been found to contain therapeutic substances which can be extracted and used in preparation of drugs, but the plant itself can also be used either directly or as an extract for medication, a practice that is particularly popular in developing countries.

2.5 Plants as sources of minerals for human nutrition

All human beings require a number of essential organic/inorganic compounds in diet to meet the need for their activities. The important constituents of diet are carbohydrates, fats, proteins, vitamins, minerals and water (Indrayan *et al.*, 2005). Every constituent plays an important role and deficiency of any one constituent may lead to abnormal developments in the body. Plants are the richest source of all the elements essential for human beings. They are in fact the inorganic counterparts of essential biological organic nutrients namely vitamins and proteins (WHO, 1996).

More than 40 elements have been considered essential to life systems for the survival of both mammals and plants. The elements play an important role as far as health and animal life is concerned. Some elements are essential for growth, for structure formation, reproduction or as components of biologically active molecules while others have some other beneficial effects (New Wall *et al.*, 1996). Essential elements activate enzymes and vitamins hence lack of them can present serious health challenges including clinical and pathological disorders in animals, plants and man. Some essential elements make vitamins work more effectively. For instance, vitamin A works best with Se and Zn while B vitamins are potentiated by Se, Zn, Co, Cu, Fe and Mn. For vitamin C, the essential elements found to promote its effectiveness are Co, Cu and Se while vitamin E is activated by Fe, Mn, Se and Zn (Mindell and Mundis, 2004). According to Ayoola *et al.* (2010), Zn, Fe and Cu in medicinal plants make them exhibit antidiabetic, antianaemic and antihelmintic properties respectively. According to Kumar *et al.* (2011), Na, Mg, Ca, Mn, Fe, Co and Zn contents in many medicinal plants are used for the management of asthma, rheumatism and diarrhea.The essential elements considered for this study are briefly discussed in the following sub-sections.

2.5.1 Calcium in human health and levels in plants

Calcium is the most common mineral in the human body. About 99% of the calcium in the body is found in bones and teeth, while the other 1% is found in the blood and soft tissue(Weaver and Heaney, 1999). Calcium levels in the blood and fluid surrounding the cells (extracellular fluid) must be maintained within a very narrow concentration range for normal physiological functioning. The physiological functions of calcium are so vital to survival that the body will demineralize bone to maintain normal blood calcium levels when calcium intake is inadequate. Thus, adequate dietary calcium is a critical factor in maintaining a healthy skeleton (Weaver and Heaney, 1999).

The mineral component of bone consists mainly of hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$) crystals, which contain large amounts of calcium and phosphate (Heaney, 2000). Calcium plays a role in mediating the constriction and relaxation of blood vessels, nerve impulse transmission, muscle contraction, and the secretion of hormones like insulin (FNB, 1997). Calcium is necessary to stabilize a number of proteins and enzymes, optimizing their activities. The binding of calcium ions is required for the activation of the seven "vitamin K-dependent" clotting factors in the coagulation (Brody, 1999).

Calcium concentrations in the blood and fluid that surrounds cells are tightly controlled in order to preserve normal physiological function (Pearce and Thakker, 1997). Calcium is stored in bones and teeth where it plays two important roles; it is an integral part of bone structure and the bone calcium also serves as a bank that can release calcium to the body fluids, if even the slightest drop in blood concentration occurs (Sizer and Whitney, 2003). Although this complex system allows for rapid and tight control of blood calcium levels, it does so at the expense of the skeleton (Weaver and Heaney, 1999).

High concentrations of Ca are also important in muscles system and heart functions(Brody, 1999). A low blood calcium level is rarely due to low dietary calcium intake since the skeleton provides a large reserve of calcium for maintaining normal blood levels. Other causes of abnormally low blood calcium levels include chronic kidney failure, vitamin D deficiency, and low blood magnesium levels that occur mainly in cases of severe alcoholism (Weaver and Heaney, 1999).Increasing dietary calcium increases urinary calcium slightly. However, other dietary factors such as sodium and protein are also known to increase urinary calcium (Martini and Wood, 2000).

The concentration of Ca in *Withania somnifera* and *Bryophyllum pinnatum* was indicated as 4.52 and 0.41µg/g respectively (Ram, 2010). The concentration of Ca in *Momordica charantia* was reported to be 0.90%, *Spondias mombin* 1.05% while *Vernonia* *amygdalina* leaves had concentration of0.45 % (Ayoola *etal.*, 2010).According to Ahmed and Chaudhary (2009), leaves and roots of *Ajuga bracteosa* has been found to haveCa concentration of 201.3 and 211.3 mg/100g respectively, while Okwu and Josiah (2006) reported mean levels of 1.04±0.30 and 0.32±0.10 mg/100 g dry weight in *Aspilia africana and Bryophylum pinnatum* respectively.According to Gjogieva*et al.*(2011), levels of Ca in*Robinia pseudoacacia* were 3057.94±1.71mg/kg. Faizul *et al.* (2012) reported levels of Calcium in root of *Paeonia emodi* as 66.26±0.00 mg/L and fruit of *Punica granatum* as 1.650±0.00 mg/L. Uptake rate of calcium is said to be usually lower than that of potassium because it can be absorbed only by young root tips (Mengel and Kirkby, 1987).

2.5.2 Chromium in human health and levels in plants

Chromium is a mineral that humans require in trace amounts, although its mechanisms of action in the body and the amounts needed for optimal health are not well defined. It is found primarily in two forms: 1) trivalent (chromium 3+), which is biologically active and found in food, and 2) hexavalent (chromium 6+), a toxic form that results from industrial pollution (MAFF, 1999).According to Bakhru (2006), the daily human intake varies considerably between regions/countries with a range from 50-200 µg/day.

Chromium works with insulin in metabolization of sugar thus normalizing blood sugar levels. Maintenance of blood sugar level is made possible by the active agent (glucose tolerance factor) consists of Cr chemically bound with nicotinic acid which is a member of vitamin B complex. Chromium can help improve glucose tolerance. Diabetes responds to Cr supplementation thus occurrence of diabetes may be due to lack of Cr in the body (Mindell and Mundis, 2004). Chromium is required in trace amounts to help increase the body sensitivity to the hormone insulin for efficient utilization of surplus glucose. It is a vital ingredient in lecithin, which help the body to keep fat in small particles (Al Durtsch, 1999).

Absorption of chromium from the intestinal tract is low, ranging from less than 0.4% to 2.5% of the amount consumed (Anderson *et al.,* 1993) and the remainder is excreted in the faeces (Offenbacher *et al.,* 1994). Vitamin C (found in fruits and vegetables and their juices) and the B vitamin niacin (found in meats, poultry, fish, and grain products) enhances absorption of Cr (Offenbacher, 1994). Absorbed chromium is stored in the liver, spleen, soft tissue, and bone (Lim *et al.*, 1983).

Chromium has long been of interest for its possible connection to various health conditions. Among the most active areas of chromium research is its use in supplement form to treat diabetes, lower blood lipid levels, promote weight loss, and improve body composition. Insulin resistance leads to higher than normal levels of glucose in the blood (hyperglycemia) (Althuis *et al.,* 2002).

The body's chromium content may be reduced under several conditions. Diets high in simple sugars (comprising more than 35% of calories) can increase chromium excretion in the urine (Kozlovsky *et al.,* 1986). Infection, acute exercise, pregnancy and lactation, and stressful states (such as physical trauma) increase chromium losses and can lead to deficiency, especially if chromium intakes are already low (Lukaski *et al.*, 1996).

Muchemi (2006) reported levels of chromium in sorghum and finger millet as 5.86 mg/kg and 3.00 mg/kgrespectively. Levels of chromium in *Murraya koenigii* (curry leaves) was found to be 24.50 µg/g while in *Azadirachta indica* (neem), it was found to be 0.18 µg/g (Sumayya *et al.,* 2010). Ghebremeskel (1991) reported the levels of Cr as 0.7µg/g in *Euclea divinorum,*and 0.8 µg/g in *Carissa edulis*. According to Chien-Yi (2005), Cr content was0.29±0.03 µg/g in *Plantaginis semen*, 1.10±0.10 µg/g in *Benincasae semen*, 1.36±0.23 µg/g in *Junci medulla* and 0.15±0.02 µg/g in *Aristolochia fangchi*.Chromium concentration in *Momordica charantia* was found to be 162.00 mg/kg,*Spondias mombin* 66.00mg/kgwhereasin *Vernonia amygdalina* leaves the concentration was 89.00 mg/kg. According to Cherop (2009), the mean levels of Cr in stem bark of *Prunus africana* were 12.31±5.47 mg/kg. According to USDA (1990), the best food sources of chromium are calves' livers, wheat germ, brewer's yeast, chicken and corn oil.

2.5.3 Copper in human health and levels in plants

Copper is an essential - vitally important - trace element required for survival by all organisms. In the body, copper shifts between the cuprous (Cu^{1+}) and cupric (Cu^{2+}) forms, though the majority of the body's copper is in the Cu^{2+} form. The ability of copper to easily accept and donate electrons explains its important role in oxidation-reduction (redox) reactions and in scavenging free radicals (Linder and Hazegh-Azam, 1996).

Copper is a critical functional component of a number of essential enzymes known as cuproenzymes which perform the following physiological functions known to be copper-dependent; plays a critical role in cellular energy production by catalyzing the reduction of molecular oxygen (O_2) to water (H_2O), making the enzyme to generate an electrical gradient used by the mitochondria to create the vital energy-storing molecule, ATP (Uauy *et al.,* 1998). It forms part of enzymes which are essential for the formation of strong and flexible connective tissue. This maintains the integrity of connective tissue in the heart and blood vessels and also plays a role in bone formation (Turnlund, 2006).

Cuproenzymes may be helping in iron metabolism since iron mobilization from storage sites is impaired in copper deficiency (Turnlund, 2006; Harris, 1997). A number of reactions essential to normal function of the brain and nervous system are catalyzed by cuproenzymes, for exampleneurotransmitter synthesis (Harris, 1997; FNB, 2001). The cuproenzyme, tyrosinase, is required for the formation of the pigment melanin which plays a role in the pigmentation of the hair, skin, and eyes (Turnlund, 2006). Some cuproenzymes work as antioxidants by catalyzing the conversion of superoxide radicals (free radicals) to hydrogen peroxide, which can subsequently be reduced to water by other antioxidant enzymes(Johnson *et al.,* 1992).

Adequate copper nutritional status appears to be necessary for normal iron metabolism and red blood cell formation. Copper is required for iron transport to the bone marrow for red blood cell formation (Turnlund, 2006). Copper is known to play an important role in the development and maintenance of immune system function. Adverse effects of insufficient copper on immune function appear most pronounced in infants. Infants with severe copper deficiency, suffer from frequent and severe infections (Failla and Hopkins, 1998).

One of the most common clinical signs of copper deficiency is anaemia that is unresponsive to iron therapy but corrected by copper supplementation. Copper deficiency may also result in abnormally low numbers of white blood cells. Other abnormalities of bone development related to copper deficiency are most common in copper-deficient low-birth weight infants and young children. Less common features of copper deficiency may include loss of pigmentation, neurological symptoms, and impaired growth (Turnlund, 2006; Uauy *et al.,* 1998).Copper deficiency also causes edema, skeletal defects, rheumatic arthritis, heart disease, ruptured blood vessels, HIV and AIDS (WHO, 1996).

Withania somnifera and *Bryophyllum pinnatum* which are ayurvedic Indian medicinal plants showed levels of copper as 3.87 and 7.54µg/g respectively (Ram, 2010). Copper concentration in *Momordica charantia* was found to be 21.00mg/kg, *Spondias mombin* 13.00mg/kg, whereas in *Vernonia amygdalina* leaves the concentration was 11.00mg/kg (Ayoola *etal.,* 2010).Leaves and roots of *Ajuga bracteosa* indicated the concentration of Cu as 0.37and 0.23 mg/100g respectively, (Ahmed and Chaudhary, 2009).This disparity in the levels may be due to the fact that the uptake pattern of various elements depends upon various factors, which include synergetic/antagonistic behavior of various elements, nature of aquatic conditions affecting the ecological conditions, pH related changes, seasonal variations among others (Ahmed and Chaudhary, 2009; Järup, 2003).

A report on some medicinal plants from Koibatek, Kenya indicated the levels of Cu in stem barks of *Osyris lanceolata* and *Prunus africana* as 10.12±5.36 and 9.45±4.00 mg/kg respectively (Cherop, 2009).Reddy and Reddy(1997) reportedCu contents in 50 medicinally important leafy material growing in India to be ranging from17.6 to 57.3 mg/kg.

Recommended daily allowances for adults is in the range of 1.5 to 3.0 mg (Mindell and Mundis, 2004). The tolerable upper intake level for adults is about 10,000 µg and between 1000 to 500 µg for children (Mindell and Mundis, 2006).WHO (1996) recommended the lower limit of the acceptable range of Cu as 20 mg/kg body weight per day (Waston, 1993). The permissible limit set by FAO/WHO (FAO/WHO, 1984) in edible plants was 3.00 mg/kg. Although the limits for Cu in medicinal plants have not yet been established, permissible limits for Cu set by China and Singapore, were 20 and 150 mg/kg respectively (WHO, 2005).

Copper toxicity is rare in the general population. Symptoms of acute copper toxicity include abdominal pain, nausea, vomiting, and diarrhea, which help prevent additional ingestion and absorption of copper. More serious signs of acute copper toxicity include severe liver damage, kidney failure, coma, and death (FNB, 2001).Good sources of Cu include sea foods, dried beans, peas, whole wheat and shrimp (Gerrior and Zizza, 1994).

2.5.4 Ironin human health and levels in plants

It is a key element in the metabolism of almost all living organisms. In humans, it is an essential component of hundreds of proteins and enzymes (Wood *et al.,* 2006; Beard and Dawson, 1997). Heme is an iron-containing compound found in a number of biologically important molecules. Hemoglobin and myoglobin are heme-containing proteins. They are involved in the transport and storage of oxygen (Yip and Dallman, 1996; Brody, 1999). Cytochromes are heme-containing compounds which are vital in mitochondrial electron transport; therefore, cytochromes are critical to cellular energy production and thus life. They serve as electron carriers during the synthesis of ATP, the primary energy storage compound in cells (Yip and Dallman, 1996).

Catalase and peroxidases are heme-containing enzymes that act as antioxidant hence protecting cells against the accumulation of hydrogen peroxide which is a potentially damaging reactive oxygen species (ROS); by catalyzing a reaction that converts hydrogen peroxide to water and oxygen (Yip and Dallman, 1996; Brody, 1999). Ribonucleotide reductase is an iron-dependent enzyme that is required for DNA synthesis (Beard and Dawson, 1997; Fairbanks, 1999). The element is thus required for the making of new cells of amino acids, of hormones and of neurotransmitter, growth, reproduction, healing and immune function (Whitney and Hamilton, 1987; Van der Strate, 2001). The high levels of Fe may be responsible for its action against cough may be as a result of a compromised human immune system (Van der Strate, 2001).Vitamin A supplement has beneficial effects on iron-deficiency anaemia and improves iron status among pregnant women and children. The combination of vitamin A and iron seems to be more effective in ameliorating anaemia than either iron or vitamin A alone (Suharno *et al.*, 1993).

Concentration levels of iron in *Artemisia absinthium(*wormwood) and *Taraxum officinale* (dandelion) were found to be 4.59 mg/l and 77.70 mg/l respectively (Simona *et al.*, 2011). According to Fatima *et al.* (2005), levels of Fe in some vegetables and seeds used as medicinal plants indicated that *Gymnema sylvestre* had 1.4068 mg/g, *Allium sativum* had 0.1320 mg/g while *Momordica charantia* had levels of 0.1723 mg/g.*Hypericum perforatum* L., *Achillea millefolium* L., *Urtica dioica* L. and *Betula pendula* Roth have shown levels of 7.56±1.16 mg/g, 20.79±0.81mg/g, 667.01±0.95 mg/g and 18.41±0.56 mg/g of dry weight(Konieczyński, and Wesołowski, 2007).Fe, Ni, Mn and Ca are useful in constipation, milk elevation and skin diseases. The recommended daily allowance of Fe is 10.0 to 15.0 mg for adults and 30 mg for pregnant women (Krayenbuehl *et al.*, 2005).

Iron is potentially toxic because free iron inside the cell can lead to the generation of free radicals that cause oxidative stress and damage to the cells. It is thus important for the body to regulate iron homeostasis systemically. The body regulates the transport of iron throughout various body compartments, such as developing red blood cells, circulating macrophages, liver cells that store iron, and other tissues (Anderson *et al.*, 2007).

2.5.5 Magnesium in human health and levels in plants

Magnesium plays important roles in the structure and the function of the human body. The adult human body contains about 25 grams of magnesium. Over 60 % of all the magnesium in the body is found in the skeleton, about 27 % is found in muscle, 6 to 7 % is found in other cells, and less than 1 % is found outside of cells (Shils, 1997).

Magnesium is involved in more than 300 essential metabolic reactions (Spencer *et al.*, 1994). For example, the metabolism of carbohydrates and fats to produce energy requires numerous magnesium-dependent chemical reactions (Rude and Shils, 2006). Magnesium is required for the active transport of ions like potassium and calcium across cell membranes. Through its role in ion transport systems, magnesium affects the conduction of nerve impulses, muscle contraction, and normal heart rhythm. Calcium and magnesium levels in the fluid surrounding cells affect the migration of a number of different cell types. Such effects on cell migration may be important in wound healing (Rude and Shils, 2006).

A study reported that zinc supplements of 142 mg/day in healthy adult males significantly decreased magnesium absorption and disrupted magnesium balance (Spencer *et al.*, 1994).Large increases in the intake of dietary fiber have been found to decrease magnesium utilization in experimental studies. Inadequate blood magnesium levels are known to result in low blood calcium levels, resistance to parathyroid hormone action, and resistance to some of the effects of vitamin D (Rude and Shils, 2006; FNB, 1997).

Prolonged diarrhea, malabsorption syndromes, celiac disease, surgical removal of a portion of the intestine, and intestinal inflammation due to radiation may all lead to magnesium depletion. Magnesium supplementation is traditionally used to correct deficiency states or avoid deficiency in people at increased risk, such as people with malabsorption syndromes and chronic alcoholics. *Diabetes mellitus* and long-term use of certain diuretics may result in increased urinary loss of magnesium.

Poor dietary intake, gastrointestinal problems and increased urinary loss of magnesium may contribute to magnesium depletion, which is frequently encountered in alcoholics. Intestinal magnesium absorption tends to decrease with age and urinary magnesium excretion tends to increase with age; thus, suboptimal dietary magnesium intake may increase the risk of magnesium depletion in the elderly (FNB, 1997).Some of the later effects of magnesium toxicity, such as lethargy, confusion, disturbances in normal cardiac rhythm, and deterioration of kidney function, are related to severe hypotension. As hypermagnesemia progresses, muscle weakness and difficulty in breathing may occur. Severe hypermagnesemia may result in cardiac arrest (Rude and Shils, 2006; FNB, 1997).

The levels of magnesium in *Artemisia absinthium*(wormwood) and *Taraxum officinale* (dandelion) were 708.05 and 728.14 mg/l respectively (Simona *et al.*, 2011).Magnesium concentration in leaves of *Croton macrostachyus* from different areas in Ethiopia varied from 2961±32 to 271±2 μg/g. For example, Dilla *Croton* leaves had the lowest Mg concentration of 271±2 μg/g while Akaki *Croton* leaves had the highest concentration at 2961±32 μg/g. Mg concentration of Abomsa and Bonga *Croton* leaves varied from 1361±54 to 384±29 μg/g (Aregahegn, 2010).Samples of *Carica papaya* leaves (green, yellow and brown) collected randomly from Ogbomoso town, Oyo state, Nigeria and analysed for levels of Mg, indicated that the levels of Mg were 67.75, 28.55 and 35.35 mg/kg respectively (Ayoola and Adeyeye, 2010).Previous studies have indicated that Mg is one of the most abundant elements in many medicinal plants (Piotr*et al.,* 2007). Its concentration level in plants depends to a large extent on type of soil (Imelouane *et al.,*2011). However, uptake of magnesiumby root cells is much lower than the uptake potassium (Reddy and Reddy, 1997).

2.5.6 Potassium in human health and levels in plants

Potassium is an essential dietary mineral and body's principal intracellular electrolyte. Normal body function depends on tight regulation of potassium concentrations both inside and outside of cells (Peterson, 1997). Potassium is the main positively chargedion (cation) in the fluid inside of cells, while sodium is the principal cation in the fluid outside of cells. Potassium concentrations are about 30 times higher inside than outside cells, while sodium concentrations are more than ten times lower inside than outside cells (Whitney *et al.,* 1991). The large proportion of energy dedicated to maintaining sodium/potassium concentration gradients emphasizes the importance of this function in sustaining life.

Tight control of cell membrane potential is critical for nerve impulse transmission, muscle contraction, and heart function (Sheng, 2000; Brody, 1999). A limited number of enzymes require the presence of potassium for their activity. The activation of sodium, potassium-ATPase requires the presence of sodium and potassium. The presence of potassium is also required for the activity of pyruvate kinase, an important enzyme in carbohydrate metabolism (Sheng, 2000).

Increased potassium intake is associated with decreased risk of stroke (Ascherio *et al.*, 1998). However, modest increase in fruit and vegetable intake (rich sources of dietary potassium), especially in those with hypertension and/or relatively low potassium intakes, could significantly reduce the risk of stroke. Potassium bicarbonate supplementation decreases urinary acid and calcium excretion, resulting in increased biomarkers of bone formation and decreased biomarkers of bone resorption(Sebastian *et al.*, 1994).

The leaves of *Bryophylum pinnatum*and *Aspilia africana* have been reported to have mean K levels of0.03±0.10 and 0.04±0.11mg/100 g of dry weight respectively (Okwu and Josiah, 2006). Dildar and Chaudhary (2009) reported levels of K in leaves and roots of *Ajuga bracteosa* as 139.2 and 159.4 mg/100g respectively.Faizul *et al.* (2012) reported concentrations of K in root of *Paeonia emodi* as 33.38 mg/L and fruit of *Punica granatum* as 55.19mg/L. According to Özcan and Akbulut (2007), K is the most abundant metal constituents in plants. The levels of K were also found to be 0.51 mg/kg in leaves of *Vernonia amygdalina*, 0.81 mg/kg in leaves of *Momordica charantia*and 1.2 mg/kg in leaves of *Spondias mombin,*according to Ayoola *etal.*(2010).Potassium ionusuallyhas a high rate at which it is taken up by plant tissues and its absorption depends on the soil type (Imelouane *et al.*, 2011). High K concentrations can interfere with Na retention, absorption and Mg utilization (Underwood, 1981).Faizul *et al.*(2012) reported levels of K in fruit of *Punica granatum* as 55.19 mg/L and root of *Paeonia emodi* as 33.38 mg/L while Sadia *et al.* (2011) showed levels of K in leaves of *Mangifera indica* and *Tagetes minuta* as 24 and 80 ppm respectively.

Toxicity could result from the overuse of potassium salt especially in an infant or a person with heart disease (Sizer and Whitney, 2003). Abnormally elevated serum potassium concentrations are referred to as hyperkalemia. Hyperkalemia occurs when potassium intake exceeds the capacity of the kidneys to eliminate it. Acute or chronic renal (kidney) failure, the use of potassium-sparing diuretics, and insufficient aldosterone secretion (hypoaldosteronism) may result in the accumulation of excess potassium due to decreased urinary potassium excretion. The sudden deaths that occur during fasting or severe diarrhea and in children with kwashiorkor or people with eating disorders are believed to be caused by heart failure as a result of potassium loss (Sizer and Whitney, 2003). Potassium availability is of a greater concern than potassium deficiency. However the body protects itself from toxicity as best as it could (Whitney *et al.*, 1991).

2.5.7 Sodium in human health and levels in plants

Sodium is the cation in the compound sodium chloride and in some other salts. Sodium (Na^+) and chloride (Cl^-) are the principal ions in the fluid outside of cells (extracellular fluid), which includes blood plasma. As such, they play critical roles in a number of life-sustaining processes (Harper *et al.*, 1997).

Sodium helps to maintain the body’s fluid balance. It is also essential for nerve transmission, muscle contraction and cardiac function (Brody, 1999; Sheng, 2000; Whitney *et al.*, 1991). Sodium is the primary determinant of extracellular fluid volume, including blood volume, a number of physiological mechanisms that regulate blood volume and blood pressure work by adjusting the body's sodium content. Its retention results in water retention and sodium loss results in water loss (Sheng, 2000; FNB, 2004). In response to a significant decrease in blood volume or pressure (such as serious blood loss or dehydration), the kidneys release enzymes which act to increase the reabsorption of sodium and the excretion of potassium. Retention of sodium by the kidneys increases the retention of water, resulting in increased blood volume and blood pressure (Sheng, 2000).

Sodium deficiency does not generally result from inadequate dietary intake, even in those on very low-salt diets (FNB, 2004). The National Research Council (NRC) recommendations advise limiting daily salt intake to less than 6 g (2400 mg sodium). This is about 1 teaspoon of sodium per day (Whitney *et al.*, 1991). The low levels of Na in these medicinal plants may be advantageous to hypertensive patients considering the direct relationship of sodium intake with hypertension in human beings (Njoku and Akumefula, 2007).Higher sodium intake causes blood pressure to increase and reduced intake causes it to decrease (Denton *et al.*, 1995). Excessive intakes of sodium chloride lead to an increase in extracellular fluid volume as water is pulled from cells to maintain normal sodium concentration(Chobanian and Hill, 2000).

The levels of Na recorded in *Brassica rapa* (Turnip)root were reported to be more than 10000 µg/g while in berries of *Pipper nigrum* (Black pepper) the levels were 269.4 µg/g (Mahwash *et al.*, 2011) while in leaves of *Bryophylum pinnatum* and *Aspilia africana* the mean levels were 0.02±0.11and 0.02±0.10 mg/100 g of dry weight respectively (Okwu and Josiah, 2006).According to Javid *et al.* (2009), the levels of Na in locally formulated herbal medicines from *Allum sativum* and *Zingiber officinalis* were 8.44 and 9. 33 mg/kg respectively. Ahmed and Chaudhary (2009) reported Na levels in leaves and roots of *Ajuga bracteosa* as21.4and 28.6 mg/100g respectively whileaccording to Gjogieva *et al.*(2011) mean Na levels were 23.11±0.29 mg/kg in *Taraxacum officinale* and 457.59±1.02 mg/kg in *Matricaria recutita*.The low levels of Na medicinal plants may be advantageous to hypertensive patients considering the direct relationship of sodium intake with hypertension in human beings (Njoku and Akumefula, 2007).

2.5.8 Zinc in human health and levels in plants

Zinc is one of the most abundant essential trace metals in human and is found in all tissues and body fluids with zinc content of the human body (70 Kg) in the range of 1.4 to 2.3 g (William and Caliendo, 1988) with estimated average daily dietary Zn intake being 15 mg/day in adults but is slightly higher for nursing mothers. About 0.2 mg/day of Zn is obtained from water (National Academy of Science, 1998). Zinc is a trace element required as a co-factor by more than 200 enzymes (Grodner *et al.*, 2000). The highest concentration of Zn occurs in the eyes, male sex organs, liver and kidneys. It is also present in the plasma, erythrocytes, leucokocytes and platelets.

Zinc is essential for proteins and synthesis of cells' genetic material DNA and RNA (Sizer and Whitney, 2003). It helps the pancrease with its digestive functions, helps metabolize carbohydrate, protein and fat, liberate vitamin A from storage in the liver and dispose of damaging free radicals (Sizer and Whitney, 2003). Adding a little zinc to the diet could reduce the duration of diarrhea attack by 20-30% and could stop up to 38% of cases from ever happening at all (Fox, 1998). Zinc could also reduce respiratory infections such as pneumonia by up to 45% and malaria cases by 35% (Fox, 1998).

Zinc also softens the effects of the common cold, boosts the immune system (Hambidge *et al.,* 1986). Zinc helps in the formation of insulin that is responsible for maintaining blood glucose level. It reduces the incidence of opportunistic infections for example pneumonia in HIV and AIDS patients by up to 45 % (Kabi, 2004). Food intake, stress situations such as fever, infection, and pregnancy lower plasma zinc concentrations whereas, for example, long-term fasting increases it (Agett and Favier, 1993). However, on a population basis, reduced plasma zinc concentrations seem to be a marker for zinc-responsive growth reductions (Brown *et al.,* 1998). Zn has been used to manage sickle-cell anaemia. Patients with sickle cell disease have been observed with zinc deficiency syndromes and some measure of success has been recorded in the use of natural products such as zinc in the management of sickle cell anaemia (Zemel *et al.*, 2002; Prasad, 2002).

Zinc deficiency can result to poor learning ability in children as a result of impaired neuropsychological function (Grodner *et al.,* 2000). Zinc deficiency cause poor wound healing, arteriosclerosis, infertility (men), prostate hypertrophy and difficulties with parturition (women). Zinc deficiency diseases include diabetes, anaemia, kidney disease, prostate cancer and cardiovascular disease (Janet, 2000). Zinc deficiency in alcoholics causes dermatitis and thinning of the hair (Walsh *et al.*, 1994). Zinc deficiency symptoms include; white spots on fingernails, slow hair growth, reduced sense of smell, spotty skin and love for salt in food. A nutritional therapy involving zinc has been shown to improve sperm counts and sperm motility (Sinclair, 2000). Zinc may improve sexual performance and its deficiency can lead to impotence (Takihara *et al.,* 1987). Leaves and roots of *Annona senegalensis*, *Costus afer* and *Cissus populnea*have been found to be rich in zinc (IZINCG, 2004).

Muchemi (2006) reported mean Zn levels in lemon grass, ginger and garlic of 33.30, 23.32 and 24.68 mg/kg respectively while Cherop (2009) reported Zn levels in *Carica papaya*as 5.50 mg/kg. The mean levels of Zn were also determined in *Hypericum perforatum* L., *Achillea millefolium* L., *Urtica dioica* L. and *Betula pendula* Roth and the levels of the mineral were found to be47.02±4.70, 42.74±2.67, 51.23±1.5and 103.36±2.60 mg/g of dry weightrespectively (Konieczyński, and Wesołowski, 2007).Ghebremeskel *et al.* (1990) reported levels of Zn in *Carissa edulis* and *Euclea divinorum*3.9 and 6.0 mg/kg respectively. Ayoola *et al.* (2010) reported Zn levels to be 59.60 mg/kg in *Spondia mombin*, 74.50 mg/kg in *Vernonia amygdalina* and 364.8 mg/kg in *Momordicacharantia.*According to Subramanian *et al.* (2012), the levels of Zn in leaves of *Murrya koenigii* L. were 6.94±0.91 mg/kg, *Solanum nigrum* L., 8.53±0.29 mg/kg and *Trigonella foenumgraecum* L, 9.85±2.54 mg/kg. The curative properties of *Vernonia lasiopus* may be attributed to the presence of these metabolites and Zn.The anthraquinones in *Aloe* species breakup residue, pus and lifeless cells, enhances blood circulation to the region and flush out material from the wounds and ulcers (Ejele and Njoku, 2008).

Zinc has a relatively low order of toxicity compared with most other trace elements. Long term ingestion of zinc higher than what the body requires could affect metabolism of other trace elements. High intake of zinc inhibits copper absorption by inducing metallothionein production. However, high doses of zinc in supplemental form apparently interfere with the absorption of magnesium. Zinc supplements of 142 mg/day in healthy adult males significantly decreased magnesium absorption and disrupted magnesium balance (Spencer *et al.*, 1994).Zinc toxicity occurs at levels exceeding 1,000 mg and effects include vomiting, nausea and impaired immune function (Mindell and Mundis, 2004). Acute Zn intoxication leads to renal failure following haemodialysis; characterized by nausea, vomiting, fever and severe anaemia.Best natural sources of zinc include liver, sea food, brewer’s yeast, pumpkin seeds and leafy vegetables.

2.6 Medicinal plants

Some of the medicinal plants studied are discussed briefly under the following sub-sections.

2.6.1*Aloe secundiflora* and its medicinal uses

Aloe secundiflora Engl. (Plate 2.1) is a succulent, perennial herb, without stem or with stem up to 30 cm long, usually solitary, sometimes suckering to form small groups.

Plate 2.1:*Aloesecundiflora*Engl. growing around Chuka town
Family:Liliaceae

It belongs to the Liliaceae family. The Meru community calls it “Kithunju”. It is generally known that almost all *Aloe* species are used medicinally where they exist. *Aloe* species are widely used in rural areas to treat a variety of ailments (Sachedina, 1998). The leaves of *A. secundiflora* are applied to wounds to assist healing. The leaf sap is drunk as an appetizer and anti-emetic. Diluted leaf sap is drunk as a cure for malaria, typhoid fever, diarrhoea, oedema, swollen diaphragm, nosebleed, headache, pneumonia, chest pain and as a disinfectant. The exudate is applied into the eyes, to cure conjunctivitis. The Meru community uses the *Aloe secundiflora*to treat malaria, pneumonia, wounds, chest pains, chicken diseases, arthritis and rheumatism.

It has been reported that when *Aloe* is able to re-balance the regulating gastrointestinal motility, increase stool specific gravity and decrease stool transit leading to curing of diarrhoea (Bland, 1985). The bitter exudate is applied to nipples to wean children. The leaves are pounded and added to drinking water for preventing or treating coccidiosis and newcastle disease in poultry. Alcohol and aqueous extracts of *Aloe vera*has been found to exhibit anti-sickling activities in patients with sickle cell disease (Ejele and Njoku, 2008).

The sap of *Aloe* contains anthraquinones, a phenolic compound that has stimulating effects on the bowels and antibiotic properties. They help with absorption from the gastro intestinal tract and have anti-microbial and pain killing effects. The anthraquinones in *Aloe* species breakup residue, pus and lifeless cells, enhances blood circulation to the region and flush out material from the wounds and ulcers (Ejele and Njoku, 2008). The structure shown in Figure 2.1 is for anthroquinone.

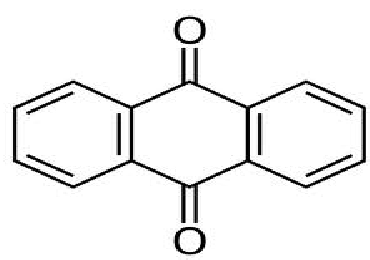


Figure 2.1: Structure of anthraquinone

Levels of minerals have been reported in *Aloe barbadensis* (*Aloevera*) as K (2.9 – 4.9 %; Ca, 3.5 – 5.0 %and Mg, 1.48 – 1.55 %of dry weight) respectively (Sahito *et al.*, 2003).

2.6.2*Anthocleista grandiflora* and its medicinal uses

Anthocleista grandiflora L. (Plate 2.2) is a large tree of moist forests in the eastern and southeastern African tropics.

Plate 2.2: *Anthocleista grandiflora* L. growingin Mt Kenya forest
Family: Gentianaceae

It belongs to the Gentianaceae family. The Meru community calls it “Murigurigu”. The tree has a number of medicinal uses. Bark is used traditionally to treat malaria, as an anthelmintic (specifically for roundworm) and in treating diarrhoea, diabetes, high blood pressure and venereal diseases (Mabogo, 1990). The bark and roots of this herb are also used to treat stomach cramps. Further north on the continent, epilepsy is remedied with the aid of bark decoctions (Neuwinger, 2000). Levels of mineral elements in this medicinal plant have not been reported.

2.6.3*Bauhinia tomentosa* and its medicinal uses

Bauhinia tomentosa (Linn) (Plate 2.3) is a large evergreen tree belonging to the family of Caesalpiniacea.

Plate 2.3:*Bauhiniatomentosa* L. growingaround Chuka town
Family: Caesalpiniaceae

The Meru community calls it “Mukuura”. Certain *Bauhinia* species have a long history of traditional medicinal applications. It has been valued in Ayurveda and Unani system of medication for possessing variety of therapeutic properties (Valdir, 2009). Most of the plants parts are used in traditional system of medicine in India. According to Ayurveda all the part of the plant is recommended in the combination with other drugs for the treatment of snake bite and scorpion-sting. In the case of snakebite, the fresh seeds are made into a paste with vinegar and applied externally to the part bitten. On Malabar Coast, a decoction of the root bark is administered in inflammation of the liver. A decoction of the root bark is prescribed for liver problems. The bruished bark is externally applied to tumors and wounds (Kumar *et al.*, 2011). There is traditional use of *B. tomentosa* roots as a vermifuge (Nadakarni, 2005; Kirtikar and Basu, 1999) and as a mouth gargle (Ganesan, 2008).

A previous study revealed that *Bacillus* species pathogens which are agents of food poisoning are sensitive to crude extracts of *B. tomentosa* roots (Sleigh and Timbury, 1998). Extracts from *B. tomentosa* roots are also effective for the treatment of infections associated with microorganisms causing candidiasis, which are frequent opportunistic pathogens in AIDS patients (Cowan, 1999).The antimicrobial activity of ethylacetate extracts from *B. tomentosa* roots might be related to the presence of flavonoids. Flavonoids are known to exhibit antimicrobial activity through formation of a complex with the bacterial cell wall (Mason and Wasserman, 1987). There is no evidence of studies conducted on levels of minerals present in *B. tomentosa.*

Chemical analysis of leaf meal and processed seed flours of *B. tomentosa* as a nutritional potential for animals showed variation in the concentration of minerals. The concentarion of Na, K, Ca and Mg in the whole raw seed of the plant were 12.0, 8.9, 6.8and 4.5 g/kg respectively and when roasted, the concentration of the minerals were 5.9, 6.0, 3.0 and 1.7 g/kg respectively (Agbede, 2007).

2.6.4*Bidens pilosa* and its medicinal uses

Bidens pilosa Linn (Plate 2.4) also known as Spanish needle, is a medicinal plant found in the family Asteraceae. It grows up to 1 meter in height.

Plate 2.4: *Bidens pilosa* L.growingaround Mt Kenya forest
Family: Asteraceae

In some tropical habitats, *B. pilosa* Linnis considered a weed. However, in some parts of the world it is a source of food or medicine (Grubben and Denton, 2004). For example, in sub-Saharan Africa, the tender shoots and young leaves are used fresh as vegetable or dried as a leaf vegetable, particularly in times of scarcity.

It is referred to as “Mucege” among the Meru community. *Bidenspilosa* has been used as a folk remedy in many third-world countries for years. Wounds, colds and flu, fever, hepatitis and jaundice, glandular sclerosis, rheumatic conditions, neuralgia, smallpox, colic, diarrhoea, diuretic, pain, snake bite, conjunctivitis, anaemia, haemorrhage and rectal prolapse are just a few of many traditional uses of this herb (Benhura and Chitsiku, 1997; Sundararajan *et al.,* 2006; Nguelefack *et al.,* 2005). The Meru community uses the plant to treat coughs, eye inflammation, malaria, ringworms, fresh cuts, athlete foot and gonorrhea.

The plant sap is applied to burns in Tanzania. In Nigeria, the powder or ash from the seed is used as a local anaesthetic and rubbed into cuts. The Giriama community from the coastal areas of Kenya use a leaf extract to treat swollen spleens in children. Pharmacological and phytochemical studies performed on *B.pilosa,* have shown antimicrobial, anti-helminthic, anti-malaria, protozooicide and anti-ulcerogenic properties (Geissberger and Sequin, 1991; Oliveira *et al.,* 2004).The seeds of *B.pilosa* are known to be excellent for stomach ulcers. This weed is rich in minerals and especially calcium which is the great healer for stomach ulcers, iron and zinc, as well as beta-carotene (Orech *et al.,* 2007).

Bidens pilosa has been one of the most promising and potent botanical anti-malarials, with a very high rate of reduction of parasitaemia in *in vitro* cultures of *Plasmodiumfalciparum,* the most deadly malarial strain, as well as other less dangerous types of malaria (Krettli *et al.,* 2001). A survey of plants traditionally used in Trinidad and Tobago found that *B. pilosa* was commonly used in the management of hypertension and diabetes (Lans, 2006). An *in vitro* study of ten medicinal plants used in Colombian folk medicine, which included *B. pilosa,* showed that this herb was active against several strains of bacteria including *Bacillus cereus* and *Escherichia coli*, outstripping the performance of Gentamycin sulfate. It was also active against *Staphylococcus aureus* (Rojas *et al.,* 2006).

Levels of some minerals in *B. pilosa*were reported in mg/100 g dry weight asNa, 0.05; K, 3.2; Ca, 2.0; Mg, 0.6; Fe, 98.6; Zn, 51 and Cu, 24 (Adeolu*et al.,* 2011).Otieno (1992) reported mineral contents in *B. pilosa* inmg/100g as Mg (41.71±1.563); Ca, 9101.0±3.782); K (474.1±3.587); Na (66.06±0.763); Zn (0.773 ±0.067) and Fe (13.51±0.020) whileBenhura and Chitsiku(1997) reported mean levels of Ca, Fe and Zn to be 7.60±0.08, 1.38±0.01 and 1.60±0.07 mg/kg respectively in *B. pilosa*which isalso said to contain beta-carotene.

2.6.5*Caesalpinia volkensii* and its medicinal uses

Caesalpinia volkensii Harms (Plate 2.5) belongs to the Caesalpiniaceae family.

Plate 2.5:*Caesalpiniavolkensii*Harms growingin Mt. Kenya forest
Family: Caesalpiniaceae

It is native to Ethiopia, Kenya, Uganda and Tanzania. *C. volkensii* is used in Kenya and Tanzania to treat malaria. The Meru community refers to it as “Mujuthi”/ “Muchuthi”. The Meru community uses the seeds and leaves of this medicinal plant to treat malaria. In the area around Nairobi (Kenya), over 60% of the herbalists prescribe a decoction of the leaves of *C. volkensii* to cure malaria, sometimes alone, but more often mixed with other plants (Schmelzer *et al.*, 2008). The leaf decoction is also taken to fight pains during pregnancy. Pregnant women take powdered pods dissolved in water to relieve stomachache. Roots are eaten cooked, raw or as addition to palm wine for their aphrodisiac properties. They are also used for treatment of gonorrhea and bilharzia (Schmelzer *et al.,* 2008).

Seeds are used to cure stomache ulcers. Flower buds are crushed and applied to the eye to treat eye problems. *Caesalpinia volkensii* has been reported to be effective against malaria, pain during pregnancy, aphrodisiac and retinoblastoma (Kokwaro, 2009). *Caesalpinia volkensii* has been found to exhibit antiplasmodial activities (Irungu *et al.*, 2011;Ochieng *et al.,* 2011). Chemical assessment shows that it contains seven furanoditerpene; voucapan-1, 5-diol, deoxycaesaldekarin D, voucapane, voucapan-5-ol, deoxycaesaldekarin C, caesaldekarin C, 5-hydroxy vinhaticoic acid and three cinnamyl esters viz triacontanyl-(*E*)-ferulate, triacontanyl-(*E*)-caffaete and 30-hydroxytriacontanyl-(*E*)-ferulate (Ochieng *et al.*, 2011).

2.6.6 *Carica papaya* and its medicinal uses

*Carica papaya*L. (Plate 2.6) is referred to as “Mubabai”in the Meru community. It belongs to the Caricaceae family.

Plate 2.6: *Carica papaya* L. tree growing around Chuka town
Family: Caricaceae

There are two types of paw-paw, the male and the female. The male doesn't bear fruits and it is more medicinal than the female. Everything about paw-paw is useful, from the root to the leaves are all medicinal.

Papaya seeds have anti-parasitic effect on intestinal worms such as roundworms (Kermanshai, 2001). The Meru community also uses the seeds of *C. papaya* in removing worms while the roots are used for treating gonorrhea and syphilis. The seeds have a peppery taste and can be dried in a dehydrator then ground in a mortor and pestle and used as a pepper (Papaya Australian, 2007). A decoction prepared from yellow pawpaw leaves help to overcome malaria fever. The primary use of papaya leaf is that of a vermifuge, it contains tannins that the fruit does not have, helping to protect against reinfection. Naturally, ripe fruit of *C. papaya* is a good source of calcium and an excellent source of vitamin A and C (Nakasone and Paull, 1998). In fact the vitamin C content in *C. papaya* is much higher than in either tomatoes or oranges (Benson and Poffley, 1998). When green unripe *C. papaya* fruit is peeled, seeded and cooked, it is used in a variety of savoury Asian dishes including pickles and chutneys and for canning in sugar syrup (Morton, 1997).

The papaya fruit is valued for its proteolytic enzymes that help digest proteins, remove intestinal worms and other parasites. Papain, a protein-digesting enzyme in *C. papaya* aids the digestion of the proteins and other foods, and is used commercially as meat tenderizer (Duke, 1984).The white milky sap of the unripe paw-paw contains a high percentage of papain which has a wide variety of medical and veterinary applications such as in drug preparations for various digestive ailments, in the preparation of vaccines, for deworming cattle, in treatment of gangrenous wounds, ingredient in the skin ointments for hard skin, for reducing fever and adhesions after surgery (Morton, 1987). Papaya fruit reduces urine acidity in humans (Duke, 1984). Smoke from burning dry pawpaw leaves is inhaled during an attack of asthma. This immediately relieves the patient. To prevent an attack, the smoke is inhaled every night.

According to Ayoola and Adeyeye(2010), levels of Ca in green leaves, yellow and brown of *Carica papaya*were; 8612.50, 3762.50 and 4362.50 mg/kg respectively while Mg levels were 67.75, 28.55 and 35.35 mg/kg respectively in those varieties of leaves.Marisa (2006) reported Fe, Zn and Cu contentsto be 0.29±0.03, 0.09 ±0.00 and 0.11±0.01 mg/100g respectively in *C. papaya*fruit and contents of K, Ca, Mg and K as 89.7±5.4, 9.8±0.7, 19.2±1.4 and 5.6 mg/100g respectively in the same while Mwangi (2012) reported mean levels of K as 243.50±0.87 µg/g); Ca (185.50±0.58µg/g) and Mg (41.00±0.17 µg/g) in *C. papaya*leaves.

2.6.7 *Carissa edulis* and its medicinal uses

Carissa edulis (Forssk) Vahl (Plate 2.7) belongs to the Apocynaceae family.

Plate 2.7: *Carissa edulis* (Forssk) Vahlgrowingaround Kaanwa
Family: Apocynaceae

It is a scrambling shrub, often climbing into adjacent vegetation, or small spiny evergreen tree, 2-5m. Leaves are opposite dark fresh green above and paler below. Flowers are white tinged with purple and 18 mm long. Fruits are almost rounded to oval containing white latex; purple to black when ripe. The Meru community calls it “Mukawa”.

The Meru community uses the roots of this medicinal plant to treat malaria, pneumonia, chest pains, colds, cough, stomachache, paining joints, worms and asthma while among the Luo community, the root decoction from *C. edulis* is used for treating measles (Geissler *et al.*,2002). The herb is also used in the treatment of headache, malaria, fever in children, gonorrhoea, syphilis, rabies and as a diuretic (Abate and Debdabe, 1989). The ripe fruits are used in treatment of dysentery and gastrointestinal problemswhile decoction from the roots is used for treating chronic chest painsalso helps to cure dysentery and diarrhea (Maundu, 1999).

Chemical compounds that have been extracted from the roots of *C. edulis* include Benzenoids (such as 2-Hydroxyacetophenone)and sesquiterpenes (such as carissone) (Bentley and Brackett, 1984). Aqueous extract of root of *Carissa edulis* (Forssk) Vahl shows an anti-viral activity and is also used as a diuretic; a drug which increases the formation of urine and thus remove excess extra cellular water from oedematous tissue. The methanol and aqueous extracts of the medicinal planthas shown good anti-plasmodial activity (Kirira *et al.*, 2006). The methanolic extract from the root of *C. edulis* contains about 5% sesquiterpenes. Isolated compounds are carissone, cryptomeridiol and β-eudesmol (Achien-Yibach *et al.*, 1985).

Fruits of *Carissa edulis* have been found to be rich in K and Fe (Musinguzi *et al.*, 2007). Trace element content analysis of*C. edulis* indicated the presence of various minerals at varied concentrations in µg/gincluding; Se (4.1), Cu (0.7), Zn (3.9), Fe (9.8), Mn (1.3), Cr (0.8) Co (1.7), Mo (0.03) and Al (2.7) (Ghebremeskel, 1991).

2.6.8*Croton macrostachyus* and its medicinal uses

Croton macrostachyus Hochst. Ex Del. (Plate 2.8) is commonly known as rushfoil or broad-leaved Croton (English)(Gidey *et al.*, 2007).

Plate 2.8: *Croton macrostachyus* Hochst. Ex Delilearound Kiang'ondu
Family:Euphorbiaceae

The Meru community refers to it as "Muntuntu". It belongs to the Euphorbiaceae, a very large family with 300 genera and 8,000 to 10,000 species, and is the most numerous in the tropics (Heywood, 1993). The genus contains over 1,200 species, which are distributed throughout the world (Berry, 2000). The most common *Croton*species is *C. macrostachyus* (Gilbert, 1995). *Croton macrostachyus* is a deciduous tree 3-25 m high, although more commonly 6-12 m high.

Many parts of the *C. macrostachyus* have medicinal value. Among the Meru community, the medicinal plant is used in treating wounds, cough, cold, cleansing digestive and blood circulation system. Boiled leaf decoction is drunk or ashes taken orally as treatment for cough while juice from fresh leaves is applied on wounds to hasten clotting. Bark from the stems and roots are boiled in water and newly born babies are bathed in the mixture as a remedy for skin rash (Orwa *et al.*, 2009). Roots are used as an anthelminthic for tapeworm, for malaria, venereal diseases, as antidiabetic, and the seeds are widely used as purgative, for constipation and asantihelminthic. Croton oil has been used in traditional Chinese medicine. It has active ingredient used as facial-rejuvenating chemical peels when used in a phenol-based solution since it has a caustic exfoliating effect on the dermal layer of the skin (Njoroge and Bussmann, 2007; Tedeg *et al.*, 2005).

The genus *Croton* is rich in terpenoids (diterpenoids and triterpenoids), alkaloids, flavonoids, lignoids, proanthcyanidins and volatile oils containing monoterpenoids, sesquiterpenoids and someshikimate-derived compounds (Salatino *et al.*, 2007). Previous studies showed the existence of crotin (a chalcone), lupeol (a triperpene), crotepoxide (a cyclohexane diepoxide), proteins, fatty acids, saponins, resins and alkaloids (Salatino *et al.*, 2007).

According to Aregahegn (2010), *C. macrostachyus* have been found to contain Ca, Mg, Fe and Zn, Cu, and Cr and their mean concentrations in µg/g were reported as 5976±37, 1361±54, 329±7.1, 34.5±2.6, 8.20±0.70 and 81.5±2.2 respectively while Kadima(2012) reported Cr levels in *Croton machrostachyus* to be below detection limits. According to Mwangi (2012), *C. macrostachyus* had the following mean levels in µg/g: K (170.83±0.60), Ca (193.83±0.73) and Mg (30.33±0.17).

2.6.9*Eucalyptus saligna*and its medicinal uses

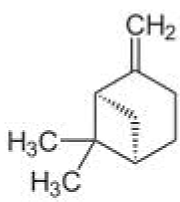
*Eucalyptus saligna*Sm. (Plate 2.9)is known as the Sydney blue gum and belongs to the Myrtaceae family.

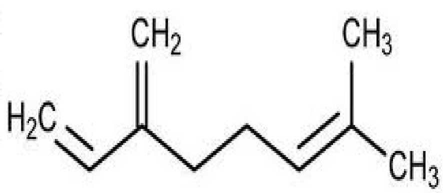
Plate 2.9:*Eucalyptussaligna* Sm.between Kaanwa and Chuka town
Family: Myrtaceae

The Meru community refers to it as "Mubau". This medicinal and aromatic plant is widely used against lung diseases like expectorants and against cough(Ghisalberti, 1996). The Meru community uses it in treating chicken pox, cold, fever, toothache and measles.

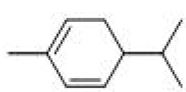
It is also a highly effective remedy against asthma, bronchitis and pneumonia (Fortin *et al.,* 1997). The*E. saligna*has antituberculosis properties (Goldstein *et al.,* 1990; Ngugen *et al.,* 1994) and essential oil obtained from the plant has antifungal properties. The plant is also used as a source of anti-malarial remedies in other parts of Africa (Iwu, 1993) and also in other parts outside the African continent (Milliken, 1997). Beside the antimicrobial and antifungal activity of this medicinal plant, it has also demonstrated analgesic and anti-inflammatory activity (Silva *et al.,* 2003). Several species of *Eucalyptus* are used in folk medicine as an antiseptic and againstinfections of the upper respiratory tract, such as cold,influenza and sinus congestion (Harborne and Baxter,1995).

Chemical composition of essential oil found in *E. saligna* are isoamyl isobutyrate, hydrocarbons monoterpens such as α-pinene, camphene, β-pinene, myrcene, α-phellandrene, p-cymene and γ-terpinene; oxygenated monoterpens such as 1,8-cineole, α-pinen oxide, fenchol, campholenal, E-pinocarveol, pinocarvon, borneol, terpinen-4-ol and α-terpineol; hydrocarbons sesquiterpens such as aromadendrene, Z-β-farnesene, β-bisabolene, Z- α- bisabolene and germacren B, oxygenated sesquiterpens such as elemol, spathulenol, cubenol and γ-eudesmol (Dongmo *et al.,* 2008). The essential oil shows antifungal activity and this is attributed to the oxygenated compounds (Griffin and Wyllie, 1999).Figures 2.2 (a), (b), (c), (d) and (e) show some examples of structures of hydrocarbons monoterpens.

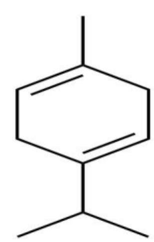




(a) β-pinene **(b) Myrcene**



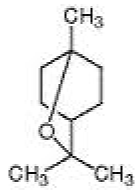
(c) α-phellandrene



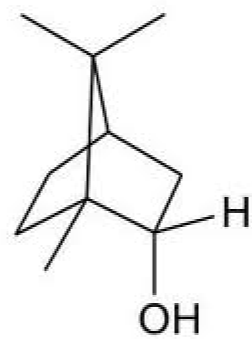
(d): γ- terpinene

Figure 2.2: Structures of hydrocarbons monoterpens.

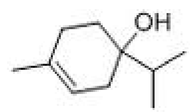
Some examples of structures of oxygenated monoterpens are shown in Figure 2.3.



(a) 1, 8-cineole



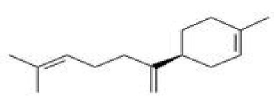
(b): Borneol



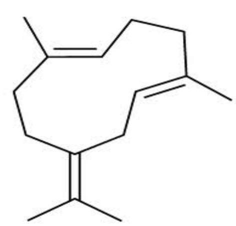
(c): Terpinen-4-ol

Figure 2.3: Structures of oxygenated monoterpens

Figure 2.4 (a), and (b) shows some examples of structures of hydrocarbons sesquiterpens.



(a)β-bisabolene



(b): Germacren B

Figure 2.4: Structures of hydrocarbons sesquiterpens.

2.6.10*Euclea divinorum*and its medicinal uses

Euclea divinorum Hiern. (Plate 2.10) is a shrub or small tree up to about 6 m tall, often branching from the base or sometimes with a single stem. Bark grey, fairly smooth in young trees but fissured in older specimens.

Plate 2.10:*Euclea divinorum* Hiernbetween Kaanwa and Chuka
Family**:** Ebenaceae

It belongs to the Ebenaceae family. The Meru people refer to it as "Mumanku". *Euclea divinorum* is used as a medicinal plant for dental hygiene, treatment of malaria, and for general strength and wound care. The Meru community uses the medicinal plant to treat stomachache, malaria, constipation and cough. They also use it as anthelmintic. In more traditional Maasai communities the plants used to cure diseases served mainly as strong purgatives and emetics; they "cleanse" the body and digestive system from polluting substances (Fratkin, 1996).The fruits of this medicinal shrub are edible and are also used in making beer. In East Africa the bark is used in the preparation of fatty-meat and milk soups. The roots are chewed to impart a red colour to the mouth. *E. divinorum* is also used for treatment of gonorrhoea (Balemie *et al.*, 2004). Root decoction of *E. divinorum* is used for toothache while its branches are used as chewing sticks for oral care (Homer *et al.*, 1990).

The root decoction and fruits are said to be strongly purgative while the bark infusion is used as an appetizer. The root is used in the production of black floor mats and a purple ink made by boiling the fruit (Cunningham and Milton, 1987).*E. divinorum* has been reported to contain 2-methylnaphthazarin which exhibits antiplasmodial activity against CQ- resistant strain (Ng'ang'a, 2012). Levels of mineral elements in*E. divinorum*have been reported in µg/g; Se (6.7), Cu (1.1), Zn (6.0), Fe (11.9), Mn (0.8), Cr (0.7) Co (1.6), Mo (0.03) and Al (4.2) (Ghebremeskel, 1991).

2.6.11*Iboza riparia*and its medicinal uses

Iboza riparia(Hochst.) N.E. Br. (Plate 2.11) is an indigenous, winter-flowering shrub that grows to about 1.5 metres tall.

Plate 2.11:*Iboza riparia* (Hochst.) N. E. Br. around Chuka town

Family: Lamiaceae

It belongs to the Lamiaceae family. The species name, *riparia*, shows that it grows naturally on river banks. The Meru community calls it “Mwaraka”. *Iboza* is super easy to grow from cuttings and can grow up to around 80 cm a year.

Ibozariparia has been effectively used in traditional African medicine as a highly powerful anti-microbic agent. The leaves are picked during the growing season and used fresh or dried in infusions, or crushed when fresh as an inhalation. The leaves contain the strongest anti-microbic substance other than the anti-fungal and some anti-malarial properties. Traditional Zulu uses of the leaves include treating respiratory complaints, malaria, flu, mouth ulcers, diarrhea, and also as an inhalant for headaches (Brown, 2001).

In Rwanda, *I. riparia*isused to treat mainly fever, cough and respiratoryproblems, stomach ache, diarrhea, dropsy, *angina pectoris*, malaria, yaws,headache, toothache and as an antibiotic (Puyvelde Van*et al.*, 1988). The leaf of this plant contains diterpene diol, for example 8(14), 15-sandaracopimaradiene-7 α, 18-diol which exhibits significant antimicrobial activity against several bacteria and funga. It also contains diterpenes such as ibozol, 7α -hydroxyroyleanone, 8 (14), 15-sandaracopimaradiene-7α,18-diol (Puyvelde Van *et al.*, 1988) and pyrones such as umuravumbolide (Davies-Coleman and Rivett, 1995) and tetradenolide (Campbell, 1997). Leaf of this medicinal plant also contains essential oil (1.9%) of which the main components are: terpineol (22.6%), fenchone (13.6%), fenchyl alcohol (10.7 %), caryophyllene (7.9 %) and perillyl alcohol (6.0 %) (Campbell *et al.*,1997). Concentration of Mg and Cr in the leaves of *I. riparia* was reported to be 6720 mg/kg and 1072 mg/kg (Kabera *et al.*, 2011).

2.6.12*Mangifera indica*and its medicinal uses

Mangifera indica L. (Plate 2.12) is a large evergreen tree, long living, 10-45 m high with a strong trunk and heavy crown. It belongs to the Anacardiaceae.

Plate 2.12:*Mangiferaindica* L.growingnear Mt Kenya forest
Family:Anacardiaceae

The Meru community refers to it as “Muembe”. It is native from tropical Asia. It has been introduced wherever the climate is sufficiently warm and damp and is now completely naturalized in many parts of tropics and subtropics (Ross, 1999).

One of the main parts used for medicinal purposes in *M. indica* is the bark. The Meru community uses the stem bark of mangifera indica to treat pneumonia, cough, chest pain, wounds, stomachache, toothache and as a stabilizer. The extract prepared from the stem bark of *M. indica* is proposed as a nutritional supplement (antioxidant) (Stoilova *et al.*, 2005) which can be effective against age-related oxidative stress in elderly people, an anti-inflammatory and anti-nociceptive (Garrido *et al.*, 2004), and immunomodulatory treatment to prevent disease progress or increase the patient’s quality of life in gastric and dermatological disorders, AIDS, cancer and asthma (Nuñez-Selles, 2005; Garcia *et al.*, 2003).

The dry bark of *M. indica* is believed to be helpful in cases of syphilis (Ross, 1999). The tender leaves of the mango tree are considered useful in diabetes. An infusion is prepared from fresh leaves by soaking them overnight in water and squeezing them well in water before filtering in the morning. This infused water should be taken every morning to control early diabetes.

The bark is used in treating cancer sore, gingivitis, diarrhea and dysentery (Boullard, 2001). The decoction prepared from stem bark is used orally for those with toothache/dental caries (Ross, 1999; Nuñez-Selles, 2005). The mango seeds are valuable in diarrhea and are also considered useful in certain disorders connected with women's reproductive organs. For example, the paste of the decorticated kernel of mango is applied inside the vagina to cure leucorrhoea, virginities, and relax walls due to multiple pregnancies. Aqueous extract from the stem bark is used to treat cancer, diabetes, asthma, infertility, lupus, prostatitis, prostatic hyperplasia, gastric disorders, arthralgies and mouth sores (Nuñez-Selles, 2005). Mangiferin in *M. indica* has a potential as a naturally-occurring chemopreventive agent (Yoshimi *et al.*, 2001).

The *M. indica* L. in three regions has been reported to have mean levels of Na as 63.06±0.78, 65.08±1.28and 60.59±1.69 mg/kg, while Fe levels were 3.70±0.073, 2.86±0.082 and 2.77±0.090 mg/kg in the same regions (Saeed *et al.*, 2010). According to

Abulude *et al*. (2006), mineral contents in *M. indica*showed that Zn, Fe and Cu in *M. indica* seed were 93.50, 92.80 and 4.20 mg/kg respectively.Ayoola (2012) reported levels of Ca, Mg, K and Na in *M. indica* in mg/kg as 2650.00, 26.30, 1365.00 and 931.50 respectively while levels of Fe and Zn were reported as 152.50 and 4.15 mg/kg respectively with levels of Cr and Cu below detection limits.

2.6.13*Prunus africana* and its medicinal uses

Prunus africana (Hook. f.) Kalkman(Plate 2.13) is commonly known as pygeum, bitter almond, red stinkwood, bitteramandel, rooistinkhout, and nuwehout. It belongs to the Rosaceae family.

Plate 2.13:*Prunus africana* (Hook. f.) Kalkmangrowingaround Chuka town
Family: Rosaceae

The Meru community refers to it as mwiria in their local language while the Luo community refers to it as ng'owo. It is an evergreen tree that can reach 24 m with a trunk diameter greater than 1 m. The bark is dark and rugged, the branches are brown and corky and the twigs knobby. The foliage is composed of shiny simple dark green leaves, arranged alternately, and has an aroma of almonds when crushed. The leaf stalks are often pink or red while its white flowers are arranged in clusters (Van Wyk *et al.*, 1997). It is widely distributed in several provinces of Kenya and especially in Mount Kenya forest.

The red or dark brown bark of the tree has a weak aroma of hydrocyanic acid. The bark is extracted with an organic solvent, yielding a lipid and sterol extract. The active ingredients are phytosterols (free and conjugated beta-sitosterol, campesterol); tripterpenoid esters; pentacyclic acids (ursolic, oleanolic, crateaegolic, epimaslinic); and aliphatic alcohols (such as n-tetracosanol and n-docosaonol) and their ferulic acid esters. Bark decoctions are traditionally used in Zulu medicine, while lipid and phytosterol extracts are most commonly used in Europe (Van Wyk *et al.*, 1997).

Traditionally, leaves of *P. africana* are employed as an inhalant for fever, to improve appetite, to treat chest and stomach pain, gonorrhea, inflammations, kidney diseases, urinary tract complains, and in Europe it has become popular for the treatment of benign prostate hypertrophy (Van Wyk *et al.*, 1997; Neuwinger, 2000). Among the Meru community of Chuka, the medicinal plant is used in treating amoeba, typhoid, chest pain, colds, malaria and general body weakness. In modern medicine, stem bark water extract is used to manufacture products used for the treatment of prostate gland hypertrophy (enlarged prostate glands) and more serious conditions of benign prostate hyperplasia, a debilitating ailment common in older men which is eased through the anti-inflammatory effect of *P.africana* extract on prostatic tissue (Breza *et al*., 1998). These extracts have been patented and are being sold in a number of pharmacies (Schipmarn, 2001).

According to Cherop (2009), the mean levels of Zn, Fe, Mn, Cu and Cr in mg/kg were found to be 17.61±6.87, 189.76±88.34, 39.62±18.75, 9.45±4.00 and 12.31±5.47 respectivelyin *P. africana*whileKadima(2012) reported that Cr levels in *P. africana* were below detection limits.

2.6.14*Senna didymobotrya*and its medicinal uses

Senna didymobotrya (Fresen) Irwin and Barneby (Plate 2.14)belongs to the Caesalpinoideae family. It grows to a maximum height of 30-90 cm.

Plate 2.14:*Senna didymobotrya* (Fresen) Irwin and Barnebyaround Mt. Kenya forest
Family: Caesalpinoideae

It is common in deciduous bushland, along lake shores, streams, rivers and other damp localities. The Meru community calls it “Mwinu”.*Senna didymobotrya* leaf is used pharmaceutically in laxative preparations (Hutchings *et al.,* 1996). The Meru community uses it for treating malaria, pneumonia, fever, amoeba, worms, measles, chicken pox, constipation, athlete foot andswellings on the skin. The pastoralists of West Pokot peel the bark, dry the stem and burn it into charcoal. They use this charcoal to preserve milk (Tabuti, 2007) and this may be due to the herb's antioxidant property. The root, bark, leaves and stem of this herb have been found to have a wide range of healing properties. In DR Congo, Rwanda, Burundi, Kenya, Uganda and Tanzania, the root decoction is drunk for the treatment of malaria, fever and jaundice. The powder of the root or leaf mixed in water or a decoction of the fresh parts is taken to treat abscesses of the skeletal muscles and venereal diseases(Tabuti, 2007).

The plant is also indicated for the treatment of fungal and bacterial infections, hypertension, haemorrhoids, sickle cell anaemia, and a range of women's diseases, such as inflammation of the fallopian tubes, fibroids and backache, to stimulate lactation, and to induce uterine contractions and abortion (Tabuti, 2007). It is also used in the treatment of animal diseases such as removal of ticks (Njoroge and Bussmann, 2006). Extracts from twigs of *S. didymobotrya,* show a significant antimalarial activity against *Plasmodium falciparum* (Clarkson *et al.,* 2004).

A number of anthraquinone derivatives have been isolated from the leaves and pods of Senna didymobotrya such as emodin, chrysophanol, physcion and knipholone. Other compounds isolated from the leaves are aloe-emodin, rhein and small quantities of dianthrone emodin, dianthrone aloe-emodin, sennoside B, C and D, catechinic tannins, flavonoids and aloe-emodin B-glucoside (Alemayehu *et al.,* 1996), some of which have antimicrobial and antioxidant activities.

2.6.15*Solanum incanum*and its medicinal uses

Solanum incanum L. (Plate 2.15) belongs to the Solanaceae family. It is a herb or shrub that grows up to 1.8 m in height with spines on the stem, leaves, stalks and calyces, and with velvet hairs on the leaves.

Plate 2.15: *Solanum incanum* L.around Chuka town
Family: Solanaceae

The whole plant which includes leaves, fruits and roots of this herb are used for medicinal purposes. In the Meru community it is called “Mutongu”.

Extracts from *S. incanum* roots are applied orally against sexually transmitted diseases (Kambizi and Afolaya, 2001). The plant*S. incanum* is used in the treatment of stomach disorders, cold and as expectorant (Thirugnanam, 2003). The fruits of *S. incanum* are applied against cutaneous mycotic infections and other pathological conditions. The berries from *S. incanum* herb are effective in the treatment of skin cancer (Son *et al.*, 2003). In Western Ethiopia, the fruit juice of *S. incanum* is used against parasites of live stocks for example in tick control (Regassa, 2000). *S. incanum* (L.) is used in the treatment of cough, cold and as expectorant (Thirugnanam, 2003). The extract of *S. incanum* has tannins and saponins. Saponins are known for their medicinal properties as a natural blood cleanser, expectorant and antibiotics (Kalanithi and Lester, 2001).

Extract of fruits of *S. incanum*have been shown to exhibit methanol have showed a very strong inhibition when tested in vitro for antimicrobial activity (Al-Fatimi *et al.,* 2007). *Solanum incanum* herb displays a superior cytotoxicity in human lung cancer cells (Liu *et al.,* 2004). Ethanol extract of ripe berries have been tested for its growth inhibiting effect with breast cancer cells and the results have been positive (Son *et al.,* 2003).

Auta and Ali(2011) reported mineral levels in fruit of*S. incanum* per 100 g (dry weight) as: P (1085.00 mg), Mg (39.14 mg), K (216.89 mg), Mn (147.78 mg), Cu (256.17 mg), Na (149.34 mg), Fe (326.50 mg) and Ca (15.29 mg) while Gisbert *et al.* (2011) reported mineral composition of *S. incunum* fruit as Na (382 mg/kg), Mg (257 mg/kg, Ca (170 mg/kg), Zn (1.88 mg/kg), Fe (1.34 mg/kg), K (2366 mg/kg) and Cu (0.68 mg/kg) which showed that K content in fruit was highest.

2.6.16*Tagetes minuta* L. and its medicinal uses

Tagetes minuta L. (Plate 2.16) is a species native to southern South America. It belongs to the Asteraceae family.

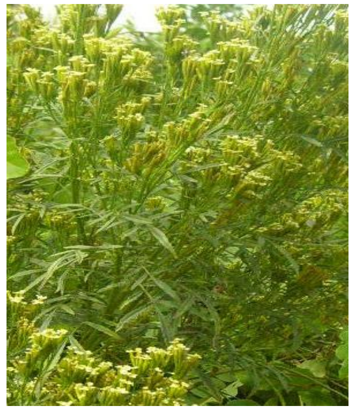


Plate 2.16:*Tagetesminuta* L.found around Nkubu

Family: Asteraceae

The Meru community calls it “Mubangi”. It grows on a broad spectrum of environments starting from extreme temperate to tropical regions of the world. The plant grows to a height of 50-150 cm with a single, highly branched stem at the top.

The Meru community uses the whole plant in treating asthma, toothache and in killing cockroaches and fleas. The Luo community uses the medicinal plant in treating wounds where the whole plant is pounded and applied in wounds (Geissler *et al.,* 2002). The leaves, stems, and flowers of *Tagetes minuta* L. are utilized in a number of areas. In Brazil, it is commercially grown and harvested for its essential oils which are used in the flavor and perfume industry as tagetes oil (Lawrence, 1985). Tagetesoil, which can be extracted with hexane (Wiese *et al.,* 1992), is used in perfumes, and as a flavor component in most major food products, including cola beverages, alcoholic beverages, frozen dairy desserts, candy, baked goods, gelatins, puddings, condiments, relishes and a raw material for perfume production (Soule, 1993).

The oils are good insect repellants and are used in the treatment of certain illnesses, such as smallpox, earache, and colds and to reduce fevers (Mangena and Muyima, 1999). The oil is a rich source of limonene (used as fragrance material for perfuming household products and as component of artificial essential oils), ocimene, dihydrotagetone, tagetone, and tagetenone (Kaul *et al.,* 2005). It has been reported that the concentrations of Na, Ca and Fe in *T. minuta* L. were 208, 109 and 14.3 mg/kg respectively (Sadia *et al.,* 2011).

Although curative properties of medicinal plants are known, studies have concentrated on active organic compounds present in these plants. However, inorganic elements are known to work more effectively when used in combination with organic compounds in treating various ailments. It is in view of this that determination of the levels of these elements in the medicinal plants is important and hence need for this research.

2.7 Analytical techniques for determination of essential elements

There are various techniques that have been employed in the analysis of essential elements. These include atomic absorption spectroscopy (AAS) (Khan *et al.,* 2011), flame atomic absorption spectroscopy (FAAS) (Mwangi, 2012), inductively coupled plasma mass spectroscopy (ICP-MS) ((Kgabi, 2010), inductively coupled plasma atomic emission spectroscopy (ICP-AES) (Popescu *et al.,* 2009), energy dispersive X-ray fluorescence spectroscopy (ED-XRF) (Naziriwo *et al.,* 2010), voltammetric method (Mellucci and Locatelli, 2007) and potentiometric method (Maslarska *et al.,* 2011). For this study FAAS was used for its sensitivity, accuracy, ease of operation and availability.FAES was used for analysis of Na, K and Ca because it is simple, relatively inexpensive and suitable for easily ionized metals.

2.7.1 Principles of atomic absorption spectroscopy (AAS)

The AAS is a method of elemental analysis that works on the principle of absorption of radiation energy by free atoms. The technique requires a liquid sample to be aspirated, aerosolized, and mixed with combustible gases, such as acetylene and air or acetylene and nitrous oxide. The mixture is ignited in a flame whose temperature ranges from 2100 to 2800 $^{\circ}$C. The characteristic wavelengths are element specific and accurate to 0.01-0.1 nm. To provide element specific wavelengths, a light beam from a lamp whose cathode is made of the element being determined is passed through the flame. A device such as photomultiplier can detect the amount of reduction of the light intensity due to absorption by the analyte, and this can be directly related to the amount of the element in the sample.

Analytical signal is obtained from the difference between the intensity of the source in the absence of element of interest and the decreased intensity obtained when the element of interest is present in the optical path. Absorption of light is associated with transition process from one steady state to another. For instance, the case of a steady state O and J, where $E_j > E_o$, the O-J transition results in the absorption of light with frequency given in Equation 2.1.

$v = \frac{E_j - E_o}{h}$……………………………………………Equation 2.1

Where;

h = Planks's constant
ν = frequency
E_o = energy at ground state
E_j = energy at excited state
O - J = transitions stimulated by absorption of external radiation

The number of atoms in the excited state relative to the number in the ground state is given by Maxwell - Boltzman law (Skoog *et al.*,2007), given in Equation 2.2.

$\frac{N_1}{N_0} = \frac{g_1}{g_0} \exp \frac{E_g - E_1}{KT}$……………………………………..Equation 2.2

Where

N_1 = Number of atoms in excited state
N_o = Number of atoms in ground state
g_1 and g_o = statistical weight of excited and ground state respectively
K = Boltzman's constant
T = Absolute temperature
E_g = Energy at ground state
E_1 = Energy at excited state

The relative fraction of atoms in the excited state is dependent on temperature whereas intensity is independent of temperature. Sample solution is aspirated through nebulizer into the air/acetylene flame flame or nitrous oxide/acetylene flame (Taylor *et al.,* 2006). An electrically heated graphite furnace is used when very high sensitivity is required. The sample solution gets dispersed into mist of droplets and then gets evaporated into dry salt.

The dry salt goes into vapour then dissociate into atoms that absorb resonance radiation from external source. The unabsorbed radiation is allowed to pass through the monochromator which isolates the existing spectral lines. The isolated analyte line falls on the the detector and the output of which is amplified and recorded. The parameter measured is absorbance (A) and is related to concentration as given by Equation 2.3.

$$A = \log \frac{I_0}{I} = \varepsilon cl \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 2.3}$$

Where,

A = Absorbance
I_o = Incident radiation
I = attenuated radiation
ε = Molar absorptivity (L mol^{-1} cm^{-1})
c = Concentration ($moldm^{-3}$)
I = Path length

Since the relationship between absorbance (A) and concentration (c) is linear over a wide range of concentration (Beer's Law), standards are used to obtain calibration curve from which concentration of analyte is established through interpolation method (Van Loon, 1980). The most important components of atomic absorption spectroscopy (AAS) are:

a) Radiation source

There are two types of radiation sources, namely;

i) Continuous source

The continuous source gives a wide range of radiation and includes deuterium lamp and mercury vapour lamp. It is less sensitive because only a small band of radiation passed by monochromator is absorbed while a large portion falls on the detector.

ii) Hollow cathode source

It is commonly used in atomic absorption spectroscopy (AAS) instrument and made up of metallic or alloy of element of interest. Hollow cathode lamp consists of a tungsten anode and cylindrical cathode sealed in a glass tube that is filled with neon or argon gas at a pressure of 1 - 5 torr. A cathode lamp is a stable light source, which is necessary to emit the sharp characteristic spectrum of the element to be determined. A different cathode lamp is needed for each element, although there are some lamps that can be used to determine three or four different elements if the cathode contains all of them. Each time a lamp is changed, proper alignment is needed in order to get as much light as possible through the flame, where the analyte is being atomized, and into the monochromator.

b) Atomizer

The two types of atomizers are flame and electrothermal atomizers. In flame atomizer, temperature is determined by flow rate and the ratio of oxidant and fuel. In flame atomizer, nebulization of sample solution into a fine aerosol solution, and dissociation of the analyte elements into free gaseous ground state form takes place. Not all the analyte goes through the flame; part of it is discarded.

Dissociation leads to atomic gas whereas some of the atoms ionize to give cations and electrons. In electrothermal atomizer, few molecules of the sample are first evaporated at low temperature and ashed at higher temperature in electrically heated graphite. After ashing, the temperature is increased to 2000-3000 °C to cause atomization of the sample.

c) Monochromators

They are analyzers that present monochromatic radiation to the detector. They are filters, prisms or gratings that disperse or separate radiation so that selected wavelength corresponding to a particular energy of the sample is transmitted. Diffraction gratings are preferred to prisms as they offer accuracy over wide range wavelengths.

a) Detectors

Detectors convert radiation energy into electrical signal and include phototube, photo multiplier tube and photodiode array detectors.

b) Readout system

These are digital and interfaced with microprocessors that allow the programming of various aspects, bringing simplicity in operations. However, AAS is a single elemental method, in which one element is determined in a series of samples and instrumental parameters optimized for the next element. A schematic diagram of equipment used is shown in Figure 2.5.

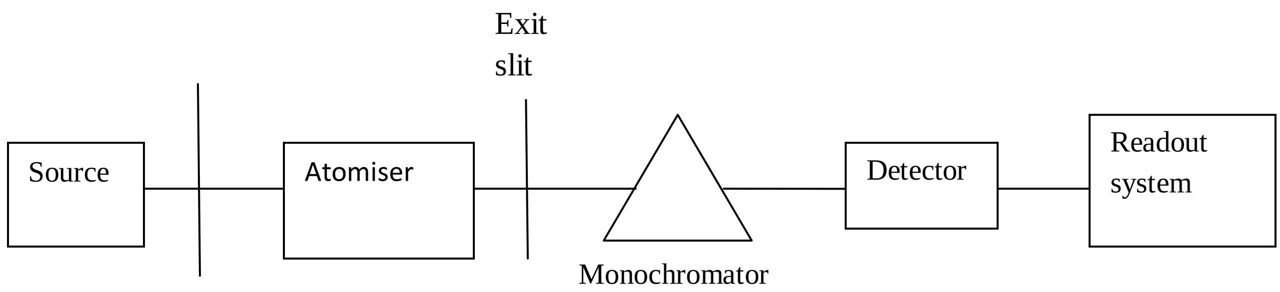


Figure 2.5: Schematic diagram of atomic absorption spectroscopy (AAS)

2.7.2Principles of flame atomic absorption spectrometry (FAAS)

Flame atomic absorption spectrometry is a quantitative analytical method based on measuring the light absorption of free, ground state atoms. The ground state atoms are excited by electromagnetic radiation (light), while absorbing photons having equivalent wavelength with the excitation energy. The absorption spectrum of atoms (similarly to emission spectrum) is line spectrum. The lines are present at exactly determined wavelengths and they have a very small, approximately 0,001 nm full width at half maximum. This type of absorption spectrum of atoms gives the high selectivity of atomic absorption spectrometry. At the best line of a given element the probability of absorption of other elements is very low thus complex systems containing several elements can be analyzed without the separation of elements. This procedure has great advantage to molecule absorption spectrometry methods where there is a higher probability of optical interfering effect due to the band absorption and usually the analysis of complex systems is possible only after the application of separation techniques. With atomic absorption we measure the concentration of free atoms in the atomizing unit. The absorbance is directly proportional to the number of free, ground state atoms in a unit of volume. Furthermore the number of free atoms in the flame is proportional to the concentration of analyte in the solution.

In order to perform atomic absorption measurements the light of the light source producing characteristic, sharp spectrum of the element to be measured should be led through the flame where the aerosol is present in form of fine spray. The narrow range of the spectrum containing the resonance line of the element is separated from the other part of spectrum with a monochromator. The selected resonance line gets to the light sensoring detector (like photomultiplier), of which signal is amplified. To exclude the emitted light of the flame, the light of the light source is chopped with a chopper and in the detector it gives alternating current, while the background radiation of the flame gives direct current.

Elements which have resonance line in the range of the spectrum that can be measured by the detector can be determined with AAS. Most of the instruments can be used in UV and visible range (190-800 nm). Noble gases, halogens and carbon, hydrogen, sulphur, oxygen, nitrogen and phosphorus cannot be determined since the resonance lines of these elements are under 190 nm. The elements of which oxides do not decomposes in flame or which produce oxides or hydroxides in flame can be determined but with difficulty.

2.7.3 Flame atomic emission spectroscopy (FAES)

In atomic emission, a sample is subjected to a high energy, thermal environment in order to produce excited state atoms, capable of emitting light. The energy source can be an electricarc, flame, or plasma. The emission spectrum of an element exposed to such an energy source consists of a collection of the allowable emission wavelengths, commonly called emission lines, because of the discrete nature of the emitted wavelengths. This emission spectrum can be used as a unique characteristic for qualitative identification of the element. Atomic emission using electrical arcs has been widely used in qualitative analysis.Emission techniques can also be used to determine how much of an element is present in a sample. For a "quantitative" analysis, the intensity of light emitted at the wavelength of the element to be determined is measured. The emission intensity at this wavelength will be greater as the number of atoms of the analyte element increases. The technique of flame photometry is an application of atomic emission for quantitative analysis. The photograph of the AAS instrument with FAAS and FAES modes is shown in Plate 2.17.

Plate 2.17 Atomic absorption spectrometer, model: varian spectr AA 10 (2005).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study area

The study area was Chuka town and its environs. The area is in Meru South District. It borders Meru Central to the North-West, Tharaka District to the North-East, Mbeere to the South-East, Embu to the South-West, and Mt. Kenya forest to the West. It lies between longitudes 37° 18' and 37° 28' E and latitudes 0° 7' and 0° 26' S. The topography of the area slopes gently from the west to the east and is influenced by the volcanic activity of Mt. Kenya. Numerous rivers which originate from Mt. Kenya forest traverse the district and flow eastwards as tributaries of Tana River, which discharge its water into the Indian Ocean. The area has deep red loam soil and has a bi-modal rainfall pattern with rains falling during the months of March to May and October to December. The upper areas experience reliable rainfall while middle areas, medium rainfall and lower regions unreliable and poorly distributed rainfall. Temperatures in the highlands range between 14 and 17 °C while those of the lowlands between 22 and 27 °C.

3.2 Research design

Descriptive survey by use of questionnaire and experimental design were employed in this study as explained in the following subsequent subsections.

3.2.1 Questionnaire

The study involved a descriptive survey by use of standard questionnaire to establish the common medicinal plants and the parts of the plants used for medication. The respondents aged 25 years and above were randomly selected. Questionnaires were administered and the respondents were expected to fill them accurately. Those who could not fill the questionnaires were guided through by a language interpreter.

3.2.2 Plant materials

A total of 19 common medicinal plants were collected randomly. They were then identified by a plant taxonomist based on the information obtained from the questionnaires and taken to the National Herbarium for confirmation.

3.2.3Analysis of selected essential elements

The experimental part of the research design involved analysis of selected essential elements in the commonly used medicinal plants which were nineteen. However, some of the medicinal plants had more than one part used for medication. For this reason, 22 samples were prepared in triplicate from the 19 medicinal plants. Analysis of the selected essential elements in the specified plant samples was also done in triplicates using flame atomic absorption spectroscopy (FAAS) and flame emission spectroscopy (FAES) accordingly.

3.3 Cleaning of glassware and sample containers

All glassware used were washed in detergent then soaked with 10% analytical grade nitric acid for 24 hours. They were then rinsed in tap water followed by distilled de-ionized water, dried in the oven at 105 $^{\circ}$C and stored in clean and dry drawers under lock and key. The plastic bottles were cleaned with detergent and tap water. They were then soaked in 1:1 nitric acid overnight and rinsed thoroughly with distilled de-ionized water.

They were then dried on an open rack and stored safely in clean and dry drawers under lock and key.

3.4 Chemicals

All the reagents used in this research were of analytical grade. These included analytical grade nitric acid and hydrogen peroxide solutions which were obtained from Thomas Baker Chemicals Ltd. Mumbai India whereas zinc, copper, iron, magnesium, chromium, calcium carbonate, sodium chloride and potassium chloride were purchased from Fluka Chemie GmbH Aldrich chemical company, inc. USA.

3.5 Preparation of standard solutions

During the elemental analysis, standard solutions for each element were freshly prepared from stock solutions using serial dilution. The standards were prepared from stock solutions each time an analysis was to be carried out, using serial dilution Equation 3.1.

$$c_1 v_1 = c_2 v_2 \qquad \text{Equation 3.1}$$

Where;

C_1 = Original concentration
C_2 = New concentration
V_1 = Original volume
V_2 =New volume

3.6 Sample size of the respondents and medicinal plants

The sample size to determine the number of respondents that were interviewed was calculated using Equation 3.2 by Daniel (1999).

$$n = \frac{z^2 p(1-p)}{d^2}$$ ……………………………………………..Equation 3.2

Where n = sample size

z = the number relating to the level of confidence (for the level of confidence of 95 percent which is conventional, z value is 1.96.

p = expected prevalence or proportion of one; if 80 percent, p = 0.80

d = precision (in proportion of one; if 12.5 percent, d = 0.125

$n = 1.96^2 \text{ x } 0.80 (1 - 0.80)/0.125^2$

$= 39$

The study area comprised of three ecological zones; the upper Chuka (Kiang'ondu), the middle Chuka (Chuka town) and the lower Chuka extending to Kaanwa. 117 respondents were interviewed which included elders, traditional healers and men and women of 25 years and above randomly selected. 19 common medicinal plants were identified and were used to prepare 22 samples based on the parts of the plants used. Each medicinal plant was obtained in triplicate.

3.7 Sampling and sample pre-treatment

The sampling sites consisted of three ecological areas; Upper Chuka (forest), Middle Chuka (Chuka town) and lower Chuka (extending to Kaanwa). Each medicinal plantwas collected randomly and in triplicate. The samples were eventually collected which comprised of leaves, roots and stem barks of the medicinal plants obtained by cutting them using a panga and a jembe accordingly. They were mixed thoroughly and carried in polythene bags to the laboratory. They were then washed carefully and thoroughly using tap water to remove foreign matter and rinsed in de-ionized water (Sidney, 1984). They were spread to dry in the air at room temperature under clean dry conditions.

The leaves of the plants were ground into a fine powder using a blender model number CT/ 404, put in transparent polythene bags and kept in lockable cupboards under lock and key. The stem barks and roots were ground in a Wiley mill and kept in labeled transparent polythene bags. They were then stored in clean and dry drawers under lock and key awaiting further treatment and analysis.

3.8 Digestion procedures

A mass of 1.000 g portion of each ground sample was weighed accurately using an electronic analytical balance and put in clean dry conical flasks. 8.0 cm^3 concentrated analytical grade nitric acid was added to each flask in a fume chamber. The mixture was then subjected to wet digestion using an electric digester. The mixture was left to cool and 2 drops of 30 % hydrogen peroxide was added to the reaction mixture. Further heating was done until white fumes were formed and a clear solution obtained. The sample solution was left to cool, and then filtered using Whatman filter papers (125mm Ø). The filtrate was transferred into 100 ml volumetric flasks. The conical flasks were rinsed with deionised water and content poured into the filtering mixture and transferred into the volumetric flask. Volume up to 100ml of the volumetric flask was made with deionised water. The filtrate were transferred into dry plastic vial tubes, closed, labelled and kept in the lockable cupboard. The same procedure was repeated for all the other samples. The blank used to zero the instrument was prepared in the same way as the samples.

3.9 Method validation

Standard questionnaires were prepared and validated to attest their accuracy and reliability. They were administered to 20 respondents in the same region prior and their response analysed to ascertain their accuracy and reliability in achieving set objectives. The procedure and method for the experimental analysis was validated by use of matrix spikes. The sample was spiked with 5 ppm of the analyte and allowed to undergo similar procedure as the sample. The % recovery was calculated using the formula in Equation 3.3.

$$\% \text{ recovery} = \frac{\text{SSC} - \text{USC}}{\text{CSS}} \times 100 \text{------------------------------------Equation 3.3}$$

Where; SSC: Spiked sample concentration
USR: Unspiked sample concentration
CSS: Concentration of spiked standard

3.10 Sample analysis

This study analysed selected essential elements in various parts ofmedicinal plants of Chuka community. The selection of these medicinal plants was based on their popularity in treatment as well as their availability. The AAS instrument used was varian spectr AA 10 (2005) which had the FAAS and FAES modes. The choice of the mode depended on the parameters to be analysed.The analysis of Zn, Fe, Cr, Cu, V,Ca and Mg were done using FAAS while Na and K were analysedusing FAES. The analysis was done in replicates under the same conditions as standards and blanks. For better precision, standards were measured before and after the sample solutions. The blank solution was measured between standards and samples to ensure stability of the base line. The operating conditions of the FAAS are given in Table 3.1.

Table 3.1 The FAAS/FAES operating conditions

Operating Parameters	Cu	Fe	K	Mg	Na	Cr	Zn	Ca
Wavelength (nm)	324.7	248.3	766.5	285.2	589.0	357.9	213.9	422.7
Slit width (nm)	0.2	0.2	0.5	0.5	0.2	0.2	0.2	0.2
Flame type	Air/ acetylene	Air/ Acetylene	Air/ propane	Air/ acetylene	Air/ Acetylene	Air/ acetylene	Air/ acetylene	Air/ acetylene
Oxidant flow rate (L/min)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

3.11 Statistical treatment of data

The raw data was processed using SPSS. One way ANOVA was used to test the hypothesis of the research study. A post ANOVA was done to determine whether mean concentrations of the selected essential elements were significantly different from one another.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Method validation

The results obtained from method validation were used to determine the reliability and consistency of analytical results.

4.1.1 Linear ranges of calibration curves

The linear ranges of the obtained calibration curves were determined by considering concentration ranges of the linear portions. Provided in Table 4.1 herein is the range of the concentration of the standards (mg/kg) along the linear portions of calibration curves for the selected essential elements in the medicinal plants.

Table 4.1 Concentration of standards and linear ranges of calibration curves

Element	Linear range (mg/kg)	Concentration range of standards (mg/kg)
Na	0.02 - 10.00	2.00 - 10.00
K	0.00 - 10.00	2.00 - 10.00
Ca	0.00 - 10.00	0.60 - 1.20
Mg	0.00 - 5.00	0.40 - 5.00
Zn	0.00 - 5.00	1.00 - 5.00
Fe	0.02 - 10.00	2.00 - 10.00
Cu	0.00 - 10.00	2.00 - 10.00
Cr	0.00 - 1.50	0.50 - 1.50

The results in Table 4.1 indicate that the established calibration curves are linear over a wide range of concentrations. This wide range of concentration was enough to bracket the elemental concentrations of the medicinal plants analysed in this study, and hence the results from the AAS instrument were precise and accurate.

4.1.2 Linearity of calibration curves

To evaluate the linearity of the established calibration curves, regression analysis was used. The absorbance readings and concentrations of ideal standards were used to calculate correlation coefficient (r) values for Zn, Fe, Cr, Cu and Mg while the emission intensity readings and corresponding concentrations of Na, K and Ca were used to calculate their correlation coefficient (r) values. Table 4.2 shows the results obtained.

Table 4.2 Correlation coefficient (r) values of AAS calibration curves

Element	Correlation values (r)
Na	0.99950
K	0.99800
Ca	0.99950
Mg	0.99950
Zn	1.00000
Fe	0.99499
Cu	0.99900
Cr	0.99950

Based on the results in Table 4.2, it can be concluded that the linearity of the established calibration curves are good and that the results are accurate.

4.1.3 Percentage recovery

The results of percentage recovery after “spiking” with 5 ppm of a standard are shown inTable 4.3

Table 4.3 Percentage recovery

Element	Sample conc. (ppm)	Spiked sample conc. (ppm)	% recovery
Na	3.14	8.12	99.6±0.10
K	3.96	8.95	99.8±0.08
Ca	0.48	5.46	99.6±0.20
Mg	0.74	5.73	99.8±0.15
Zn	0.67	5.66	99.8±0.12
Fe	4.65	9.64	99.8±0.10
Cu	0.16	5.14	99.6±0.08
Cr	1.23	6.22	99.8±0.21

From the results in Table 4.3, the results obtained are accurate since they are within acceptable limits ranging between 99-101% (EURACHEM, 2000).

4.1.4 Validation of questionnaires

The questionnaires were validated by giving them to 20 respondents but not the same respondents used in the study. The respondents filled the questionnaires without any problems, an indication that they were well designed and reliable for the study.

4.2 Plant part(s) used in treatment of various ailments by Chuka community

The plant part(s) used by the Chuka community for treatment of human ailments are shown in Table 4.4. The study showed that various plant part(s) are used for treatment of various ailments.

Table 4.4 Plant part(s) used by the Chuka community for the treatment of human ailments

Part (s)	No of times used	%
Leaf	58	35.15
Root	55	33.33
Stem bark	38	23.03
Seed	6	3.63
Latex	3	1.81
Fruit	3	1.81
Others	2	1.21
Total	165	100

From Table 4.4, the most widely used plant part is the leaf accounting for 35.15% of the reported plant parts used for herbal medication followed with roots at 33.33 %. Other parts of the medicinal plants registered the lowest popularity in application at 1.21 %. This shows that the Chuka community mainly uses leaves and roots of medicinal plants in the management and treatment of disease. The use of leaves for medication is better than roots as far as sustainable use and conservation of medicinal plants are concerned since the plants are able to leaf again unlike the use of roots. Apparently, leaf is the most popular of the plant parts used and this is in agreement with reports by Neli *et al.* (2012), Gidey(2010) and Okoli *et al.*(2007). Figure 4.1 illustrates the percentages of the parts used for herbal medication among the Chuka community.

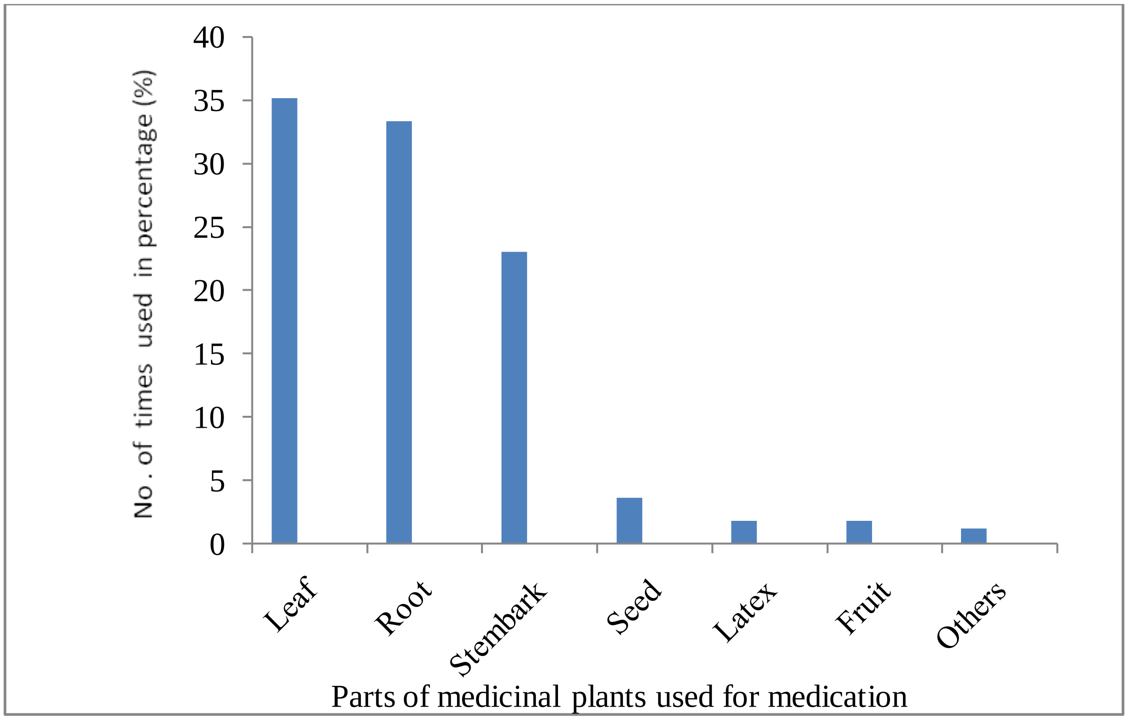


Figure 4.1 Percentages of parts of the medicinal plants used for treatment

4.3 Common ailments treated by medicinal plants from Chuka community

A total of 138 medicinal plants find applications by the Chuka community for treatment of various ailments in humans and animals as indicated in Appendix X. A total of 134 of these medicinal plants are used for treatment of human ailments and this constitutes 97.1 % of the total number of medicinal plants mentioned in this study. Only 2 plants (1.45 %) were used for both human and veterinary diseases. This concurs with report by Ermias *et al.* (2008).A summary of common ailments treated with the medicinal plants from Chuka community has been extracted from Appendix X and this has been provided in Table 4.5.

Table 4.5 Common ailments treated by medicinal plants from Chuka community

S/n	Ailment	No. of times mentioned	%
1	Malaria	40	13.89
2	Cough	33	11.46
3	Cold	22	8.30
4	Chest pain	23	7.99
5	Wound	16	5.56
6	Stomachache	15	5.21
7	Toothache	14	4.86
8	Worms	17	5.90
9	Amoeba	11	3.82
10	Constipation	9	3.13
11	Paining joints	7	2.43
12	Gonorrhea	6	2.08
13	Typhoid	5	1.74
14	Diarrhoea	5	1.74
15	Skin infection	5	1.74
16	Measles	5	1.74
17	General body weakness	5	1.74
18	Arthritis	4	1.39
19	Purification of blood	4	1.39
20	Purification of digestive system	3	1.04
21	Fever	3	1.04
22	Chicken pox	3	1.04
23	Rheumatism	3	1.04
24	Syphilis	2	0.69
25	Sprain	2	0.69
26	Removing thorn	2	0.69
27	Boil	2	0.69
28	flu	2	0.69
29	Asthma	2	0.69
30	Eye infammation	2	0.69
31	Cancer	2	0.69
32	Lung ailment	2	0.69
33	Tuberculosis	1	0.35
34	Heart burn	1	0.35
35	Swollen breast	1	0.35
36	Abortion	1	0.35
37	Appetizer	1	0.35

Table 4.5 continued

S/n	Ailment	Frequency	%
38	Snake bite	1	0.35
39	Scorpion bite	1	0.35
40	Athletes foot	1	0.35
41	Heartache	1	0.35
42	Ear inflammation	1	0.35
43	Blood booster	1	0.35
44	Umbilical cord	1	0.35

From Table 4.5, it can be noticed that human ailments that are commonly treated by the medicinal plants from this region include malaria, cough, chest pains, worms, amoeba, typhoid, stomachache, pneumonia, toothache, constipation, diarrhoea, arthritis, general body weakness and measles, among others. This indicates that the plants have a high medicinal value as reported by Njuguna and Shin-Ichiro (2008); Jamir *et al.* (1999) and Kassaye *et al.* (2006). Common health ailments were malaria (13.89 %), cough (11.46 %), cold (8.30 %), chest pain (7.99 %) and worms (5.90 %). From these results, malaria still remains a big challenge and concern of members of the Chuka community. This is in agreement with reports by Rukunga and Simon (2006), WHO (2008), FAO (1995) and Kabi (2004). Table 4.6 shows common plants in traditional medicine of the Chuka community, parts used and the ailments they treat.

Table 4.6 Medicinal plants in traditional medicine of the Chuka community, parts used and the ailments they treat.

Plant species	Family	Local name	Part (s) used	Ailments
Aloe secundiflora Engl.	Aloaceae	Kithunju	Leaves	Malaria, pneumonia, wounds, chest pains, chicken diseases, arthritis, rheumatism and diarrhoea.
Anthocleista grandiflora L.	Gentianaceae	Murigurigu	Stem bark	chest pains, cold, malaria, amoeba, worms
Bauhinia tomentosa L.	Caesalpiniaceae	Mukuura	Stem bark	cough, malaria
Bidens pilosa L.	Asteraceae	Mucege	Roots, leaves	coughs, eye inflammation, malaria, ringworms, fresh cuts, gonorrhea, athlete foot and diabetes
Caesalpinia volkensii Harms.	Caesalpiniaceae	Mujuthii/mucuthi	Seeds, leaves	Malaria
Carica papaya L.	Caricaceae	Mubabai	Roots, seeds,	syphilis, gonorrhea, lung ailment, worms, amoeba, malaria.
Carissa edulis (Forssk) Vahl	Apocynaceae	Mukawa	Roots	malaria, pneumonia, chest pains, colds, cough, stomachache, paining joints, worms and asthma
Commiphora zimermanii Engl.	Burseraceae	Mutungugu/Mutungururi	Stem bark	coughs , malaria, constipation, stomachache, skin rushes
Croton microstachyus Hochst. Ex Delile	Euphorbiaceae	Mutuntu	Leaves	wounds, cough, cold, cleansing digestive and blood circulation system, bleeding (blood clotting)
Dovyalis abyssinica (A.Rich.) Warb.	Salicaceae	Mukambura	Roots	colds, chest pains, stomachache, cough
Eucalyptus saligna Smith	Myrtaceae	Mubau	Leaves, stem bark	chicken pox, cold, fever, toothache, measles

Cont'
Medicinal plants in traditional medicine of the Chuka community, parts used and the ailments they treat.

Euclea divinorum Hiern.	Ebenaceae	Mumanku	Roots, leaves	stomachache, malaria, worms, constipation, cough
Iboza riparia (Hochst.) N.E. Br.	Lamiaceae	Mwaraka	Leaves	colds and flu, bronchitis, stomach upsets, flatulence, mouth ulcers, diarrhea, and fevers
Mangifera indica L.	Anacardiaceae	Muembe	Stem bark, leaves, fruit	Pneumonia, cough, chest pain, wounds, stomachache, stabilizer and toothache.
Prunus africana (Hook.f.) Kalkman	Rosaceae	Mwiria	Stem bark	amoeba, typhoid, chest pain, colds, malaria, general body weakness, cancer of breast and prostate cancer
Senna didymobotrya (Fresen) Irwin & Barneby	Caesalpiniaceae	Mwinu	Leaves, roots	malaria, pneumonia, fever, amoeba, worms, measles, swellings on the skin, chicken pox, constipation and athlete foot
Solanum incanum L.	Solanaceae	Mutongu	Fruit juice, roots	stomachache, headache, cough, wound, ring worm, amoeba, toothache, diarrhoea, swollen joints, sprains and anti-rabies
Species name	Family	Local name	Part (s) used	Ailments
Tagetes minuta L.	Asteraceae	Mubangi	Leaves	asthma, toothache, cockroaches and fleas
Vernonia lasiopus O. Hoffm.	Asteraceae	Mwatha	Leaves	Amoeba, anti-rabies, tapeworms

4.4 Levels of minerals in medicinal plants by Chuka community

The levels of Na, K, Mg, Ca, Zn, Fe, Cu and Crin 19 common medicinal plants are discussed below.

4.4.1 Sodium levels in medicinal plants

Levels of Na in 22 samples ofmedicinal plantsfrom Chuka analysed in this study are given in Table 4.7.

Table 4.7 Sodium levels (mg/kg) in medicinal plants

Plant species	Part (s) used	Mean±SD n=3	Range
Aloe secundiflora	Leaves	8.41 ± 0.04^{p}	8.37-8.45
Anthocleista grandiflora	Stembark	3.47 ± 0.03^{e}	3.44-3.50
Bauhinia tomentosa	Leaves	2.71 ± 0.02^{a}	2.69-2.72
	Stem bark	2.85 ± 0.02^{b}	2.84-2.87
Bidens pilosa	Leaves	4.34 ± 0.03^{k}	4.30-4.36
Caesalpinia volkensii	Leaves	4.83 ± 0.10^{m}	4.73-4.93
Carica papaya	Seeds	5.32 ± 0.02^{n}	5.30-5.34
Carissa edulis	Roots	3.60 ± 0.02^{g}	3.59-3.62
Commiphora zimermanii	Stem bark	3.45 ± 0.01^{e}	3.44-3.45
Croton macrostachyus	Leaves	5.90 ± 0.10^{o}	5.79-5.99
Dovyalis abyssinica	Stem bark	3.16 ± 0.02^{c}	3.14-3.17
Eucalyptus saligna	Leaves	2.76 ± 0.04^{a}	2.72-2.80
Euclea divinorum	Stem bark	4.52 ± 0.06^{i}	4.47-4.58
Iboza riparia	Leaves & stem	4.26 ± 0.04^{j}	4.21-4.28
Mangifera indica	Stem bark	3.27 ± 0.03^{d}	3.25-3.30
Prunus africana	Leaves	2.72 ± 0.01^{a}	2.71-2.73
	Stem bark	3.83 ± 0.01^{i}	3.82-3.83
Senna didymobotrya	Leaves	3.73 ± 0.06^{h}	3.69-3.79
	Stem bark	3.57 ± 0.04^{fg}	3.53-3.60
Solonum incanum	Roots	4.46 ± 0.02^{i}	4.44-4.48
Tagetes minuta	Leaves& stems	3.51 ± 0.05^{e}f	3.46-3.55
Vernonia lasiopus	Leaves & stems	3.57 ± 0.03^{fg}	3.54-3.59

Mean±SD followed with the same letters within the same column are not significantly different from one another (α=0.05, p>0.05).

From Table 4.7, it can be noted that the levels of Na ranged from 2.69-8.45 mg/kg. *A.secundiflora*(leaves) had the highest mean levels of Na with (8.41±0.04 mg/kg) followed by *C. macrostachyus* (leaves) with mean Na levels of 5.90±0.10 mg/kg and finally *C. papaya* (seeds) with 5.32±0.02 mg/kg. *B. tomentosa* (leaves) had the lowest mean Na levels 2.71±0.02 mg/kg. These mean levels are significantly different at p>0.05 and α=0.05.

The low levels of Na in these medicinal plants concurs with levels reported elsewhere (Javid *et al*., 2009). Javid *et al.* (2009), reported mean levels of Na in locally formulated herbal medicine from *Allium sativum*and *Zingiber officinalis* as8.44 and 9.33 mg/kg respectively. The medicinal plants accumulated low amount of Na and possible reasons for this are provided by Järup(2003);Ahmed and Chaudhary (2009). These low levels of Na may be advantageous to hypertensive patients undertaking treatments for other ailments. Moreover, the use of *M. indica* and *B.pilosa* in management of diabetes may be attributed to these low levels of Na (Njoku and Akumefula, (2007).

4.4.2 Potassium levels in medicinal plants

Elemental analysis was done to determine the levels of K in common medicinal plantsof Chuka community using FAES. A summary of mean levels of K obtained from common medicinal plants from Chuka community is presented in Table 4.8.

Table 4.8 Potassium levels (mg/kg) in medicinal plants

Plant species	Part (s) used	Mean±SD n=3	Range
Aloe secundiflora	Leaves	453.00±2.29^{r}	450.50-455.00
Anthocleista grandiflora	Stembark	28.83±0.58^{c}	28.50-29.50
Bauhinia tomentosa	Leaves	66.00±1.50^{e}	64.50-67.50
	Stem bark	138.83±0.76^{h}	138.00-139.50
Bidens pilosa	Leaves	341.67±3.01^{p}	338.50-344.50
Caesalpinia volkensii	Leaves	196.17±1.26^{j}	195.00-197.50
Carica papaya	Seeds	230.00±1.73^{i}	229.00-232.00
Carissa edulis	Roots	3.83±0.76^{a}	3.00-4.50
Commiphora zimermanii	Stem bark	75.67±5.01^{f}	70.00-79.50
Croton macrostachyus	Leaves	289.00±1.32^{n}	288.00-290.50
Dovyalis abyssinica	Stem bark	9.00±0.50^{b}	8.50-9.50
Eucalyptus saligna	Leaves	77.33±1.04^{f}	76.50-78.50
Euclea divinorum	Stem bark	3.83±0.29^{a}	3.50-4.00
Iboza riparia	Leaves & stem	336.83±0.29^{o}	336.50-337.00
Mangifera indica	Stem bark	1.67±0.29^{a}	1.50-2.00
Prunus africana	Leaves	87.33±1.04^{g}	86.50-88.50
	Stem bark	3.83±1.26^{a}	2.50-5.00
Senna didymobotrya	Leaves	165.67±3.01^{i}	162.50-168.50
	Stem bark	199.67±1.76^{k}	198.00-201.50
Solonum incanum	Roots	47.83±0.29^{c}	47.50-48.00
Tagetes minuta	Leaves& stems	257.00±1.32^{m}	256.00-258.50
Vernonia lasiopus	Leaves & stems	441.67±1.76^{q}	440.00-443.50

Mean±SD followed with the same letters within the same column are not significantly different from one another ($\alpha=0.05$, $p>0.05$).

With reference to Table 4.8, it can be noted that the mean levels of K in these medicinal plants ranged from 1.50-455 mg/kg. *A. secundiflora*(Leaves) had the highest mean levelsof453.00±2.29 mg/kg, followed by*V. lasiopus*(leaves and stem bark)with 441.67±1.76mg/kg.*M. indica*(stem bark)had the lowest mean levels of K (1.67±0.29

mg/kg).The mean levels of K in leaves of *A. secundiflora* and stem bark of *V. lasiopus*are significantly different atp>0.05 and α=0.05. Leaves of *P. africana* had higher mean levels of K (87.33±1.04 mg/kg) compared to the stem bark of the same plant (3.83±1.26 mg/kg) while stem bark of *B. tomentosa* had higher mean levels of K (138.83±0.76 mg/kg) than the leaves of the same plant (66.00±1.50 mg/kg.These mean levels were significantly different at p>0.05 andα=0.05. The mean levels of K in seeds of *C. papaya* in the present study are comparable to values reported by Mwangi (2012) as 243.50±0.87 µg/g in *C. papaya*leaves. The mean levels of K in this study are also comparable to those reported by Faizul (2012) which indicated levels of K in fruit of *Punica granatum* as 55.19 mg/L and root of *Paeonia emodi* as 33.38 mg/L. Sadia *et al.* (2011) showed levels of K in leaves of *Mangifera indica* and *Tagetes minuta* as 24 and 80 ppm respectively. However, the levels of K in bark of *Mangifera indica* in the present study are lower. This could be as a result of the medicinal plant accumulating less potassium. For *Tagetes minuta*, the present study shows that the plant accumulated a higher concentration of K probably due to anthropogenic activities and geo-climatic conditions.

The presence of K in *A. secundiflora* and *S. incanum* may explains their use in inhibiting diarrhoea and hence effective against some disease causing agents and also replenish K lost as reported elsewhere (Bland, 1985). High levels of K in *A. secundiflora, V.lasiopus* and *B. pilosa* may make them be good sources of natural mineral suppliments as reported by Sebastian *et al.* (1994) and Althuis *et al.* (2002).

4.4.3 Magnesium levels in medicinal plants

Levels of Mg in medicinal plants were determined using FAAS. Table 4.9 gives a summary of mean levels of Mg obtained from common medicinal plants from Chuka community using AAS.

Table 4.9 Magnesium levels (mg/kg) in medicinal plants

Plant species	Part (s) used	Mean±SD n=3	Range
Aloe secundiflora	Leaves	163.00±1.00^{n}	162.00-164.00
Anthocleista grandiflora	Stembark	8.83±0.29^{b}	8.50-9.00
Bauhinia tomentosa	Leaves	14.50±1.32^{e}	13.00-15.50
	Stem bark	20.33±0.29^{f}	20.00-20.50
Bidens pilosa	Leaves	30.67±1.76^{i}	29.00-32.50
Caesalpinia volkensii	Leaves	12.17±0.29^{d}	12.00-12.50
Carica papaya	Seeds	40.00±0.50^{k}	39.50-40.50
Carissa edulis	Roots	13.00±0.00^{d}	13.00-13.00
Commiphora zimermanii	Stem bark	12.33±0.29^{d}	12.00-12.50
Croton macrostachyus	Leaves	77.17±1.04^{m}	76.00-78.00
Dovyalis abyssinica	Stem bark	6.00±0.00^{a}	6.00-6.00
Eucalyptus saligna	Leaves	11.50±0.00^{cd}	11.50-11.50
Euclea divinorum	Stem bark	7.67±0.29^{b}	7.50-8.00
Iboza riparia	Leaves & stem	51.55±1.58^{l}	50.00-53.15
Mangifera indica	Stem bark	25.17±1.04^{g}	24.00-26.00
Prunus africana	Leaves	37.17±0.29^{j}	37.00-37.50
	Stem bark	10.50±0.00^{b}	10.50-10.50
Senna didymobotrya	Leaves	24.83±0.29^{g}	24.50-25.00
	Stem bark	19.83±1.04^{h}	19.00-21.00
Solonum incanum	Roots	6.33±0.29^{a}	6.00-6.50
Tagetes minuta	Leaves& stems	28.17±0.58^{h}	27.50-28.50
Vernonia lasiopus	Leaves & stems	26.17±0.29^{g}	26.00-26.50

Mean±SD followed with the same letters within the same column are not significantly different from one another ($\alpha=0.05$, $p>0.05$).

From Table 4.9, it can be seen thatmean levels of medicinal plants in the present study ranged from 6.00-164.00 mg/kg.*A. secundiflora*(leaves) had the highest mean levels of Mg (163.00±1.00 mg/kg), followed by *C. macrostachyus* (leaves) with 77.17±1.04mg/kg. *D. abyssinica*(stem bark) showed the lowest mean levels of Mg (6.00±0.00 mg/kg).Stem bark of *B. tomentosa* had higher levels of Mg (20.33±0.29mg/kg) than leaves of the same plant (14.50±1.32mg/kg) while the leaves of *P. africana* had higher levels of Mg (37.17±0.29mg/kg) than the stem bark of the same plant (10.50±0.00 mg/kg).

The mean levels of stem bark and leaves of *B. tomentosa, P. africana* and *S. didymobotrya* differed significantly at$p>0.05$and $\alpha=0.05$. These mean levels obtained in the study compare favourably with Mg levels in medicinal plants reported elsewhere (Konieczyński and Wesołowski, 2007; Mwangi, 2012;Ayoola and Adeyeye, 2010). Mwangi (2012) reported mean levels of Mg in leaves of *C. papaya* as (41.00±0.17 µg/g).Ayoola and Adeyeye (2010) reported levels of Mg in green, yellow and brown *C. papaya* leaves as 67.75 mg/kg, 28.55 mg/kg and 35.35 mg/kg respectively.

This study shows that Mg is abundant in the medicinal plants and this is in agreement with report by Piotr(2007). The availability of Mg in medicinal plants may be correlated with the use of the medicinal plants in wound healing, malaria treatment and coughs and chest pains as reported by Rude and Shils(2006). This explains the use of *D. abyssinica* in treating lung related diseases such as coughs and chest pains. The use of *A. secundiflora* in treating headache may be as a result of presence of Mg. The combination of the secondary metabolites and Mg must be responsible in their ability to manage health problems. The high levels of Mg particular in *A. secundiflora, C. macrostachyus* and *I. riparia* may make these medicinal plants good sources of natural Mg supplements for human beings.

4.4.4 Calcium levels in medicinal plants

A summary of mean levels of the elements in common medicinal plants of Chuka community is given inTable 4.10.

Table 4.10 Calcium levels (mg/kg) in medicinal plants

Plant species	Part (s) used	Mean±SD n=3	Range
Aloe secundiflora	Leaves	76.00±2.00[h]	74.00-78.00
Anthocleista grandiflora	Stembark	0.22±0.01[a]	0.21-0.22
Bauhinia tomentosa	Leaves	1.55±0.02[de]	1.53-1.56
	Stem bark	2.07±0.01[e]	2.06-2.08
Bidens pilosa	Leaves	1.61±0.04[cde]	1.58-1.66
Caesalpinia volkensii	Leaves	2.49±0.02[e]	2.47-2.51
Carica papaya	Seeds	1.34±0.02[bcde]	1.31-1.35
Carissa edulis	Roots	0.84±0.02[abcd]	0.81-0.85
Commiphora zimermanii	Stem bark	2.16±0.01[e]	2.15-2.17
Croton macrostachyus	Leaves	3.45±0.05[f]	3.41-3.50
Dovyalis abyssinica	Stem bark	0.49±0.02[ab]	0.48-0.51
Eucalyptus saligna	Leaves	1.36±0.05[bcde]	1.31-1.40
Euclea divinorum	Stem bark	2.16±0.03[e]	2.13-2.18
Iboza riparia	Leaves & stem	4.96±0.01[g]	4.95-4.97
Mangifera indica	Stem bark	0.66±0.01[abc]	0.65-0.66
Prunus africana	Leaves	1.97±0.02[e]	1.94-1.98
	Stem bark	0.55±0.02[abc]	0.53-0.57
Senna didymobotrya	Leaves	1.78±0.03[de]	1.75-1.80
	Stem bark	1.84±0.05[de]	1.78-1.88
Solonum incanum	Roots	2.00±0.03[e]	1.98-2.03
Tagetes minuta	Leaves& stems	1.93±0.01[de]	1.92-1.94
Vernonia lasiopus	Leaves & stems	2.07±0.02[e]	2.05-2.09

Mean±SD followed with the same letters within the same column are not significantly different from one another ($\alpha=0.05$, $p>0.05$).

According to Table 4.10, levels of Ca in these medicinal plants ranged from 0.21-78.00 mg/kg. The mean levels of Ca were higher in leaves of *A. secundiflora* (76.00±2.00 mg/kg) compared to the other medicinal plants. Stem bark of *A.grandiflora* showed the lowest level of Ca (0.22±0.01 mg/kg). The levels of Ca in leaves of *S. didymobotrya* were 1.78±0.03 mg/kg while in the stem bark the levels were 1.84±0.05 mg/kg. However, these levels were insignificantly different at $p>0.05$ and $\alpha=0.05$. The mean levels of Ca in these medicinal plants were relatively low except for *A. secundiflora* that had significantly the highest mean level of the mineral. The *A. secundiflora* leaves used for this research were obtained from a garden where they were grown. The anthropogenic activities and geo-climatic conditions among others may have influenced the levels as reported by other researchers (Järup, 2003;Ahmed and Chaudhary, 2009).

Faizul *et al.* (2012) reported levels of calcium in root of *Paeonia emodi* as 66.26±0.00 mg/L and fruit of *Punica granatum* as 1.650±0.00 mg/L. The variation in mean of Ca levels in this study compare with results reported by Faizul *et al.*(2012) and this could be as result of varied uptake of the mineral ion by the medicinal plants. Its availability in the soil as a result of geo-climatic conditions and athropogenic activities may also explain its level in the medicinal plants. The availability of Ca in the plants may be explaining why *S. incunum, C. edulis,* and *A. secundiflora* are important in treating bone related ailments such as swollen joints, paining joints and arthritis. Moreover, the use of

*C.macrostachyus*in stopping bleeding through clotting may be due to Ca as indicated in reports of other researchers (Brody, 1999; FNB, 1997).

4.4.5 Zinc levels in medicinal plants

Table 4.11 gives a summary of mean levels of Zn incommon medicinal plants from Chuka community.

Table 4.11 Zinc levels (mg/kg) in medicinal plants

Plant species	Part (s) used	Mean±SD n=3	Range
Aloe secundiflora	Leaves	4.24±0.06[n]	4.18-4.29
Anthocleista grandiflora	Stembark	0.44±0.00[b]	0.44-0.44
Bauhinia tomentosa	Leaves	0.45±0.01[b]	0.45-0.46
	Stem bark	1.15±0.00[g]	1.15-1.15
Bidens pilosa	Leaves	1.38±0.01[i]	1.37-1.39
Caesalpinia volkensii	Leaves	1.27±0.12[h]	1.14-1.35
Carica papaya	Seeds	1.03±0.01[f]	1.02-1.03
Carissa edulis	Roots	0.86±0.01[e]	0.85-0.87
Commiphora zimermanii	Stem bark	0.67±0.00[d]	0.67-0.67
Croton macrostachyus	Leaves	0.91±0.01[e]	0.90-0.91
Dovyalis abyssinica	Stem bark	0.64±0.00[d]	0.64-0.64
Eucalyptus saligna	Leaves	0.36±0.01[a]	0.35-0.37
Euclea divinorum	Stem bark	0.59±0.00[c]	0.59-0.59
Iboza riparia	Leaves & stem	2.94±0.01[i]	2.93-2.95
Mangifera indica	Stem bark	0.45±0.01[b]	0.45-0.46
Prunus africana	Leaves	1.05±0.01[f]	1.05-1.06
	Stem bark	0.86±0.00[e]	0.86-0.86
Senna didymobotrya	Stem bark	0.88±0.01[e]	0.87-0.88
	Leaves	0.69±0.01[d]	0.69-0.70
Solonum incanum	Roots	2.38±0.03[k]	2.35-2.41
Tagetes minuta	Leaves& stems	1.57±0.00[j]	1.57-1.57
Vernonia lasiopus	Leaves & stems	3.37±0.04[m]	3.32-3.40

Mean±SD followed with the same letters within the same column are not significantly different from one another ($\alpha=0.05$, $p>0.05$).

From Table 4.11, it is observed that the mean levels of Zn in the medicinal plants ranged from 0.35-4.29mg/kg. *A. secundiflora* (leaves) had the highest mean levels of Zn (4.24±0.06mg/kg) followed by *V. lasiopus* (leaves and stem)which had3.37±0.04 mg/kg. *E. saligna*(Leaves) had the lowest mean levels of Zn (0.36±0.01mg/kg). The mean levels of Zn in leaves and stem barks of *P. africana, B. tomentosa* and *S. didymobotrya* were not significantly different at $p>0.05$ and $\alpha=0.05$. According to Subramanian *et al.* (2012), the levels of Zn in leaves of *Murrya koenigii* L. were 6.94±0.91 mg/kg, *Solanum nigrum* L., 8.53±0.29 mg/kg and *Trigonella foenumgraecum* L, 9.85±2.54 mg/kg. These levels are relatively low, just like in the present study. However, they are slightly higher comparedwith levels of Zn in the present study.

Reports by other researchers (Ghebremeskel *et al.*, 1991; Cherop, 2009;Benhura and Chitsiku, 1997)correlate with levels of some medicinal plants in the present study. Benhura and Chitsiku(1997) reported mean levels of Zn to be 1.60±0.07 mg/kg in *B. pilosa*. Cherop (2009) reported Zn levels in *C. papaya*as 5.50 mg/kg whileGhebremeskel *et al.* (1990) reported levels of Zn in *C. edulis* and *E. divinorum*as3.9 mg/kg and 6.0 mg/kg respectively. The variations in the levels of Zn may be due to seasonal variations, anthropogenic activities, soil composition among other reasons (Järup, 2003);Ahmed and Chaudhary, 2009).

The use of *V. lasiopus* in treating malaria could be attributed to the significant level of zinc in the medicinal plant and significant levels of Zn in *A. secundiflora* may explain its wide use against lung diseases like expectorants, cough, asthma, bronchitis, pneumonia, wounds and ulcers. This is supported by reports by other researchers (Fox, 1998; Fortin *et al.*, 1997;Ejele and Njoku, 2008; Ngugen *et al.*, 1994).

4.4.6 Iron levels in medicinal plants

Mean levels of Fe in common medicinal plants from Chuka community analysed in this study are summarized inTable 4.12.

Table 4.12 Iron levels (mg/kg) in medicinal plants

Plant species	Part (s) used	Mean±SD n=3	Range
Aloe secundiflora	Leaves	4.65±0.06[i]	4.59-4.70
Anthocleista grandiflora	Stembark	2.31±0.01[de]	2.30-2.31
Bauhinia tomentosa	Leaves	0.76±0.02[a]	0.74-0.78
	Stem bark	2.44±0.05[ef]	2.39-2.48
Bidens pilosa	Leaves	7.60±0.08[n]	7.51-7.67
Caesalpinia volkensii	Leaves	1.47±0.02[b]	1.45-1.49
Carica papaya	Seeds	3.31±0.06[jk]	3.26-3.37
Carissa edulis	Roots	3.48±0.03[k]	3.45-3.51
Commiphora zimermanii	Stem bark	5.31±0.08[m]	5.25-5.40
Croton macrostachyus	Leaves	2.57±0.03[fg]	2.54-2.60
Dovyalis abyssinica	Stem bark	2.72±0.03[gh]	2.69-2.75
Eucalyptus saligna	Leaves	1.82±0.03[c]	1.79-1.84
Euclea divinorum	Stem bark	20.13±0.31[q]	19.80-20.40
Iboza riparia	Leaves and stems	10.39±0.01[p]	10.38-10.39
Mangifera indica	Stem bark	2.11±0.02[d]	2.09-2.12
Prunus africana	Leaves	1.68±0.02[c]	1.67-1.71
	Stem bark	3.04±0.01[i]	3.04-3.05
Senna didymobotrya	Leaves	3.34±0.02[jk]	3.32-3.35
	Stem bark	3.15±0.04[ij]	3.12-3.19
Solonum incanum	Roots	2.84±0.45[h]	2.56-3.35
Tagetes minuta	Leaves and stems	9.43±0.11[o]	9.33-9.54
Vernonia lasiopus	Leaves and stems	4.78±0.02[i]	4.77-4.81

Mean±SD followed with the same letters within the same column are not significantly different from one another (α=0.05, p>0.05).

From the results presented in Table 4.12, it can be noted that levels of iron ranged from 19.80-20.40 mg/kg. Stem bark of *E. divinorum*had the highest level of Fe (20.13±0.31mg/kg), followed by *Iboza riparia* (10.39±0.01mg/kg). *B. tomentosa* (leaves) had the lowest concentration levels of Fe (0.76±0.02mg/kg). The stem bark of *P.africana* also had higher levels of Fe (3.04±0.01 mg/kg) than the leaves of the same plant (1.68±0.02mg/kg). The mean levels of Fe in stem bark of *B.tomentosa* and *P. africana* were not significantly different at $p>0.05$ and $\alpha=0.05$. *A.secundiflora* and *V. lasiopus* had Fe mean levels of 4.65±0.06 and 4.78±0.02mg/kg respectively. However, these mean levels were insignificantly different. These mean levels compare with those of other medicinal plants reported elsewhere (Simona *et al.*,2011;Fatima *et al.,* 2005; Konieczyński, and Wesołowski, 2007). Simona *et al.* (2011) reported concentration levels of iron in *Artemisia absinthium(*wormwood) as 4.59 mg/l while Fatima *et al.* (2005) reported levels of Fe in *Gymnema sylvestre*as 1.4068 mg/g, *Allium sativum*as 0.1320 mg/g and*Momordica charantia*as 0.1723 mg/g. *Hypericum perforatum* L., *Achillea millefolium* L. and *Betula pendula* Roth have shown levels of 7.56±1.16 mg/g, 20.79±0.81 mg/g and 18.41±0.56 mg/g of dry weight (Konieczyński, and Wesołowski, 2007).

The *E. divinorum* is used in treating cough and malaria. The high levels of Fe may be responsible for its action against cough which may be as a result of a compromised human immune system (Van der Strate, 2001).Given the level of Fe in the analysed samples, it is also evident that some of the medicinal plants in this study such as *E. divinorum* and *A. secundiflora* can serve as sources of iron especially in anaemic patientsand as natural mineral supplement as suggested by other researchers (Sebastian *et al.*, 1994; Althuis *et al.*, 2002).

4.4.7 Copper levels in medicinal plants

A presentation of mean levels Cu obtained from common medicinal plants of Chuka community analysed in this study is inTable 4.13.

Table 4.13 Copper levels (mg/kg) in medicinal plants

Plant species	Part (s) used	Mean±SD n=3	Range
Aloe secundiflora	Leaves	0.15±0.01[bcde]	0.14-0.15
Anthocleista grandiflora	Stembark	0.04±0.01[ab]	0.04-0.05
Bauhinia tomentosa	Leaves	0.15±0.01[bcde]	0.15-0.16
	Stem bark	0.02±0.01[a]	0.01-0.02
Bidens pilosa	Leaves	0.16±0.00[bcde]	0.16-0.16
Caesalpinia volkensii	Leaves	0.20±0.01[cde]	0.20-0.21
Carica papaya	Seeds	0.01±0.00[a]	0.01-0.01
Carissa edulis	Roots	0.07±0.00[abc]	0.07-0.07
Commiphora zimermanii	Stem bark	0.11±0.01[abcd]	0.10-0.11
Croton macrostachyus	Leaves	0.16±0.00[bcde]	0.16-0.16
Dovyalis abyssinica	Stem bark	0.04±0.01[ab]	0.04-0.04
Eucalyptus saligna	Leaves	0.17±0.00[bcde]	0.17-0.17
Euclea divinorum	Stem bark	0.00±0.01[a]	BLD
Iboza riparia	Leaves & stem	0.38±0.00[f]	0.38-0.38
Mangifera indica	Stem bark	0.19±0.23[cdef]	0.05-0.45
Prunus africana	Leaves	0.17±0.00[bcde]	0.17-0.17
	Stem bark	0.07±0.01[abc]	0.07-0.08
Senna didymobotrya	Leaves	0.10±0.00[abcd]	0.10-0.10
	Stem bark	0.01±0.00[a]	0.01-0.01
Solonum incanum	Roots	0.02±0.01[a]	0.01-0.02
Tagetes minuta	Leaves& stems	0.25±0.01[e]	0.24-0.26
Vernonia lasiopus	Leaves & stems	0.22±0.00[de]	0.22-0.22

*BLD means below detection limit

Mean±SD followed with the same letters within the same column are not significantly different from one another (α=0.05, p>0.05)

The mean levels of Cu ranged from 0.01-0.38 mg/kg. Leaves and stem barks of *I. riparia*had the highest mean levels of Cu (0.38±0.00mg/kg), while the least amount was in seeds of *C. papaya* and stem bark of *S. didymobotrya* at levels of 0.01±0.00mg/kg as shown in Table 4.13. The level of Cu was below detection limit and was not detected in *E. divinorum* stem bark even after concentration. The mean levels of Cu in leaves of *A. secundiflora* (0.15±0.01 mg/kg), *E. saligna* (0.17±0.00 mg/kg), *B. tomentosa* (0.15±0.01 mg/kg), *P. africana* (0.17±0.00 mg/kg), *S. didymobotrya* (0.10±0.00 mg/kg), *B. pilosa* (0.16±0.00 mg/kg) and stem bark of *M.indica* (0.19±0.23 mg/kg) were not significantly different at p>0.05 and α=0.05.These mean levels compare with those reported by Ahmed and Chaudhary (2009).

According to Ahmed and Chaudhary (2009), leaves and roots of *Ajuga bracteosa* indicated the concentration of Cu as 0.37and 0.23 mg/100g respectively.However, these levels are slightly higher than the levels in the present study. This disparity in the levels may be due to the fact that the uptake pattern of various elements depends upon various factors, which include synergetic/antagonistic behavior of various elements, nature of aquatic conditions affecting the ecological conditions, pH related changes, seasonal variations among others (Ahmed and Chaudhary, 2009; Järup, 2003).

The Cu levels in all the medicinal plants considered in this study are within the acceptable ranges as reported (FAO/WHO, 1984; Waston, 1993; Mindell and Mundis, 2004).

The availability of Cu in the medicinal plants plays a number of roles in treatment of ailments. In the treatment of bone related ailments such as arthritis, paining and swollen joints, Cu as a mineral is important based on its functional roles as reported (Turnland, 2006; Harris, 1997). It also assists in healing of wounds and treating lung related ailments such as coughs and colds because it boosts body immunity according to Failla and Hopkins (1998).

4.4.8 Chromium levels (mg/kg) in medicinal plants

Levels of Cr in medicinal plants were determined using atomic absorption spectroscopy (AAS). The mean levels of Cr as provided in Table 4.14 are for medicinal plants from Chuka community analysed in this study.

Table 4.14 Chromium levels (mg/kg) in medicinal plants

Plant species	Part (s) used	Mean±SD n=3	Range
Aloe secundiflora	Leaves	0.75±0.01[d]	0.74-0.76
Anthocleista grandiflora	Stembark	0.66±0.01[c]	0.65-0.67
Bauhinia tomentosa	Leaves	0.84±0.01[f]	0.83-0.85
	Stem bark	1.50±0.02[pq]	1.48-1.52
Bidens pilosa	Leaves	1.24±0.02[k]	1.23-1.26
Caesalpinia volkensii	Leaves	0.97±0.01[h]	0.96-0.98
Carica papaya	Seeds	1.57±0.02[r]	1.56-1.59
Carissa edulis	Stem bark	1.38±0.01[n]	1.38-1.39
Commiphora zimermanii	Stem bark	1.31±0.03[i]	1.28-1.34
Croton macrostachyus	Leaves	0.59±0.02[b]	0.58-0.61
Dovyalis abyssinica	Stem bark	1.43±0.01[o]	1.42-1.44
Eucalyptus saligna	Leaves	0.79±0.02[e]	0.77-0.81
Euclea divinorum	Stem bark	1.52±0.01[q]	1.51-1.53
Iboza riparia	Leaves & stem	1.19±0.01[j]	1.18-1.20
Mangifera indica	Stem bark	1.32±0.02[im]	1.30-1.34
Prunus africana	Leaves	0.92±0.03[g]	0.90-0.95
	Stem bark	1.34±0.02[m]	1.33-1.36
Senna didymobotrya	Leaves	0.49±0.02[a]	0.47-0.50
	Stem bark	1.60±0.01[r]	1.59-1.61
Solonum incanum	Stem bark	1.48±0.01[p]	1.47-1.49
Tagetes minuta	Leaves& stems	1.26±0.01[k]	1.25-1.27
Vernonia lasiopus	Leaves & stems	1.05±0.03[i]	1.02-1.07

Mean±SD followed with the same letters within the same column are not significantly different from one another ($\alpha=0.05$, $p>0.05$)

From Table 4.14 the range of Cr levels ranged from 0.47-1.61 mg/kg. Stem barks of *S. didymobotrya*had the highest mean levels of Cr (1.60±0.01mg/kg) followed by seeds of *C. papaya*with1.57±0.02mg/kg. Leaves of *S. didymobotrya* had the lowest mean levels of Cr (0.49±0.02mg/kg).The mean levels of Cr in *S. didymobotrya* (stem bark) and *C. papaya*(seeds) are not significantly different at $p>0.05$ and $\alpha=0.05$.

These findings compare with reports indicated by other researchers (Ghebremeskel *et al.*, 1991;Chien-Yi, 2005;Sumayya *et al.*, 2010).Sumayya *et al.* (2010) reported levels of Cr in *Azadirachta indica* (neem) to be 0.18 µg/g. Ghebremeskel (1991) reported the levels of Cr as 0.7µg/g in *Euclea divinorum*,and 0.8 µg/g in *Carissa edulis*. According to Chien-Yi (2005), Cr content was0.29±0.03 µg/g in *Plantaginis semen*, 1.10±0.10 µg/g in *Benincasae semen*, 1.36±0.23 µg/g in *Junci medulla* and 0.15±0.02 µg/g in *Aristolochia fangchi.*Cr levels in all the medicinal plants under study were below the permissible limits (WHO, 2005).

The levels of Cr in the medicinal plants under study are of vital importance and must be playing vital roles in the management of ailments. For example, the use of *P. africana* in the management of diabetes can be attributed to the Cr in the medicinal plants (Althuis *et al.*, 2002; Ayoola *et al.*, 2010; Mindell and Mundis, 2004).

4.5 Correlation between various metal pairs

The degree of interaction between various metal pair associations was determined using Pearson's correlation (2-tailed) at 0.05 level of significance. This enables the establishment of those metals that are interacting antagonistically as well as those interacting synergistically and their implications.

4.5.1 Metal pair interaction in medicinal plants

The correlation between various metal pairs in medicinal plants determined usingPearson's coefficient of correlation is presented in Table 4.17.

Table 4.15 Correlation between various metal pairs in medicinal plants

Metal pair interactions	Correlation values (r)
Mg-Na	+ 0.823
Mg-Zn	+ 0.657
Mg-Ca	+ 0.887
Mg-K	+ 0.673
Mg-Cr	- 0.361
Na-Zn	+ 0.595
Na-Ca	+ 0.776
Na-K	+ 0.568
Zn-Ca	+ 0.665
Zn-K	+ 0. 756
Ca-K	+ 0.489
Cu-Zn	+ 0.369
Cu-K	+ 0.464

The results presented in Table 4.17 indicate that a high degree of positive correlation exists in Mg-Na, Mg-Ca, Na-Ca and Zn-K interactions in the medicinal plants under study because of high positive correlation values. This shows that the elements are more potent together than when used separately. This synergism between metal pairs promotes effectiveness of the minerals hence chances of micronutrient deficiency and emergences of deficiency diseases among those using these medicinal plants are minimized. This interaction implies that the uptake of any of these metals does not interfere with the absorption of the other element and therefore the variation in the mean levels may be as a result difference in the soil composition, anthropogenic activities among others (Järup, 2003; Ahmed and Chaudhary, 2009).

Similarly, there is a partial positive correlation existing between Cu-K, Cu-Zn, Ca-K and Na-K because of their low positive correlation values. This shows that there is tendency of the metals interacting partly synergistically when in association. This shows that the extent of synergism is minimal. There is a negative correlation in Mg-Cr interaction because the calculated correlation value is negative. In such antagonistic interactions, there is competitive inhibition of a mineral when concentration of one of the mineral involved is high thus affecting each other's bioavailability. High concentration of Mg in medicinal plants could inhibit effectiveness of Cr which may lead to poor growth. The uptake of Mg may lower the uptake of Cr in the medicinal plants. This antagonistic interaction may result into a build up of Mg to toxic levels and deficiency of Cr.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From this study, the following conclusions can be made:

(i) The Chuka community has a diversity of medicinal plants used for management and prevention of different ailments.

(ii) Leaves are the most used parts of the medicinal plants and this is more sustainable compared to the use of roots.

(iii) All the medicinal plant samples were found to contain the selected essential elements in varying proportions except Cu which was not detected in stembark of *Euclea divinorum*.

(iv) Mean levels of Na, K, Ca, Mg and Zn were highest in *Aloe secundiflora* and lowest in *Bauhinia tomentosa, Mangifera indica, Anthocleista grandiflora, Dovyalis abyssinica* and *Eucalyptus saligna respectively*.

(v) *Senna didymobotrya* (stem bark), *Iboza riparia,* and *Euclea divinorum* had the highest mean levels of Cr, Cu and Fe respectively while *Senna didymobotrya* (leaves), *Euclea divinorum* and *Bauhinia tomentosa* had the lowest mean levels of the same respectively.

(vi) *Aloe secundiflora* and *Euclea divinorum* had the highest mean levels of macronutrients and micronutrients respectively.

(vii) *Bauhinia tomentosa* had the lowest mean levels of macronutrients and macronutrients.

5.2 Recommendations from this work

(i) Medicinal plants from Chuka community may be good sources of cheap mineral supplements to people compared to the relatively expensive and inaccessible synthetic ones.

(ii) The Chuka community should be sensitized on the need to grow the medicinal plants in their farms as a way of protecting endangered species such as *Prunus africana* and*Carissa edulis*.

(iii) The knowledge of role of medicinal plants as a source of good health in the light of essential elements as therapeutic agents should be dessiminated to the public.

5.3 Recommendations for further work

(i) More traditional medicinal plants from Chuka community and other parts of Kenya should be analysed for all essential elements.

(ii) Seasonal variation in the level of essential elements in medicinal plants needs to be assessed.

(iii) Factors that influence bioavailability of essential elements in medicinal plants should be investigated.

(iv) Levels of non-essential elements in the medicinal plants considered in this study should be analysed.

(v) Soils from which the medicinal plants analysed in this study grow should be analysed for mineral elements to determine their contribution to the levels of essential elements in the medicinal plants studied.

(vi) Speciation of essential elements in traditional plants should be done

(vii) The levels of essential elements in prepared decoctions should be analysed.

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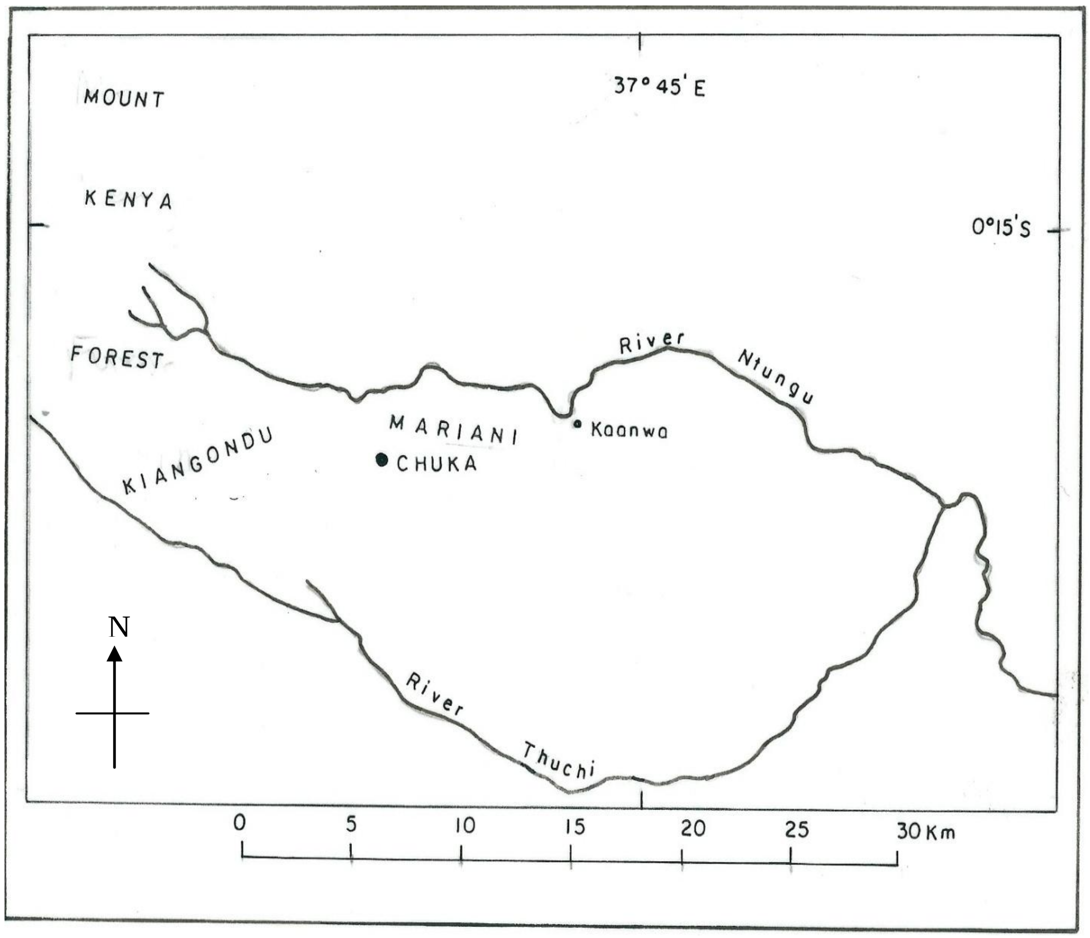
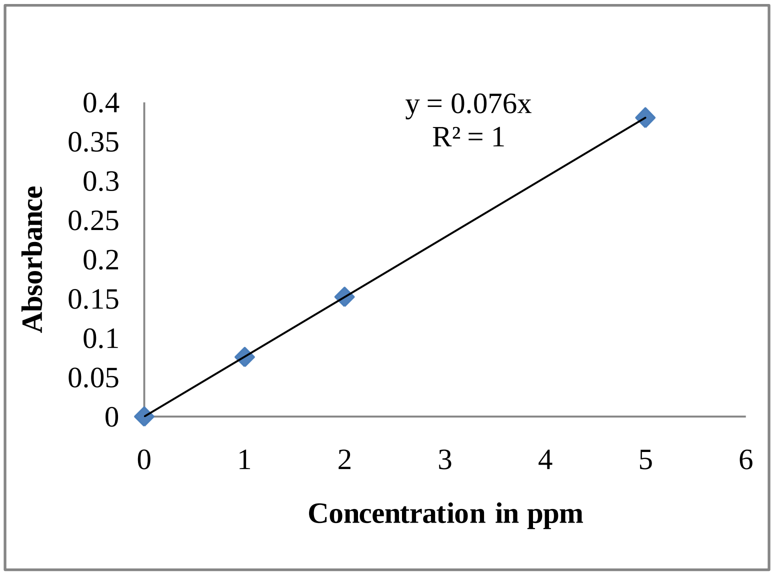
APPENDICES

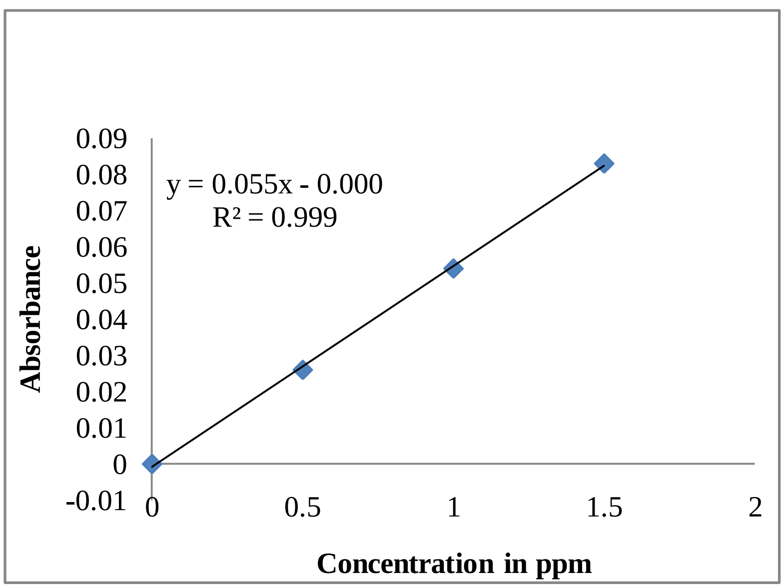
APPENDIX I: Map of Chuka in Meru South District



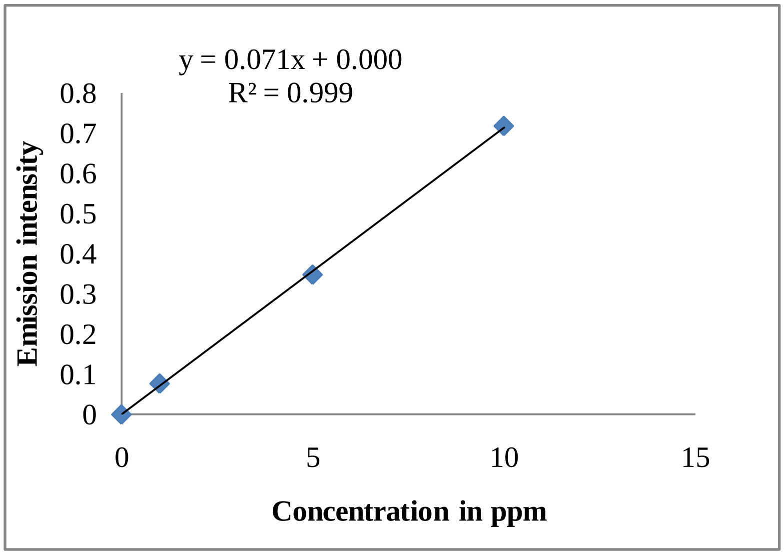
APPENDIX II: Standard calibration curve for zinc



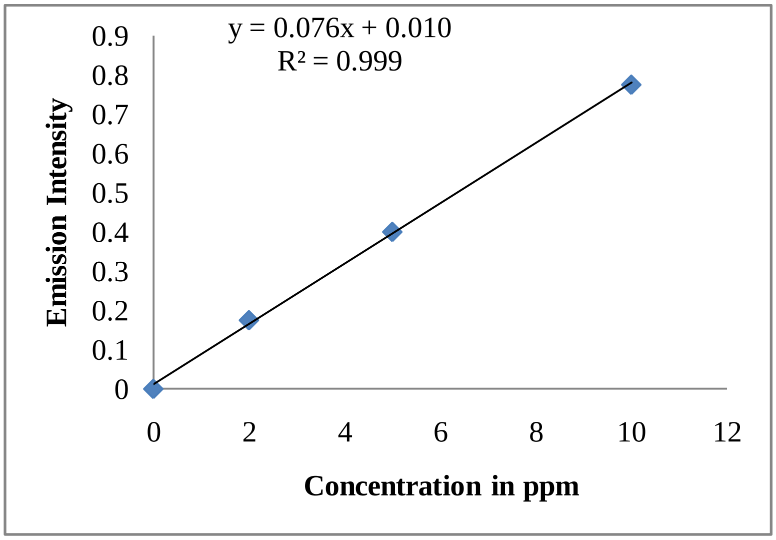
APPENDIX III: Standard calibration curve for chromium



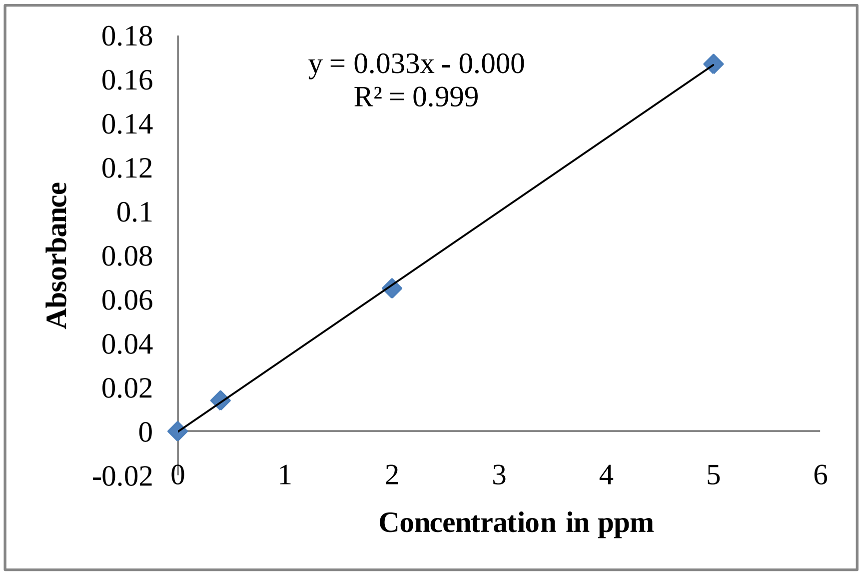
APPENDIX IV: Standard calibration curve for calcium



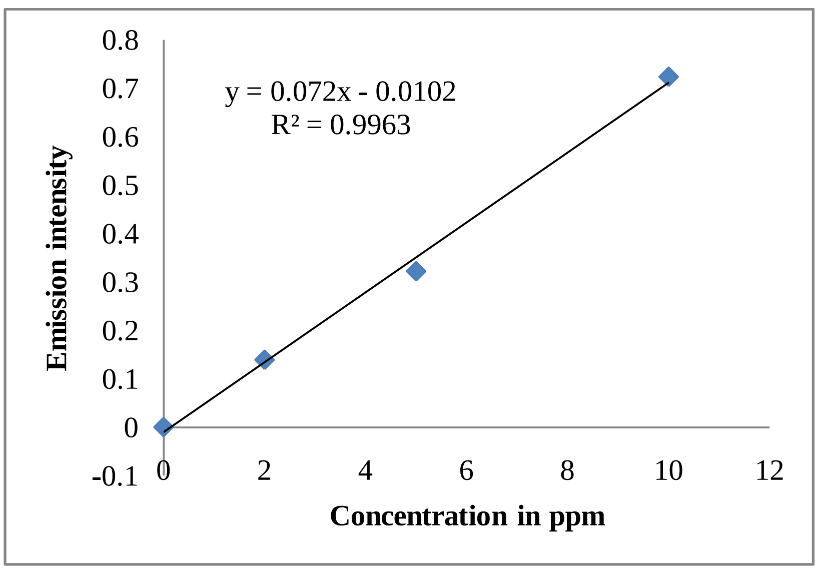
APPENDIX V: Standard calibration curve for sodium



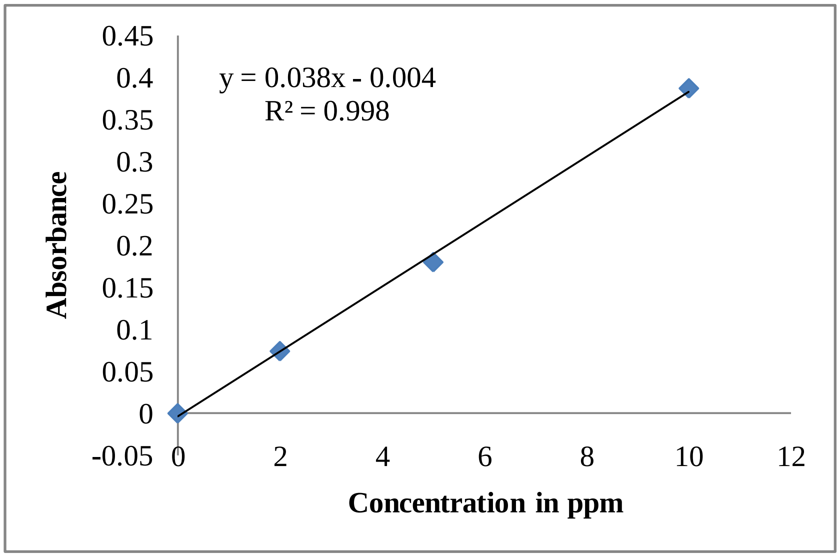
APPENDIX VI: Standard calibration curve for magnesium



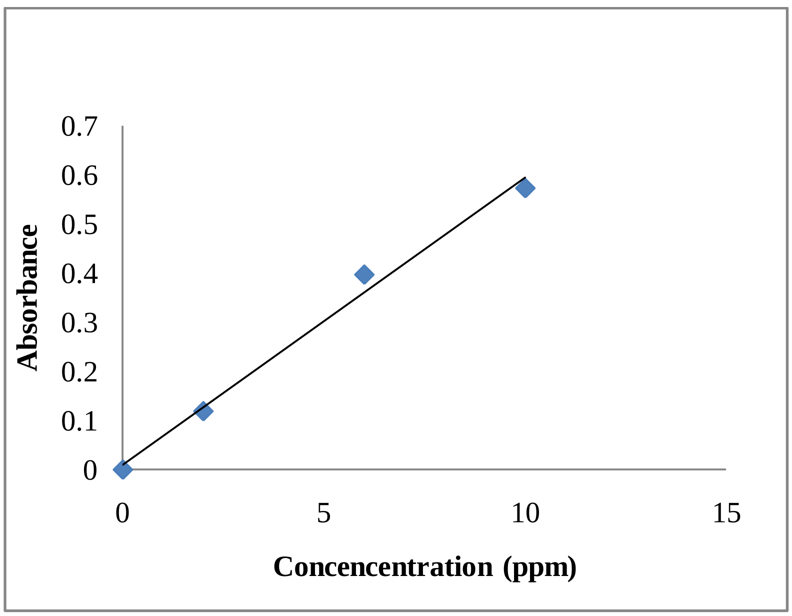
APPENDIX VII: Standard calibration curve for potassium



APPENDIX VIII: Standard calibration curve for copper



APPENDIX IX: Standard calibration curve for iron



APPENDIX XII

Plant species, parts used for medication and the ailments they treat

S/N	Local name	Plant species	Family name	Parts used	No. of times plant is mentioned	Ailment treated
1	Araka (magana)	*Tithonia diversifolia* (Hernst.) A. Gray	Asteraceae	leaves	15	herbicide
2	Ciaking'ari	NOT FOUND		leaves	13	wounds
3	Bangi	*Cannabis sativa* L.	Cannabaceae	leaves	12	wounds
4	Butonwa/Muruja	*Ageratum conyzoides* L.	Asteraceae	leaves,roots	12	wounds, chest pain
5	Gakenia	*Lantana trifolia* L.	Verbenaceae	leaves	12	stomachache
6	Kithunju	*Aloe secundiflora* Engl.	Aloaceae	leaves	12	malaria, pneumonia,wounds , chest pains, chicken diseases,arthritis, rheumatism
7	Gacheni	NOT FOUND		leaves	11	malaria
8	Gitiindi (banana)	*Musa paradisiaca* sub sp. *sapetium*	Musaceae	fruit, leaves,	11	family planning, wounds
9	Jerusalem	*Euphorbia milii* Des Moul	Euphorbiaceae	latex	10	skin infection
10	Kabinga	*Sida massaica* Vollesen	Malvaceae	leaves	9	sprain
11	Karigarigo	*Kigelia africana* (Lam.) Benth.	Bignoniaceae	roots	9	worms
12	Karigarigu (muugo)	NOT FOUND		roots	8	chestpains, coughs
13	Mubabai	*Carica papaya* L.	Caricaceae	roots,seeds,young leaves	8	syphilis,gonorrhoea, lung ailment, worms, amoeba, malaria, resp.
14	Mubangi	*Tagetes minuta* L.	Asteraceae	leaves	8	asthma, toothache, cockroaches, fleas,
15	Mubau	*Eucalyptus saligna* Smith	Myrtaceae	leaves, stem bark	8	chicken diseases,cold, fever,toothache,measles
16	Karigimunaria	*Vernonia branchycalyx* O. Hoffm.	Compositae	roots	7	stomachache
17	Karuita	NOT FOUND		roots	7	gonorrhoea
18	Mucege	*Bidens pilosa* L.	Asteraceae	roots, leaves	7	coughs, eye inflamation, malaria,ringworms, fresh cuts,gonorrhoea

19	Muembe	*Mangifera indica* L.	Anacardiaceae	stem bark, leaves	7	pneumonia, coughs,chest pains, wounds,stomachache,stabilizer, toothache
20	Karura	*Asparagus racemosus* Willd	Asparagaceae	leaves	6	boils, removing thorn
21	Kii kia Ngigi	NOT FOUND		leaves	6	umbilical cord treatment, skin infections
22	Kinyani	NOT FOUND		leaves	6	wounds
23	Kirurita	*Hypoestis sp*	Acanthaceae	leaves, roots	6	chestpains, typhoid, malaria, worms as a decoction with other plants
24	Kitunguu Saumu	*Allium sativum* L**.**	Amaryllidaceae	bulb	6	toothache
25	Mukambura	*Dovyalis abyssinica* E. Mey. ex Arn.	Salicaceae	roots	6	colds,chest pains, stomachache,cough
26	Mujuthii	*Caesalpinia volkensii* Harms.	Caesalpiniaceae	seeds,leaves	6	malaria
27	Mwaraka	*Iboza riparia* (Hochst.) N.E. Br.	Lamiaceae	leaves	6	colds and flu, bronchitis, stomach upsets, flatulence, mouth ulcers, diarrhea, and fevers
28	Mwiria	*Prunus africana* (Hook. f.) Kalkman	Rosaceae	stembark	6	amoeba, typhoid,chestpains, colds, malaria, general body weakness
29	Mariaria	NOT FOUND		leaves	5	amoeba, worms
30	Matuma(Ruguru)	*Colacasia esculenta* (L.) Schott	Araceae	leaves	5	colds
31	Mbaki	*Nicotiana tabacum* L.	Solanaceae	leaves	5	fresh wounds
32	Mbootwa/Mboota	*Physalis peruviana* L.	Solanaceae	leaves	5	worms
33	Meenywa	*Aframomun melegueta* K. Schum	Zingiberaceae	seeds	5	amoeba
34	Miraa	*Catha edulis* (Vahl) Forssk. ex Endl.	Celastraceae	mature leaves	5	toothache
35	Mirindi/Mwako	*Maesa lanceolata* Forssk	Myrsinaceae	stem bark	5	stomachache
36	Mkungani	NOT FOUND		roots	5	lung ailment
37	Mukuura	*Bauhinia tomentosa* L.	Caesalpiniaceae	stem bark	5	cough, malaria
38	Mumanku	*Euclea divinorum* Hiern	Ebenaceae	roots, leaves	5	stomachache,malaria,worms, constipation,cough
39	Mutongu	*Solanum incanum* L.	Solanaceae	fruit juice, roots	5	stomachache, headache, cough, wounds, worms, amoeba, toothache, diarrhoea, swollen joints, sprains, anti-rabies

40	Mutungugu/Mutungururi	*Commiphora zimermanii* Engl.	Burseraceae	stembark	5	coughs, , malaria, constipation, stomachache,skin rushes
41	Mwinu	*Senna didymobotrya* (Fresen) Irwin & Barneby	Caesalpiniaceae	leaves,roots	5	malaria, pneumonia, fever, amoeba, worms, measles, swellings on the skin,chicken pox,constipation
42	Muangua	*Millettia dura* Dunn	Fabaceae	stembark	4	ECF (cattle)
43	Muarubaine	*Melia azadirachta* L.	Meliaceae	stem bark,leaves	4	malaria,coughs,cold
44	Mubarwa	NOT FOUND		stem bark	4	diarrhoea
45	Mubegenyi	NOT FOUND		roots	4	gonorrhoea
46	Mubindabindi	*Fagaropsis angolensis* Engl.	Rutaceae	roots	4	malaria, pain in joints
47	Mubini	NOT FOUND		roots	3	chest pains
48	Mubiru	*Vangueria madagascariensis* J. F. Gmel.	Rubiaceae	young roots	3	worms
49	Mubugu/Mujana	*Caesalpinia mexicana* A. Gray	Fabaceae	roots	3	toothache
50	Mubuuna/mubono	*Plumeria alba* L.	Apocynaceae	leaves (sap)	3	removal of thorn, wounds
51	Mucharage	*Olea capensis*	Oleaceae	stem bark	3	rheumatism, malaria, arthritis
52	Muchimoro/ Tonga/Gichomoro	*Lantana camara* L.	Verbenaceae	fruit	3	amoeba
53	Muchunkwa	*Citrus sinensis* Chalybeum Engl. (L.) Osbeck.	Rutaceae	roots	3	flu, colds
54	Muempu	NOT FOUND		seeds	3	wounds
55	Mugana	NOT FOUND		leaves	3	typhoid
56	Mugumo	*Ficus thonningii* Blume	Moraceae	roots	2	diarrhoea
57	Mugunika	NOT FOUND		roots	2	joints
58	Mugunkumanga	*Punica granatum* L.	Punicaceae	roots	2	pneumonia,wounds
59	Muguruka	*Securidaca longipedunculata* Fresen	Polygalaceae	roots	2	coughs
60	Mugurukia Nthurio	*Clematis hirsuta* Guill & Perr.	Ranunculaceae	stem bark	2	colds

61	Muthiga	*Warburgia ugandensis* Sprague	Canellaceae	stem bark	2	constipation-induces diarrhoea, toothache
62	Mukandu	*Ocimum gratissimum* L.	Lamiaceae	leaves	2	chest pains, colds, malaria, skin infection, cough
63	Mukangi	NOT FOUND		roots	2	paining joints
64	Mukanyanga	NOT FOUND		roots	2	chestpains
65	Mugeeta/muchigichi	*Rapanea melanophloeos (*L.) Mez	Myrsinaceae	roots, leaves	1	pneumonia, malaria
66	Mugerwe	NOT FOUND		leaves	1	wounds
67	Mugiimbi	*Eleusine coracana* Gaertn	Poaceae	flour	1	measles
68	Mugorona/Muborona	*Rhamnus prinoides* L'Her.	Rhamnaceae	roots	1	malaria
69	Mugucwa/Munenenka	*Zanthoxylum chalybeum* Engl.	Rutaceae	stembark/leaves	1	malaria, pneumonia, cough
70	Muguiithia/mukiithia	*Clausena anisata* (Willd.) J. Hk. ex Benth.	Rutaceae	roots	1	coughs, malaria
71	Mugumbau	NOT FOUND		roots	1	coughs, malaria,pneumonia
72	Mugumbee/Kaigambeu	*Withania somniferum* (L.) Dunal	Solanaceae	roots	1	malaria, pneumonia, cough, wounds
73	Mukarakara	*Allophylus abyssinicus* (Hochst.) Radlk.	Sapindaceae	stem bark	1	heartache, chest pain
74	Mukawa	*Carissa edulis* (Forssk) Vahl	Apocynaceae	root	1	malaria,pneumonia, chestpains,colds,cough,stomachache, paining joints, worms, asthma, allergy
75	Mukeu	*Dombeya sp*	Asteraceae	roots,stembark	1	stomachache,heartburn
76	Mukinduri/Muchiri	*Croton megalocarpus* L.	Euphorbiaceae	roots, leaves	1	malaria,coughs, cancer, toothache.
77	Mukorombothi	NOT FOUND		stem bark	1	coughs
78	Mukui	*Newtonia buchananii (Baker) G. C. C. Gilbert & Boutique*	Mimosaceae	stem bark	1	chest pains, cold, malaria, gonorrhoea
79	Mukungu	NOT FOUND		stembark	1	toothache
80	Mukungugu (Forest type)	*Erythrina mela*		stem bark	1	chest pain, stomachache, cold
81	Mukunyi	*Cardiospermum corindum* L.	Sapindaceae	roots	1	worms, amoeba, paining joints
82	Mukurata	*Viagra microfeira*		roots	1	chest pains,toothache, malaria

83	Mukuruu/ Mukururu/Ngukura	*Flueggea virosa* (Willd.) Voigt	Phyllanthaceae	young leaves, roots	1	coughs, malaria
84	Mukuu	*Ficus sycomorus* L.	Moraceae	stembark,stem latex	1	constipation-induces diarrhoea, toothache
85	Mukwego	*Bridelia micrantha* (Hochst.) Baill.	Phyllanthaceae	stembark	1	diarrhoea,cough.purification of blood,cleaning of digestive sytem
86	Munakiri	NOT FOUND		roots	1	pneumonia, malaria
87	Munenenka/Mugucwa/Mung'ang'a	*Zanthoxylum sp.*	Rutaceae	stembark,leaves	1	malaria,fever, coughs
88	Muniniku	NOT FOUND		roots	1	cough
89	Munkuura/mumbukura	*Mondia whitei* (Hook.f.) Skeels	Apocynaceae	roots	1	cough
90	Mupera	*Psidium guajava* L.	Myrtaceae	leaves	1	worms,cough
91	Muratha Mbugi	NOT FOUND		leaves	1	swollen breasts
92	Murema Ngigi	*Euphorbia compactum*	Euphorbiaceae	leaves	1	ear, wounds, stuck placenta in cattle, ECF in cattle
93	Murigi	*Kigelia africana* (Lam.) Benth.	Bignoniaceae	stem bark	1	purification of blood, cleaning of digestive sytem
94	Murigurigu	*Anthocleista glandiflora* L.	Gentianaceae	stem bark	1	chest pains, cold, malaria,amoeba, worms
95	Murimu	*Citrus limon* (L.) Osbeck	Rutaceae	leaves	1	chestpain,cough
96	Muringa	*Cordia africana* Lam.	Boraginaceae	young shoots	1	eye inflammation in cattle
97	Muroroma	*Ximenia americana*	Olacaceae	leaves,roots	1	toothache, pneumonia
98	Muruga iria	*Rotheca myricoides* (Hochst.) Steane & Mabb.	Lamiaceae	roots, leaves,stem bark	1	colds, cough,typhoid,backbone
99	Murungo/Mugena Nkuru/Murugarungo	NOT FOUND		roots	1	paining joints and bones,chest pains,cold, rheumatism
100	Mururuku	*Terminalia brownii* Fresen.	Combretaceae	stem bark,roots,	1	malaria, pneumonia, sterilize dogs,cough, induce abortion, syphilis,gornorrhoea
101	Musibi	NOT FOUND		leaves	1	stomachache
102	Mutagata	*Harrisonia abyssinica* Oliv.	Rutaceae	roots	1	malaria
103	Mutambi/Musambi	*Strychnos henningsii* Gilg.	Loganiaceae	leaves, stem bak	1	malaria, stomachache, mosquito repellant
104	Mutanga Arimu	NOT FOUND		stems, leaves	1	worms in cattle

105	Mutankoma	NOT FOUND		stem bark	1	malaria
106	Mutare	*Rubus pinnata* Willd. Var. afrotropicus (Engl.) C.E. Gust.	Rosaceae	roots	1	gonorrhoea
107	Muthaara	*Indigofera electa* L.	Fabaceae	roots	1	chestpains
108	Muthagara	NOT FOUND		roots	1	cold, constipation
109	Muthaitii	*Ocotea usambarensis* Engl.	Lauraceae	stembark	1	coughs, cold, chest pains,appetizer
110	Muthanduku	*Acacia mearnsii* De Wild.	Fabaceae	leaves	1	chicken pox, measles
111	Muthare	*Dracaena sp.*	Asparagaceae	leaves	1	general body weakness
112	Muthengera	NOT FOUND		roots	1	typhoid, amoeba
113	Muthiga	*Warburgia ugandensis* Sprague	Canellaceae	stembark,leaves	1	general body weakness, pneumonia
114	Muthiga wa Macheru	NOT FOUND		roots	1	coughs, chest congestion
115	Muthithi	*Tamarindus indicus* L.	Fabaceae	roots	1	cancer
116	Muthugucii	NOT FOUND		roots,	1	malaria
117	Muthumuki	NOT FOUND		stem bark	1	tapeworm
118	Muthunthii	*Maytenus senagalensis* (Lam.) Exell	Celastraceae	roots, leaves	1	T.B. stomachache, toothache, malaria, cold,boils, cough
119	Mutiiru/Mutitiiru	NOT FOUND		stembark	1	coughs,chicken pox
120	Mutuntu	*Croton microstachyus* Hochst. ex Delile	Euphorbiaceae	leaves,roots, stem bark	1	wounds, cough,cold,cleansing digestive and blood circulation system
121	Muturatura/Gitura	*Solanum aculeastrum* Dunal.	Solanaceae	leaves	1	toothache
122	Mutuu	*Rauvolfia caffra* Sond.	Apocynaceae	stembark	1	general body weakness
123	mutwithi/Mu G. K./Muruja/Runyagwe	*Conyza bonariensis* (L.) Cronquist	Asteraceae	roots	1	toothache
124	Muuga	*Coffea arabica* L.	Rubiaceae	roots	1	flu
125	Muuti	*Erythrina abyssinica* (Lam.) ex DC.	Fabaceae	stembark	1	toothache,chestpains, malaria, worms when mixed with others

126	Muutii	*Tithonia aspera*	Asteraceae	leaves, stem bark	1	wounds, coughs,cold,stomachache, general body weakness
127	Mwangati	NOT FOUND		stembark	1	pneumonia
128	Mwania	NOT FOUND		roots	1	malaria
129	Mwariki jwa gichunko	*Jatropha caucus* L.	Euphorbiaceae	seeds (oil)	1	constipation
130	Mwatha	*Vernonia lasiopus* O. Hoffm	Asteraceae	leaves	1	amoeba, dog poison,worms
131	Mwimba Nthurio	*Clematis brachiata* Thunb.	Ranunculaceae	stembark,roots	1	chestpains, cough and headache
132	Mwiria Njara	NOT FOUND		roots	1	cough, malaria, pneumonia, cold
133	Mwogorana	NOT FOUND		roots	1	worms
134	Mogoya/Mujara	*Plectranthus barbatus* var. Gymnostomus Benth.	Lamiaceae	leaves	1	cold
135	Ntonga	*Ovariodendron anisatum* Verdc.	Annonaceae	leaves	1	stuck placenta in cattle, snake bite, scorpion bite
136	Thaa ya Ngombe	*Urtica massaica* Mildbr.	Urticaceae	leaves	1	cleaning circulatory system, adds blood in the body
137	Thendwe	NOT FOUND		seeds	1	amoeba
138	Thibini	NOT FOUND		leaves	1	pneumonia,