DETERMINATION OF MICRONUTRIENTS, HEAVY METALS AND PROXIMATE ANALYSIS OF SELECTED INDIGENOUS VEGETABLES IN KIRINYAGA EAST SUB-COUNTY, KIRINYAGA COUNTY

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented for an award diploma or conferment of degree in any institution or University

Signature... Date. 24/10/2025 ....

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Recommendation

This thesis has been examined, passed and submitted with our approval as University supervisors.

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DEDICATION

This thesis is dedicated to my esteemed parents Simon Mwangi, Lilian Njeri Maina and my sister Faith Wamuyu Maina, whose unwavering support, encouragement, and values have been the cornerstone of my academic and personal development. Their steadfast belief in the pursuit of knowledge has inspired and sustained me throughout this journey.

I also dedicate this work to all those who have contributed, directly or indirectly, to my education and growth. Your influence is deeply appreciated and respectfully acknowledged.

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ABSTRACT

Socio-economic changes that have taken place in Africa have influenced peoples eating habits in both rural and urban set-ups. Indigenous vegetables are important for food insecurity, malnutrition reduction and therapeutics in sub-Saharan African countries. In Kirinyaga County, indigenous vegetables are underutilized or neglected due to some nutritional content are known and others unknown. Limited data exist on the precise levels of key micronutrients (e.g. iron, zinc, magnesium) in specific indigenous vegetables cultivated in Kirinyaga East Sub-County. Variability in nutrient content due to farming practices, soil types, and climatic conditions in the region has not been comprehensively studied. Leaves are the most preferred parts of indigenous vegetables for consumption. Although they have nutritional benefits, there is a need to determine the safety levels due to toxic metals in vegetables contaminated with pesticides, heavy metals and toxins leading to failure of certain organs of the human body. The study aimed to determine levels of micronutrients (calcium, iron, magnesium and zinc), heavy metals (lead and cadmium) using AAS (atomic absorption spectrometer) using and proximate analysis (ash content, moisture content, crude fat, protein content, carbohydrates and crude fiber) of selected African indigenous vegetables (African nightshade, Spider plant, Vine spinach and Pumpkin leaves) in Kirinyaga east sub-county. The results revealed that African indigenous vegetables are rich in essential micronutrients. Pumpkin leaves had the highest calcium levels (14,070.81 mg/kg), spider plant showed the highest iron concentration (233.53 mg/kg), African nightshade recorded the highest zinc content (483.33 mg/kg), while vine spinach was richest in magnesium (570.87 mg/kg). Proximate analysis indicated that spider plant and African nightshade contained higher protein levels (up to 17.9%), while moisture content ranged from 82–91%. Crude fat levels were consistently low, confirming African indigenous vegetables as nutrient-dense but energy-light vegetables Cadmium and lead concentrations varied across species and locations, with African nightshade and vine spinach showing relatively higher levels. However, all values remained within WHO/FAO permissible limits, indicating that the vegetables are safe for human consumption in terms of heavy metal contamination. African indigenous vegetables have high nutritional potential and can be promoted as affordable dietary sources of essential minerals and protein to combat malnutrition.

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LIST OF ABBREVIATION AND ACRONYMS

AIVs: African Indigenous Vegetables

ANOVA: Analysis of Variance

AOAC: Association of Official Agricultural Chemists

ATP: Adenosine Triphosphatase

EFSA: European Food Safety Agency

EP: End Point

FAO: Food and Agriculture Organization

IoM: Institute of Medicine

KCADP: Kirinyaga County Annual Development Plan

KF: Karl Fischer

LOD: Loss on Drying

NACOSTI: National Commission for Science, Technology & Innovation.

NAM: National Academy of Medicine

NGOs: Non-Governmental Organization

RDA: Recommended Dietary Allowance

WHO: World Health Organization

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Traditional vegetables are valuable sources of nutrients with some having important medicinal properties and substantially contributing to food security (Hilou *et al*., 2006). Indigenous vegetables possess the ability to improve the country's food and nutrition security as they contain high nutritional value and are drought-resistant. Overcoming food and nutritional insecurity among women, pregnant and lactating mothers and children under five years of age remain a challenge in many developing countries. In most African countries, people's diet relies heavily on rice, cassava, potatoes which are high in calories but deficient in essential micronutrients, (Shackleton *et al*., 2009). Such diet is bulky, have low nutrients density and poor bioavailability of minerals and vitamins and therefore, result in impaired growth, development and host of chronic diseases. The availability of African indigenous vegetables during the rainy season and their climate-adaptability make them an attractive option for nutritional supplementation for those most in need. Therefore, they must be processed to maintain or improve their nutritional content, organoleptic qualities, and long-term storage properties (Gido *et al*., 2017).

Deficiencies in iron, zinc, vitamin A and iodine are widespread affecting about 300million people every year, with many more risk of experiencing these deficiencies (FAO, 2020). Indigenous vegetables have been part of traditional diets in various communities worldwide, yet many of these crops are underutilized and their nutritional value is unknown (Keatinge, 2012). Their utilization could improve the cassava and maize based diet and thus reduces the chronic nutrient deficiencies. According to previous studies, most of the traditional varieties are ready for harvest much faster than non-native crops, so they could be promising options in erratic rainy seasons (Habwe *et al*., 2009).

A meaningful way to diversify the food supply is to cultivate and market previously underutilized species. However, they are characterized by not being known and traded globally and usually having only local importance. Despite this their consumption has decreased over the years often because their nutritional value is often compared with the exotic vegetables (Weinberger and Msuya, 2004). Accordingly, they have been widely ignored in research. Increasingly, however, there is a growing realization worldwide that these plants can make an essential contribution to food and nutritional security, especially for poorer segments of the population. Moreover, they are adapted to local conditions and are often produced with less resource input. Despite official statistics indicating low consumption level of vegetables in Africa, it appears that traditional vegetables are usually consumed with staple food in various forms. (Hussain *et al*., 2011). In spite the known nutritional contribution of African indigenous vegetables to the diets, and their health benefits and protective properties, there has been very little collective effort towards exploiting these biologically available resources for improving nutritional status (Kwenin *et al*., 2011). The bioavailability of their nutrient and the mineral content has not been well investigated. Therefore, there is a need to optimize the nutrient content and other properties of traditional vegetables in the daily food of the population.

Although the African indigenous vegetables have health benefits, there has also been an increase stimulation of research in regards to the risk associated with consumption of vegetables contaminated with pesticides, heavy metals and toxins. These toxic metals are circulated by biogeochemical processes and these may lead to toxic manifestation when intakes are in excess levels leading to failure of certain organs of the human body (Radwan & Salama, 2006). There is a need to take into consideration of their safety level because it is suspected that vegetables have been contaminated due to increase contamination of the environment by toxic substances (Amoah *et al*., 2006). There is a high need to conduct research to provide scientifically proven information by assessing the levels of the heavy metals in the indigenous vegetables. The continuous up take of these heavy metals may accumulate to high toxic levels.

Contamination can arise as a consequence of treating soil with organic fertilizers, such as sewage sludge and manure, and from the irrigation water, as well as from the ability of pathogens to persist and proliferate in vegetables (Hamilton *et al*., 2006). In developing countries, the use of waste water and fertilizers for vegetable production is a contributing factor to the contamination of vegetables (AdeOluwa & Cofie, 2012).

Indeed, little effort has been made to assess the nutritional value of traditional African vegetables and the products from these vegetables should be a priority of crop research. Nutrient analysis allows for identification of nutritional characteristics of food. Evaluating the nutritional importance of indigenous vegetables can lead to better understanding of the value of these plants (Gizaw, 2019).

The four African indigenous vegetables i.e. African nightshade (*Solanum scabrum*), spider plant (*Cleome gynandra*), vine spinach (*Basella alba*) and pumpkin leaves (*Cucurbita maxima*) were selected for this study due to their widespread consumption and cultural significance within Kenyan communities (Abukutsa *et al*., 2005). These vegetables are among the most commonly cultivated indigenous species in Kirinyaga County and are recognized for their high nutritional and medicinal value. They provide essential micronutrients such as iron, zinc, calcium and magnesium, which are vital in addressing nutrient deficiencies prevalent in local populations. Moreover, these species exhibit strong adaptability to diverse agro-ecological conditions, drought resistance and affordability, making them accessible to both rural and urban households. Despite their nutritional potential, there is limited empirical data on their proximate composition, micronutrient content and possible heavy metal accumulation.

For this purpose, we will assess the nutritional value and mineral content of four indigenous vegetables namely spider plant (*Cleome gynadra*), African nightshade (*Solanum*), Vine spinach *(Bacella alba)* and Pumpkin leaves (*Cucurbita maxima*).

1.2 Statement of the Problem

Indigenous vegetables are locally important crops that contribute significantly to food security, human nutrition and sustainable livelihoods, yet they remain underutilized and undervalued compared to exotic species. Despite their potential to alleviate micronutrient deficiencies and enhance dietary diversity, limited scientific data exist on their actual nutritional composition and safety. In particular, little is known about the precise concentrations of key micronutrients such as iron, zinc, calcium, and magnesium in commonly consumed African indigenous vegetables grown in Kirinyaga East Sub-County. Furthermore, the possibility of contamination from heavy metals due to increased use of agrochemicals, wastewater irrigation, and industrial activities has not been adequately investigated. This lack of empirical information on both nutritional value and toxicological safety creates a significant knowledge gap that hinders informed dietary recommendations, public health interventions, and agricultural policies promoting indigenous vegetables in Kenya.

A major concern in recent years is the overuse of chemical fertilizers, pesticides, and herbicides in farming practices within the region. These inputs, while aimed at increasing yields and controlling pests, can degrade soil health, affect the nutrient profile of crops, and introduce toxic residues into the food chain. Over time, the excessive application of these chemicals has raised concerns about environmental pollution, biodiversity loss, and long-term food safety. The contamination of indigenous vegetables with harmful residues and heavy metals, such as lead, cadmium, and arsenic, is now a pressing issue—exacerbated by poor handling practices and limited regulatory enforcement.

Traditional vegetables are known to be rich in nutritional mineral content. Consumption of such vegetables has historically helped reduce nutrition-related conditions like anemia, male infertility, and other ailments. However, in recent years, health facilities have reported an increase in mineral malnutrition, particularly among infants and nursing mothers. Clinical reports highlight a rising incidence of iron deficiency anemia and zinc-related male infertility in the area. Although African indigenous vegetables have immense health benefits, their safety must be scrutinized, especially in light of growing concerns over heavy metal contamination due to industrial and agricultural activities.

For this reason, there is a critical need to determine the micronutrient levels, assess the presence of toxic heavy metals, and conduct a proximate analysis of African indigenous vegetables as consumed in Kirinyaga East Sub-County. This research seeks to fill these gaps, providing essential data to guide informed decisions on nutrition, food safety, and sustainable agricultural practices in the region.

1.3 Objective of the Study

1.3.1 General Objective

To determine micronutrients, heavy metals and proximate analysis of selected African indigenous vegetables (African nightshade, Spider plant, Vine spinach and Pumpkin leaves) in Kirinyaga east sub-county.

1.3.2 Specific Objectives

i. To quantitatively determine the concentration levels of micronutrients (calcium, iron, magnesium and zinc) in African night shade, spider plant, vine spinach and pumpkin leaves.
ii. To carry out proximate analysis of the African indigenous vegetables (African night shade, spider plant, vine spinach and pumpkin leaves) by chemically determining moisture content, ash content, crude fat, crude protein, crude fiber, and carbohydrate levels.
iii. To determine the concentration levels of heavy metals (cadmium and lead) in the selected African indigenous vegetables.
iv. To compare and evaluate the variation in chemical composition (micronutrient and heavy metal concentrations, proximate parameters) across different geographical locations within Kirinyaga East Sub-County.

1.4 Research Questions

i. What are the concentration levels of micronutrients (calcium, iron, magnesium and zinc) in the selected African indigenous vegetables (African night shade, spider plant, vine spinach & pumpkin leaves)?
ii. What are the levels of proximate constituents namely moisture, ash, protein, crude fats and carbohydrates of the selected African indigenous vegetables?
iii. What are the concentration levels of the selected heavy metals (lead and cadmium) present in the selected African indigenous vegetables (African night shade, spider plant, vine spinach & pumpkin leaves)?
iv. Are there statistically significant differences in the chemical composition of the vegetables across different sampling locations in Kirinyaga East Sub-County?

1.5 Significance of the Study

Indigenous vegetables play a vital role in enhancing food and nutritional security, especially among vulnerable groups such as children, pregnant and lactating mothers, and low-income households (Shackleton *et al*., 2009). Despite their known nutritional and health benefits, their consumption has been declining due to limited awareness and inadequate scientific data on their nutrient composition and safety (Weinberger & Msuya, 2004) & (Kwenin *et al*., 2011). Medicinal and nutritional reports have indicated increasing cases of micronutrient deficiencies, particularly iron and zinc, among infants, women, and men in Kenya, yet these populations frequently consume indigenous vegetables (FAO, 2020). Determining the nutritional and toxicological composition of these vegetables is, therefore, essential in addressing mineral malnutrition and promoting food-based interventions for public health improvement.

The findings from this study will provide scientific data on the micronutrient, heavy metal, and proximate composition of commonly consumed African indigenous vegetables African nightshade, spider plant, vine spinach, and pumpkin leaves cultivated in Kirinyaga East Sub-County. Such information will be critical for nutritionists, public health practitioners and agricultural stakeholders in promoting safe consumption and developing strategies for sustainable production of indigenous vegetables (Gido *et al*., 2017). Additionally, the results will contribute to the existing body of knowledge on agro-biodiversity and its role in improving dietary quality, income generation, and resilience to food insecurity (Hussain *et al*., 2011). By providing scientifically grounded data on the nutritional potential and safety of indigenous vegetables, this study supports ongoing efforts to promote these species as affordable, locally available and culturally accepted solutions for combating hidden hunger and improving community well-being (Abukutsa *et al*., 2005).

CHAPTER TWO

LITERATURE REVIEW

2.1 Vegetables and Nutrients

Vegetables are the fresh and edible portions of herbaceous plant. They contain plant species which include young succulent leaves, fruits, roots stem and seeds. They are considered essential for well-balanced diets since they supply vitamins, minerals, dietary fiber, and phytochemicals (Dias, 2012). Vegetables are an important component of a healthy diet and, if consumed daily in sufficient amounts, could help prevent major diseases. Therefore, vegetables should be included in every day's meal. Among the foods incorporated into daily diet is vegetables (Mohammed & Sharif, 2011).

2.1.1 African Nightshade (*Solanum scabrum*)

The origin of majority of the *solanum* species is within South American. The most popular can be found in areas of Europe and Asia but most valued *Solanum* species vegetable, said to be *Solanum scabrum*, is native to Australia. African nightshade is largely domesticated in Nigeria but also popular in Kenya. While African nightshade was formerly known as "food for the poor" by the middle class of areas like Kenya, there have been changes over the last decade that have helped African nightshade makes its way from growing wild or being semi-cultivated to be available in supermarkets (Agwa, 2019). Traditionally, African nightshade was collected from the wild and given as a souvenir by family and friends, who were traveling from rural areas to town dwellers. Due to promotion by NGOs and research and other interest groups, this trend was changed based on awareness of nutritional and medicinal benefits. African nightshade has become a domesticated and commercialized production from commercial and substance farming (Abukutsa *et al*., 2005).

African nightshade species include *Solanum scabrum*, *Solanum villosum*, *Solanum nigrum*, and *Solanum americanum*.

Figure 1: African night shade *(Solanum scabrum)*

African nightshade is an erect dicot with many branches growing 0.5 to 1.0m high. The plant has thin oval leaves which are approximately 15cm in length. The plant has numerous flowers that are black or purple and round berries, berries can be orange or black depending on the species. There are many diversities in African nightshades related to growth patterns, leaf sizes, tastes (bitterness) flowering time, color, as well as nutritional and nutraceutical value, along with quantities and composition of anti-nutrient factor (Ondieki *et al*., 2011).

African nightshade is widely used as a traditional medicine in Africa and other areas, though in some places around the world the leaves are considered poisonous. The leaf extracts of S. scabrum are used for the treatment of diarrhea, some eye infections and jaundice. The leaves of African nightshade may also be used to help treat duodenal ulcers, boils and swollen glands (Yanlan *et al*., 2013).

2.1.2 Spider Plant ***(Cleome Gynadra*)**

Spider plant is an erect herbaceous annual herb with hairy, often purple stems and many branches growing to height of about one meter. Spider plant (Cleome gynandra), also known as cat's whisker or African cabbage belongs to the family Cleomaceae It is among the main indigenous African leafy vegetables that form an important part of African traditional diets in the rural households where high levels of under-nutrition prevalence have been reported (Omondi *et al*., 2017). These vegetables are also now popular in urban areas The plant has edible leaves each leaf has up to seven leaflets spreading like fingers which are 2-10cm long and 2-4cm wide. The flowers are rather showy, long and bearing many small white or pink flowers. The elongate fruit resembles a pod, but it is referred to as capsule, containing many dark small dark seeds. Spider plant originated in Africa and tropical Asia but now has a worldwide distribution. Spider plant leaves are eaten as a cooked green vegetable, have a mild bitter taste and contain 5% proteins, 6% carbohydrates and high in vitamin A and Calcium and iron. Nderema is rich in vitamin A, vitamin C, iron and calcium (Oyango *et al*., 2013).

Figure 2: Spider plant *(Cleome gyadra)*

2.1.3 Vine Spinach (*Bacella alba*)

Bacella alba is an edible perennial vine in the family Bacella. It is found in tropical Asia and Africa where it’s widely used as a leaf vegetable. It is famously known as Nderema in some parts of Kenya. It is also known as Malabar spinach (Oyugi *et al*., 2021). *Bacella alba* is a fast growing, soft-stemmed vine, reaching 10metres in length. Its thick, semi- succulent, heart -shaped leaves have a mild favor and mucilaginous texture. It is rich in vitamin A, vitamin C, iron and calcium. There are two varieties-red and green. Malabar spinach is high in vitamin A, vitamin C iron and calcium. It is low in calories by volume. Malabar spinach may be used to thicken soups or stir-fries with garlic and ginger (Maina, 2021).

Figure 3: Vine spinach *(Bacella alba)*

2.1.4 Pumpkin Leaves (*Cucurbita maxima*)

Pumpkins originated in North America. Seeds from related plants have been found in Mexico dating back days. The name pumpkin originated from the Greek word for "large melon" which is "pepon." Pepon was changed by the French into "pompon." The English people changed "pompon" to "Pumpion"American colonists changed "pumpion" into "pumpkin". Native American (Known as Red Indians) used pumpkin as a staple in their diets centuries before the pilgrims landed. The pumpin leaves are widely incorperated as part of the dietary constituent in the society (Akidahusu & Salawu, 2005). Pumpkins are grown from the lowlands up to altitudes of about 2500 meters above sea level. They are warm-season crops adapted to mean temperatures of 18-27ºC.Pumpkins do well in places where medium to heavy applications of compost or well-decomposed manure is done. They can be planted on almost any well-drained fertile soil with a neutral pH. Pumpkins are drought-tolerant and are sensitive to water logging since it encourages the development of leaf diseases (Fadupin *et al*., 2014)

Figure 4: Pumpkin leaves *(Cucurbita maxima)*

2.2 Minerals

Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the elements or minerals for their normal life processes. Minerals may be broadly classified as macro (major) or micro (trace) elements. The third category is the ultra-trace elements. The macro-minerals include calcium, phosphorus, sodium and chloride, while the micro-elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulfur (Eruvbetine, 2003). It is often important to know the mineral content of foods during processing because this affects the physicochemical properties of foods (Prapasri *et al*., 2011).

Table 1: Recommended Mineral Content

Mineral	Recommended Dietary Allowance (RDA) or Dairy Adequate intake		Upper limit
	Women	Men	
Calcium	Ages 31-50:1,000milligrams Ages 51+:1,200 Milligrams	Ages 31-50:1,000milligrams Ages 51+:1,200 Milligrams	2,500 milligrams
Iron	Ages 31-50:18mlligrams Ages 51+:8 Milligrams	Ages 31-50:8mlligrams Ages 51+:8 Milligrams	45 milligrams
Zinc	8 milligrams	11 milligrams	40 milligrams
Magnesium	Ages 19-30:310 milligrams. Ages 31-70+:320 milligrams	Ages 19-30:400 milligrams. Ages 31-70+:420 milligrams	350 milligrams(from supplements)
Manganese	1.8milligrams	2.3 milligrams	11 milligrams
Iodine	150 micrograms	150 micrograms	1,100 micrograms

(Meyers *et al*., 2006)

2.2.1 Calcium

Calcium is the most abundant mineral in the body. Humans need calcium to build and maintain strong bones. It is also necessary for maintaining healthy communication between the brain and other parts of the body. It plays a role in muscle movement and cardiovascular function. Calcium functions as a constituent of bones and teeth, regulation of nerve and muscle function. In blood coagulation, calcium activates the conversion of prothrombin to thrombin and also takes part in milk clotting. It plays a vital role in enzyme activation (Olle & Bender, 2009). Calcium activates large number of enzymes such as adenosine triphosphatase (ATP), succinic dehydrogenase, lipase etc. It is also required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability. A reduced extracellular blood calcium increases the irritability of nerve tissue, and very low levels may cause spontaneous discharges of nerve impulses leading to tetany and convulsions (Murray *et al*., 2000). Calcium plays a primary role in the offset of daily losses through sweat, excreta, shading of skin nails and hair (Reker *et al*., 2004)

2.2.2 Iron

Iron is an important mineral that is involved in various bodily functions, including the transport of oxygen in the blood. This is essential for providing energy for daily life. Dietary iron is found in animal and plant foods. Iron deficiency can be treated by adding iron-rich foods to your diet (Péneau *et al.*, 2008).

Iron deficiency is when your body's iron stores are too low. Common causes include not getting enough iron in your diet, chronic blood loss, pregnancy and vigorous exercise. Iron is important in oxygen transportation red blood cells contain hemoglobin, which is a complex protein that carries oxygen from the lungs to the rest of the body (Péneau *et al.*, 2008). Hemoglobin is partly made from iron, and accounts for about two thirds of the body's iron. It is also important in Myoglobin which is a special protein that helps store oxygen in muscle cells. Myoglobin contains iron and is responsible for the red colour of muscle (Stoltzfus, 2003).

In low and middle income countries under nutrition including iron deficiency is a major public health problem contributing to 45% of deaths among children under 5 years of age. Iron deficiency may occur due to increased iron requirement (like childhood, and pregnancy), decreased intestinal iron absorption, blood loss, inflammation, and low iron-rich food intake. Moreover, breastfeeding alone is no longer sufficient to meet iron demand and iron-rich meals should be introduced to make up for the shortcoming (Semagn *et al.*, 2023). Expectant women require extra iron to prevent premature delivery; athletes also need extra iron to keep the blood and oxygen pumping to their heart and other muscles as they contract (Maina & Mwangi, 2008).

2.2.3 Zinc

Zinc is such a critical element in human health that even a small deficiency is a disaster. Zinc supplementation is a powerful therapeutic tool in managing a long list of illnesses. Zinc is an essential trace mineral, is required for the metabolic activity of 300 of the body's enzymes, and is considered essential for cell division and the synthesis of DNA and protein. These enzymes are involved with the metabolism of protein, carbohydrate, fat and alcohol (Wong *et al.*, 2019). Zinc is also critical to tissue growth, wound healing, taste acuity, connective tissue growth and maintenance, immune system function, prostaglandin production, bone mineralization, proper thyroid function, blood clotting, cognitive functions, fetal growth and sperm production. Zinc is an essential nutrient that everybody needs but getting enough zinc is especially important for men, as a deficiency has been linked to lower testosterone levels (Bhowmik *et al*., 2010). Zinc also possesses an essential role in transcriptional regulation of the cellular metabolic network. Zinc balances body fluids' pH, and promotes collagen formation (for skin, hair, and nails); besides, it also assists in enhancing mental prowess and memory. Additionally, Zn discounts oxidative stress, apoptosis and aging, and other related immune responses (Prasad, 2014).

2.2.4 Magnesium

Magnesium serves as a cofactor for more than three hundred enzymes in the body and, as such, controls varied biochemical reactions as energy metabolism, protein synthesis, and neuromuscular impulse transmission. Furthermore, magnesium is important in regulating the physiological functions of the brain, heart and skeletal muscles; it also acts as a calcium antagonist, and has anti-inflammatory properties (Kamga, 2013). Magnesium is the fourth most common mineral in the human body after calcium, sodium, and potassium and is the second most common intracellular cation after potassium. Magnesium is necessary for the structural function of proteins, nucleic acids and the mitochondria, and is required for both aerobic and anaerobic energy production. It also plays a crucial role in the transport of calcium and potassium across cell membranes (Veena & Natalie, 2016).

Intake recommendations for magnesium and other nutrients have been provided by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), by the American National Academy of Medicine (NAM), previously called the Institute of Medicine (IoM), and by the European Food Safety Agency (EFSA). Dietary sources rich in magnesium are cocoa, nuts, whole seeds, unground grains, legumes and green leafy vegetables. The green part of the plants is particularly rich in magnesium because it constitutes the prosthetic ion in chlorophyll (Saris *et al*., 2000).

2.3 Proximate Analysis

Proximate Analysis is the partitioning of compounds in a plant extract into six categories based on the chemical properties of the compounds. The six categories are: moisture, ash, crude protein (or Kjeldahl protein), crude lipid, crude fibre and nitrogen-free extracts (digestible carbohydrates). Proximate and nutrient analysis of medicinal plants plays a crucial role in assessing their nutritional significance. As various medicinal plant species are also used as food along with their medicinal benefits, evaluating their nutritional significance can help to understand the worth of these plants species (Pandey *et al*., 2006). Carbohydrates, proteins and fats form the key portion of the diet, whereas minerals and vitamins form somewhat a minor part. As plants form main portion of our diet; so their nutritive value is imperative (Jimoh and Oladiji, 23 2005). Besides these biochemicals; the moisture, fiber, ash contents and the energy values of individual vegetable species have also been reported to be important to the human health as well as for soil quality (McSweeney *et al*., 2005)

2.3.1 Moisture Content of Vegetables

Moisture determination is one of the most important and most widely used measurements in the processing and testing of foods. Since the amount of dry matter in a food is inversely related to the amount of moisture it contains, moisture content is of direct economic importance to the processor and the consumer (Luoh, 2014). Of even greater significance, however, is the effect of moisture on the stability and quality of foods. Grain that contains too much water is subject to rapid deterioration from mold growth, heating, insect damage, and sprouting. The rate of browning of dehydrated vegetables and fruits increases with an increase in moisture content. Moisture or water content is a measurement of the total water contained in a food product, usually expressed as a percentage by weight on a wet basis. Although water activity is related to moisture content through the moisture sorption isotherm at a given temperature and humidity, this relationship is complex and is specific to the food product (Ndirangu *et al*., 2017). To avoid microbial growth, the moisture content and water activity must be kept below approximately 10% and 0.60–0.65, respectively (Mercer, 2008), depending on the type of food. Fresh foods, which are high in moisture content often have a water activity close to 0.99 and are particularly prone to microbial growth (Jay, Loessner & Golden, 2005).

2.3.1.1 Dry Method for Moisture Determination.

Thermal drying methods are usually used in the procedures for determining the moisture content stipulated in food standards. The material is heated to a certain temperature, and the weight loss is used to calculate the sample's moisture content. The type of oven, temperature, and drying time all affect the moisture value (Mibei, 2011). As a result, the methods provide estimated moisture values at the same time rather than precise ones. The rate of water evaporation from a solid phase's surface depends on the drying temperature and the water vapour pressure. This technique is known as loss on drying (LOD). This method is simple, relatively rapid, and permit the simultaneously analyzes of large number of samples (Ndirangu *et al*., 2017)

2.3.1.2 Distillation method for Moisture Determination

Methods for distillation are based on precise measurements of the water that has been evaporated from a food sample. In practice, evaporation methods rely on estimations of the water that has been evaporated from a food sample. In essence, distillation procedures entail heating weighted food samples while they are in the presence of an organic solvent that is insoluble in water (Mibei, 2011). The sample's water evaporates, is collected in a graduated glass tube, and its volume is calculated there. The method suitable for use on foods that include volatile oils, such as herbs or spices, because the oils stay dissolved in the organic solvent and do not affect the measurement of the water.

2.3.1.3 Determination of Moisture using Karl Fischer method

The Karl Fischer (KF) titration is a method of determining the water content of solid, liquid and gaseous samples. It is the technique preferred for use in industrial quality control. In principle it involves the oxidation of sulfur dioxide by iodine, in the presence of water, in a buffered solution. An alcohol is used as the preferred solvent. The water is converted stoichiometrically and therefore its quantity is determined indirectly (Felgner *et al*., 2008). The end-point (EP) is reached when there is an excess of iodine. HI is colorless, but I_2 is a dark reddish-brown hue, therefore there is a detectable change in color when water interacts with the additional chemical reagents. This is why the reaction was first used. Iodine and sulfur dioxide are gaseous substances that would typically evaporate out of solution. In order to retain the S_2O and I_2 in solution, solvents (such as C_5H_5N) have been added to the above-mentioned reaction, however the essential principles of the procedure remain the same (Schöffski & Strohm, 2006).

2.3.2 Ash Content of Vegetables

Ash refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in a foodstuff. The ash content is a measure of the total amount of minerals present within a food, whereas the mineral content is a measure of the amount of specific inorganic components present within a food, such as Ca, Na, and K (Bakkali, 2009).

There are two major types of ashing; first one is dry ashing, which is primarily for proximate composition and for some types of specific mineral analyses; it requires high temperature muffle furnace capable of maintaining temperatures of between 500 and 600ºC for many hours. Therefore, water and other volatile materials are vaporized and organic substances are burned in the presence of the oxygen in air to carbon (IV) Oxide, water and Nitrogen (Chatepa & Masamba, 2020). Most minerals are converted to oxides, sulfates, phosphates, chlorides or silicates as this method is based on the fact that minerals are not destroyed by heating, and that they have a low volatility compared to other food components. Second method is wet ashing (oxidation), which is used prior to the analysis of certain minerals using different techniques (Barin, 2012).

2.3.3 Crude Fibre Content of Vegetables

After the material has been treated under standard conditions with light petroleum, boiling dilute sulphuric acid, boiling dilute sodium hydroxide solution, dilute hydrochloric acid, alcohol, and ether, the organic residue left behind is known as crude fiber. The main components of crude fiber are cellulose and lignin (Whitney *et al*., 2005). Unprocessed fiber materials that, in theory, neither humans nor animals can digest. All vegetables have a significant amount of fibre, which indicates that they can support the maintenance of a healthy and functional digestive system. Fibre helps the body excrete waste and toxins more quickly, preventing them from remaining in the intestine or bowel for extended periods of time, where they could build up and cause a number of diseases (Afolabi *et al*.,2012).

2.3.4 Crude Fat Content in Vegetables

There is a lot of interest in dietary fat. Though for very different reasons, industrial food processors, government organizations, and consumers all have an intense interest in fat. In order to improve human health, consumers are concerned about consuming less cholesterol, saturated fat, and total fat (Chao *et al*., 1991). Food processors need to control fat because they have to meet consumer demands for lower-fat products (also known as "fat-free" or "low-fat" foods), control costs, and adhere to labeling regulations. For government organizations to guarantee accurate food production, appropriate techniques for determining fat content must be in place. The quantitative extraction and analysis of fat is far from simple, even though determining the amount of fat present is one of the most often carried out analyses in a food laboratory (Lumley and Colwell, 1991). The task of choosing an appropriate method for fat determination becomes more challenging for the analyst due to the growing availability of processed, composite, and novel foods.

2.3.5 Protein Content in Vegetables

Although protein is an essential nutrient, not all foods high in protein are equally beneficial, and you might not need as much as you think (Black *et al*., 2008). Protein is one of the three vitally important components, along with carbohydrates and fat. Protein is one of your body's "building blocks" because it is composed of over 20 amino acids, which help to form and repair muscle fiber. Adults should eat 0.8 grammes (g) of protein per kilogram of body weight or slightly more than 7 grammes per 20 pounds of body weight per day. It was estimated in 2005 that 20% of lowland children under five were overweight. Vegetables are major source of energy, nutrients, elements, protein, omega-3 fatty acids, and widely accessible energy for global agricultural production (Black *et al*., 2008).

2.3.5.1 Kheldahl method

The most widely used method for determining protein is still the Kjeldahl method. It was Kjeldahl who devised this technique. This method's fundamental idea is to estimate the total amount of nitrogen in food and then convert that nitrogen to protein percentage, assuming that all of the nitrogen in food is present as protein. Therefore, the actual percentage of nitrogen in food protein is calculated using a conversion factor (Sáez *et* *al*., 2013). The process involves heating a material with sulfuric acid, which causes the organic material to break down through oxidation and release reduced nitrogen in the form of ammonium sulfate. In this stage, the medium's boiling point is raised (from 337 °C to 373 °C) by adding potassium sulphate. The sample has finished its chemical breakdown when the medium, which was initially quite dark in color, has turned clear and colorless. After that, a tiny amount of sodium hydroxide is added to the solution during distillation, turning the ammonium salt into ammonia. Back titration is used to measure the amount of ammonia present, which in turn determines the amount of nitrogen present in the sample. A boric acid solution is dipped into the end of the condenser. After the acid and ammonia react, the remaining acid is titrated using a sodium carbonate solution and a methyl orange pH indicator (Barbano *et al*., 1990)

2.3.6 Carbohydrates Content in Vegetables

The majority of energy in food is derived from carbohydrates. The main energy source in the diet is carbohydrate. According to recommendations from the Institute of Medicine, 45–65% of total calories should come from carbs (3). Dietary Guidelines for Americans recommend eating a diet high in carbohydrates, which includes fruits, vegetables, grains, nuts, seeds, and dairy products. Meals high in carbohydrates are the only ones that provide resistant starch and dietary fiber (DRI, 2015).

Carbohydrate includes, polyhydroxy aldehydes, ketones, alcohols, acids, their simple derivatives and their polymers having linkages of the acetal type. Each of these three groups may be subdivided. Sugars may be monosaccharides, disaccharides, or polyols (sugar alcohols). All types of dietary carbohydrates are beneficial to human behavior and health when consumed. It is a crucial part of diets that promote health. It is an energy source and a significant modulator of behavior, the neurological system, and metabolism. Foods high in carbohydrates provide a variety of vital nutrients and metabolically active compounds that are crucial for maintaining health and preventing disease (Sucrose *et al*., 1998).

2.4 Heavy metals

Heavy metals are metallic and metalloids that have relatively high density and are toxic. Heavy metals contamination of soil and vegetables is currently a challenging environmental issue. Toxic or heavy metals are naturally occurring substances that are not good for human health. Conversely, they might negatively impact our surroundings and all living things, including your body. They may obstruct regular biological functions. They might attach themselves to proteins in your body that healthy minerals like zinc or magnesium would normally activate. They might lead to chronic symptoms by raising oxidative stress and inflammation (Lutsevich *et al*., 2010). There are present studies that have proved presence of some of the heavy metals in some of the vegetables such as lead, cadmium, nickel, cobalt, manganese etc. Many of these heavy metals are environmentally persistent and non-degradable contaminants. They exist in the vegetables as a result of deposition on the soil surface, then absorbed by the apoplast of plant roots and further distributed and accumulated into their edible and non-edible parts, posing an imminent danger to the food chain (Prasad *et al*.2021).

Other sources of contamination of heavy metals include use of untreated waste water for irrigation, pesticides, harvesting process, storage and the point of selling (Sharma *et al*., 2007) Vegetables are very important since they are high in fibre, antioxidants, minerals and vitamins. Therefore, it is important to take serious consideration on the heavy metals contamination since they are significant in food assurance. (Gupta *et al*., 2019). Toxic metals can accumulate in the body throughout life. There are other metallic element such as zinc and copper which are important nutrients and play a big role in the human health but excessive amount ingested can result adverse health effects. The continuous uptake of heavy metals could bio-concentrate and bio-magnify to toxic levels resulting in malfunction of certain organs of the body (Bernard & Gelas, 2014).

2.4.1 Copper

Copper is an essential nutrient for the survival of both plant and animals. Some studies have shown copper being involved in function of different enzymes. Studies have confirmed that copper is required for infant growth, host defense mechanism, bone strength, red and white cell maturation, iron transport, cholesterol metabolism, glucose metabolism and brain development (Manuel & Ricardo,1996). Intake of high doses of copper leads to acute toxicity which includes symptoms of gastric pain, vomiting and diarrhea. In areas with soft water, copper can leach from copper pipes and result in high copper concentrations in drinking water. Gastrointestinal disorders in infants have been seen in infants with intake of copper contaminated water containing 3.7mg/L (Dubinina *et al.*, 2023).

Copper contamination can also be found in plants as it enters the air, mainly through release during the combustion of fossil fuels. Copper in air will remain for a long period of time, before it gets precipitated and deposited. Copper accumulates in plants and animals when found in soils at high concentrations. (Lokeshwari & Chandrappa, 2006).

2.4.2 Lead

In many regions of the world, the extensive use of lead, a highly toxic metal, has resulted in environmental contamination and health issues. In a dry environment, lead appears as a bright silvery metal with a hint of blue. When exposed to air, it starts to tarnish and, depending on the circumstances, forms a complex mixture of compounds (Sharma & Dubey,2005). The primary sources of lead exposure are domestic sources, food and smoking, drinking water, and industrial processes. Lead was originally found in gasoline and house paint, but it was also found in lead bullets, plumbing pipes, pewter mugs, storage batteries, and other items.

Unlike other metals like zinc, copper, and manganese, which have biological functions, lead is an extremely toxic heavy metal that disrupts several physiological processes in plants. A high lead concentration speeds up the generation of reactive oxygen species, damages lipid membranes, damages chlorophyll and photosynthetic processes, and inhibits the plant's ability to grow as a whole (Najeeb *et al*., 2014). According to certain studies, lead can prevent tea plants from growing through decreasing biomass and lowering the quality of the tea's constituent parts (Yongsheng *et al*., 2011). Lead treatment causes extreme instability in ion uptake by plants, even at low concentrations. This instability results in significant metabolic changes in photosynthetic capacity and ultimately in a strong inhibition of plant growth.

2.4.3 Cadmium

Cadmium is a by-product of zinc production which humans or animals may get exposed to at work or in the environment. Once this metal gets absorbed by humans, it will accumulate inside the body throughout life. This metal can cause both acute and chronic intoxications in humans, who are primarily exposed through ingestion and inhalation. For several decades, cadmium deposited in the environment will persist in soils and sediments. These metals slowly accumulate in plants, where they concentrate and eventually find their way into the human body through the food chain (Mutlu *et al*., 2012). Because of its high rate of soil-to-plant transfer, cadmium is mostly found in fruits and vegetables (Satarug *et al*., 2011). Highly toxic and unnecessary, cadmium is known to negatively impact cellular enzymatic systems, cause oxidative stress, and cause nutritional deficiencies in plants (Irfan *et al*., 2013).

2.4.4 Chromium

Seventh most common element on Earth is chromium. In the environment, chromium can be found in various oxidation states, ranging from chromium (II) to chromium (VI). The two most prevalent forms of chromium are hexavalent and trivalent, both of which are poisonous to humans, animals, and plants (Mohanty & Kumar Patra, 2013). Oil and coal combustion, petroleum derived from ferro cromate refractory material, pigment oxidants, catalysts, chromium steel, fertilizers, oil well drilling, and metal plating tanneries are among the natural processes that produce chromium. Anthropogenically, fertilizers and sewage discharge chromium into the environment (Ghani, 2011). In the metallurgy, electroplating, paint and pigment manufacturing, tanning, wood preservation, chemical manufacturing, and pulp and paper manufacturing industries, chromium is widely used. These sectors contribute significantly to chromium pollution, which negatively impacts ecological and biological species (Ghani, 2011).

Many industrial and agricultural practices raise the level of toxicity in the environment, raising concerns about chromium pollution. The biggest worry in recent years has been chromium pollution, especially from hexavalent chromium (Zayed & Terry, 2003). When plants consume these plant materials, the excess chromium beyond the permissible limit enters the food chain and negatively impacts the biological components of the plant. Reduced biomass, leaf chlorosis, decreased root growth, and inhibited seed germination are typical symptoms of Cr phytotoxicity. The biological processes of many plants, including maize, wheat, barley, cauliflower, citrullus, and vegetables, are significantly impacted by chromium toxicity. Plants that are poisoned by chromium experience necrosis and chlorosis Chromium toxicity affects iron-containing enzymes such as catalase, peroxidase, and cytochrome oxidase (Ghani, 2011).

2.4.5 Atomic Absorption Spectrometry

Atomic absorption spectrometry (AAS) is an analytical technique that measures the concentrations of elements. Atomic absorption is so sensitive that it can measure down to parts per billion of a gram (µg dm^3) in a sample. The technique makes use of the wavelengths of light specifically absorbed by an element. They correspond to the energies needed to promote electrons from one energy level to another, higher, energy level. Atoms of different elements absorb characteristic wavelengths of light (Orech, 2007). Analyzing a sample to see if it contains a particular element means using light from that element. For example, with lead, a lamp containing lead emits light from excited lead atoms that produce the right mix of wavelengths to be absorbed by any lead atoms from the sample. In AAS, the sample is atomized, it is converted into ground state free atoms in the vapor state and a beam of electromagnetic radiation emitted from excited lead atoms is passed through the vaporized sample. Some of the radiation is absorbed by the lead atoms in the sample (Nephelometer, 2004).

A typical atomic absorption instrument holds several lamps each for a different element. The lamps are housed in a rotating turret so that the correct lamp can be quickly selected. A monochromator is used to select the specific wavelength of light, it is a spectral line which is absorbed by the sample, and to exclude other wavelengths. The selection of the specific light allows the determination of the selected element in the presence of others. The light selected by the monochromator is directed onto a detector that is typically a photomultiplier tube. This produces an electrical signal proportional to the light intensity (L’vov, 2005).

Two systems are commonly used to produce atoms from the sample. Aspiration involves sucking a solution of the sample into a flame; and electro thermal atomization is where a drop of sample is placed into a graphite tube that is then heated electrically. Some instruments have both atomization systems but share one set of lamps. Once the appropriate lamp has been selected, it is pointed towards one or other atomization system (Oduor, 2014). The absorption obeys Beer's law. The most commonly-used primary radiation sources are the hollow-cathode lamp (HCL) and the electrode less discharge lamp (EDL). They both belong to low pressure discharges. The hollow-cathode lamp consists of a hollow cathode made of a highly pure metal whose spectrum is to be produced with an inner diameter in the 2-5 mm range (Paul, 2014). Sample preparation is often simple, and the chemical form of the element is usually unimportant. This is because atomization converts the sample into free atoms irrespective of its initial state. The sample is weighed and made into a solution by suitable dilution (Welz & Sperling, 2008)

CHAPTER THREE
MATERIALS AND METHODS
3.1 Location of the Study

The study was carried out in three regions namely; Kianyaga, Karumande and Kiandai in Kirinyaga East sub-county, Kirinyaga County as shown in figure 5. Kirinyaga County borders Nyeri County, Murang`a County and Embu County. It covers a total area of 1478 km^2, of which 308 km^2 is covered by forest. The county lies between 1,158 and 5,380 metres above sea level in the South and at the Peak of Mt. Kenya respectively. The county has five constituencies namely Mwea, Gichugu (Kirinyaga East), Ndia (Kirinyaga West), and Kirinyaga Central. The county has six rivers namely Sagana, Nyamindi, Rupingazi, Thiba, Ragati and Rwamuthambi all channeled to Tana River. The county is divided into three ecological zones: the lowland, which includes areas between 1158 and 2000 meters above sea level, the midland, which includes areas between 2000 and 3400 meters above sea level, and the highland, which includes areas above 3400 meters to 5380 metres above sea level. Kirinyaga County lies at 0° S 28.4452' latitude and 37^{o} E 14.1923' longitude (Narita *et al*., 2020). The type of soil in Kirinyaga area is loam soil, it is considered ideal for gardening and agricultural uses because it retains nutrients well and retain water while allowing excess water to drain away. There are two distinct rainy seasons in the county: the long rains, which fall from March to May and have an average depth of 2,146 mm, and the short rains, which fall from October to November and have an average depth of 1,212 mm. Rainfall decreases as one moves eastward along the semi-arid zones in the Mwea constituency from the high-altitude slopes of Mount Kenya. During the hot season, the mean temperature varies from 8.1°C in the upper zones to 30.3^{o}C in the lower zones (Mathew, 2019). It is endowed with a forest cover which is inhabited by a variety of wildlife including elephants, buffaloes, monkeys, bushbucks and colorful birds while the lower parts of the forest zone provide grazing land for livestock.

Kirinyaga County grows some of the best coffee in the world, tea, French beans, vegetables like African nightshade, cowpeas, amaranth and best aromatic rice in the East Africa region. Moreover, the county boasts of agricultural exports such as horticulture and macadamia. Kirinyaga County economy is highly dependent on the performance of the agricultural sector (Mathew *et al*.,2019). The performance of the main cash crops that is tea and coffee have a direct impact on the livelihoods.

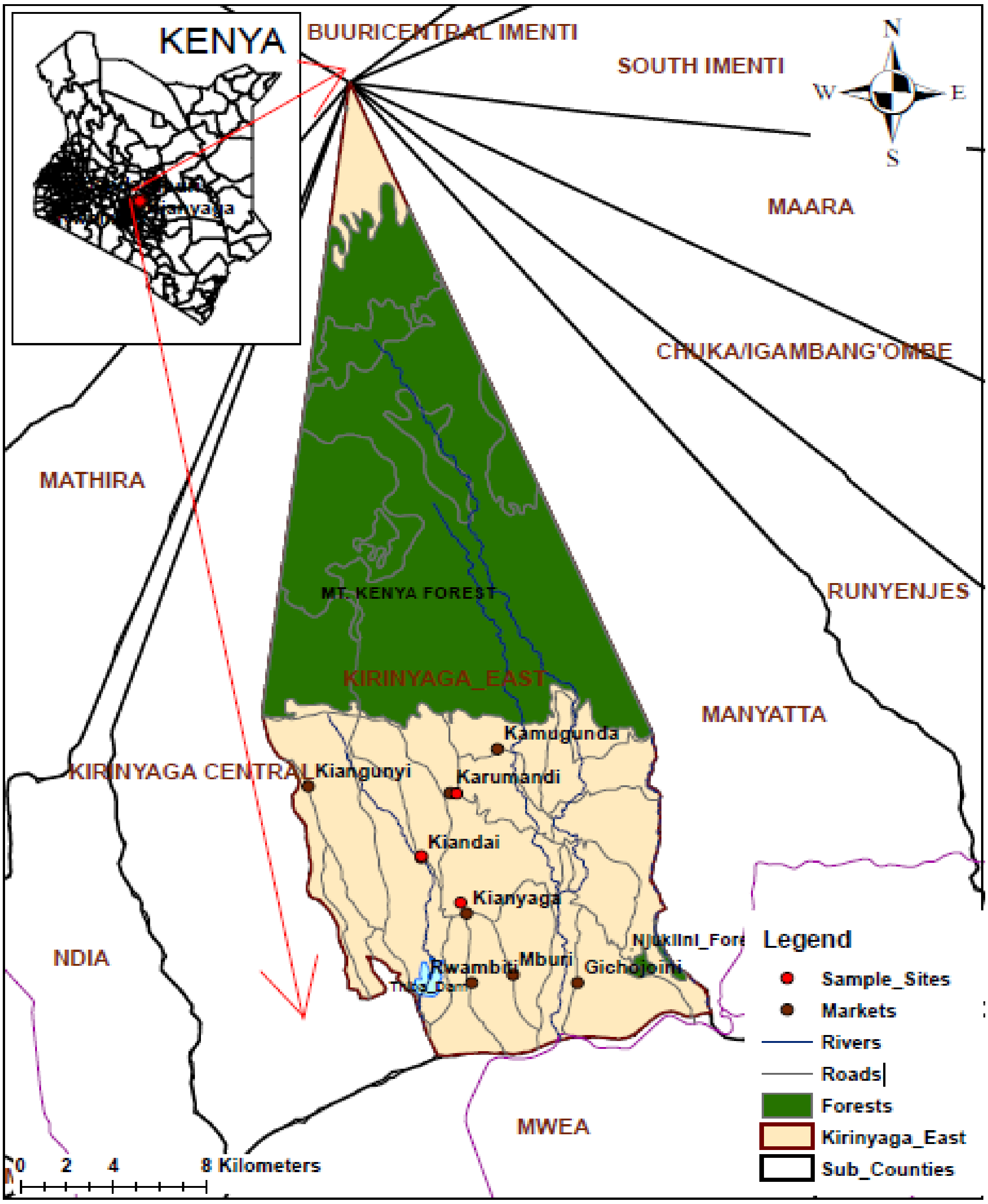

Figure 5: Map of Kirinyaga County (Mathew *et al*., 2019)

3.2 Research Design

This study was adopted from Randomized Block Design (RBD) which is ideal for enhancing the accuracy and generalizability of the findings. This design was appropriate for studies since variability in environmental or agronomic factors may influence the results. In this case, samples of selected indigenous vegetables were collected from three distinct locations within Kirinyaga East Sub-County (Kianyaga, Karumandi, and Kiandai), each serving as a block. The RBD helped to minimize the effect of uncontrolled environmental and soil-related factors across these locations by grouping similar experimental units together.

Vegetable samples were collected randomly within each block to ensure representativeness, and each sample was analyzed independently for micronutrient content, heavy metal contamination, and proximate composition. Randomization within blocks will help eliminate bias and confounding variables, ensuring that any observed differences in nutrient or contaminant levels can be more reliably attributed to the type of vegetable rather than to environmental variation.

The choice of Kirinyaga East Sub-County as the study area is deliberate. This region is known for its rich agricultural activity and diversity in indigenous vegetable production and they provided consistent access to the four African indigenous vegetables under study. However, despite the popularity and availability of these vegetables, their nutritional and safety profiles are under-documented. Additionally, the sub-county's varying soil types, climatic conditions, and farming practices present a unique opportunity to assess how these factors influence the nutritional and toxicological composition of the vegetables.

3.3 Sample Collection and Preparation

3.3.1 Sampling Collection

To control for environmental variability and ensure representative sampling across different agro-ecological zones, a Randomized Block Design (RBD) was used for sample collection. The three selected regions within Kirinyaga East Sub-County, Kianyaga, Karumandi, and Kiandai each served as a block in the experimental design. Within each block, four selected African indigenous vegetables (African nightshade (*Solanum scabrum*), Spider plant (*Cleome gynandra*), Vine spinach (*Basella alba*), and Pumpkin leaves (*Cucurbita maxima*)) was targeted for sampling.

In each of the three blocks (locations), farms growing the target vegetables was identified. Within each farm, a plot was divided into smaller strata (grids or rows). From

these strata, a random selection method (random number table) was used to select sampling points. For each vegetable species, 10 individual samples was randomly collected within each block (location). This results in:
3 (blocks) × 4 (vegetables) ×10 (samples) = 120 total samples

The samples were collected at physiological maturity, selecting only healthy, pest-free and disease-free leaves for analysis. These ten samples per indigenous vegetable in each block were then pooled to form a one composite sample per vegetable per block composite sample for each vegetable species within each block. This resulted to 12 composite samples for the laboratory analysis:
3 Blocks × 4 Vegetable Species = 12 Composite Samples
This procedure minimized biasness, allowing control for block effects (environmental variation), and enhanced statistical power during analysis.

3.3.2 Sample Preparation

Each sample was placed in a clean, labeled polyethylene bag indicating the vegetable species, location, date of collection, and sample code. Samples were immediately placed in cooler boxes to prevent deterioration and transported to the laboratory at Chuka University. In the lab, samples were gently washed with distilled water to remove soil and debris, and air-dried at room temperature until constant weight is achieved. Dried samples were grounded into fine powder using a clean laboratory mill and stored in air-tight containers in a cool, dry place until analysis.

3.3.2.1 Determination of Nutrient Content in Plant Leaves

A mass of 2g of dried leaves was weighed on analytical balance and transferred to beaker. The samples were then treated with 20ml HNO_3. Each sample was placed directly on the hot plate then one ml of 30% H_2O_2 and 5ml of HNO_3 solution was added for digestion procedure. This ensures that the elements of interest are present in a form suitable for analysis. In the first step, temperature was increased linearly from 25◦ C to 90◦ C in four minutes. In the second step, temperature was held constant at 90◦ C for two minutes. The samples were then covered for six minutes. In the last step temperature was held constant at 90˚C for 10 minutes. After about 30 minutes of digestion, the brown fumes ceased and the samples were cooled for 30 minutes and then

10 ml of distilled water was added to the clear solution. The clear sample solution was filtered and topped to 100ml with distilled water. Elemental analyses (Fe, Zn, Ca, Mg, Pb, Cd) were performed using a Shimadzu AA-7000 Atomic Absorption Spectrophotometer (Shimadzu Corporation, Kyoto, Japan) equipped with a deuterium background corrector and appropriate hollow-cathode lamps. Samples were measured using an air–acetylene flame; detection limits and operating wavelengths followed manufacturer recommendations.

For blank sample 10ml of distilled water was used and 20ml of HNo3 was added to the same beaker. The blank sample was placed directly on the hot plate then one ml of 30% H_2O_2 and 5ml of HNO_3 solution was added for digestion procedure. In the first step, temperature was increased linearly from 25◦ C to 90◦ C in four minutes. In the second step, temperature was held constant at 90◦ C for two minutes. The blank samples were then covered for six minutes. In the last step temperature was held constant at 90°C for 10 minutes. After about 30 minutes of digestion, the brown fumes ceased and the blank sample was then cooled for 30 minutes and then 10 ml of distilled water was added to the clear solution. The clear blank sample solution was filtered and topped to 100ml with distilled water.

For standard preparation of calcium 0.249 g of calcium carbonate was suspended in water and dissolved with a minimum of 1:1 nitric acid. 10 ml of concentrated nitric acid was added then made up to 1000 ml with deionized water. For iron preparation, 0.700 g of $FeSO_4$ $(NH_4)2SO_4.6H_2O$ was dissolved in a mixture of 10 ml 50% (v/v) hydrochloric acid and 3 ml of concentrated hydrochloric acid and made up to 1000 ml with deionized water. For Magnesium preparation, 0.165 g MgO, was dissolved in a minimum 10ml of 50% (v / v) HNO_3 and made up to 1000 ml with deionized water. For the case of Zinc preparation, 0.191 g of ZnCl was dissolved in deionized water and made up to 1000 ml with deionized water. For lead standard preparation 0.4g of $Pb(NO_3)_2$ was dissolved in water containing 2ml of HNO_3 top up with deionized water to make 250ml (García & Baez, 2012). For cadmium standard preparation ,100mg of pure cadmium sulphate was dissolved in a solution of 20ml distilled water and 5ml concentrated HCl then it was slightly heated for the metal to dissolve. The mixture was dissolved further with distilled water to make 1000ml stock.

3.3.2.2 Determination of Ash Content

Dry ashing method of the vegetables was used for determination of the total ash (Yang *et al*., 2013) by use of muffle furnace as shown in figure 6. An empty crucible was weighed and 2g sample was added then reweighed. It was then ignited in a muffle furnace at a temperature of 550 °C for 4hrs. Muffle furnace was turned off and opened once the temperature drops to below 250 °C. The door was carefully opened to avoid losing ash that may be fluffy. The crucible and its contents was removed from the muffle furnace and placed in a desiccator and allowed to cool completely. The cold crucible and its content was transferred from the desiccators and reweighed (Nielsen & Ismail, 2017).

$$Ash\ Content\ (\%) = \frac{W2 - W1}{W0} \times 100$$

Where:

W_0= Weight of the sample taken (g)

W_1= Weight of empty crucible (g)

W_2= Weight of crucible + ash after ignition.

Figure 6: Muffle Furnace

3.3.2.3 Determination of Moisture Content

The loss on drying (LOD) method was used for determining the moisture content in selected indigenous vegetables. A mass of 20g of each sample was weighed into a 250ml beaker. The empty beaker was first dried in an oven for 2hrs and weighed. The sample was then introduced into the beaker and heated in an oven for 8hrs at 105°C until a constant weight was achieved. It was cooled in dry atmosphere of a desiccator, reweighed and measured into constant weight (Pomeranz & Meloan, 1994). The moisture content was calculated as follows;

For fresh basis:

$$Moisture\ content(\%) = \frac{W1 - W2}{W1} \times 100$$

Where:

W1= Weight of the sample before drying (g)

W2= Weight of the sample after drying (g)

For Dry basis:

$$Moisture\ content(\%) = \frac{W1 - W2}{W2} \times 100$$

Where:

W1= Weight of the sample before drying (g)

W2= Weight of the sample after drying (g)

3.3.2.4 Determination of Crude Fibre Content

Crude fibre was analyzed following the Muslin cloth method. The crucibles were prepared by heating for 30 minutes in a furnace regulated at 550ºC then cooled. 2g of the grounded sample was weighed into 1 litre conical flask. 200ml of 2.5% H_2SO_4 solutions was added to each sample in the flask and gently boiled for 30 minutes maintaining constant volume by the use of boiling chips and rotating the flask every few minutes to ensure that the particles of sample on the side of the flask was brought into the boiling medium thus also enhancing thorough mixing. The hot solution was allowed to cool and filtered through linen cloth stretched over a funnel. The residues will thoroughly be washed with hot water, 10% hydrochloric acid until neutral to litmus. It will then be finally washed with 1% ethanol followed by diethyl ether. The remaining insoluble matter was quantitatively transferred after acid digestion into the original flask and 200ml of hot 2.5% sodium hydroxide solution was added. Taking the same precaution as observed in the acid digestion, the mixture was boiled for exactly 30 minutes, allowed to stand for 1 minute and filtered immediately as before. Each insoluble residue was washed with hot water until it was base free then dried to a constant weight in an oven at 100ºC for 2hours, cooled in desiccators and weighed. Ashing of the sample was then done at 550C in a muffle furnace for 2hr to grayish ash, cooled in a desiccator and finally weighed (Chiteva & Wairagu, 2013).

Calculation:

Weight of sample = C

Weight of crucible with dry residue = B

Weight of crucible with ash = A

$$\text{Crude fibre}(\%) = (A - B)/C \times 100$$

3.3.2.5 Determination of Crude Fat in Vegetables

This estimation was performed using the Soxhlet extraction method as shown in figure 7. 3 gm of sample was weighed into the thimble/flask. The sample was dried in an oven at 102ºC for 5 hrs then the thimble was inserted in a Soxhlet liquid/solid extractor. A clean dry 150 ml round bottom flash was weighed and 90 ml of petroleum ether was poured into the flask. The extraction unit was assembled over in an electric heating mantle or a water bath. The solvent was heated in the flask until it boils, the heat source was adjusted so that solvent drips from the condenser into the sample chamber. The extraction process continued for 2hours 30min. The extraction unit was removed from the heat source and the extractor and condenser detached then the flask on the heat source was replaced and the solvent evaporated off. The flask was placed in an oven at 105ºC for 30 minutes & the contents was dried until constant weight. (Almazan & Adeyeye, 1998).

The flask and the content was cooled in a desiccator & weighed.

Calculation of % crude fat

Weight of empty flask (g) = W1

Weight of flask and extracted fat (g) = W2

Weight of sample = S

$$\text{Crude fat}(\%) = (W2 - W1) \times 100/S$$

Figure 7: Soxhlet Extractor Apparatus

3.3.2.6 Determination of Protein in Vegetables

The crude protein was determined by the Kheldahl method. The determination of crude protein involved three steps namely; digestion, distillation and titration.

3.3.2.6.1 Digestion

Approximately 2.0 g of the dried and ground vegetable sample was weighed accurately into a clean, dry Kjeldahl digestion flask. To each flask, 10 g of anhydrous potassium sulfate (K_2SO_4) and 0.5 g of copper sulfate ($CuSO_4$) were added as catalysts, followed by 20 mL of concentrated sulfuric acid (H_2SO_4). The mixture was gently swirled and placed on a Kjeldahl digestion block preheated to 420°C. Digestion continued until the solution became clear, indicating complete oxidation of organic matter and conversion of nitrogenous compounds into ammonium sulfate $(NH_4)_2SO_4$. After cooling, the digest was transferred quantitatively into a 100 mL volumetric flask and diluted to the mark with distilled water.

3.3.2.6.2 Distillation

A mixture of 15 ml of hydrochloric acid and 70 ml of water was accurately measured to form acid standard solution then added to the titration flask. For reagent blank, 1 ml of acid and approximately 85 mL water was added followed by three to four drops of methyl red indicator solution. In addition, two to three drops of tributyl citrate, an antifoam agent was added to digestion flask to reduce foaming. This was followed by addition of another 1g aluminium oxide granule. Sufficient 45% sodium hydroxide solution (approximately 80 mL) was added to make mixture strongly alkali on the side of flask slowly. The flask was connected to distillation apparatus and distilled until at least 150 ml distillate was collected in titrating flask (AOAC, 1990).

3.3.2.6.3 Titration

The collected distillate was titrated with 0.1 N hydrochloric acid (HCl) until the color changed from green to pink, indicating the endpoint. A reagent blank was also prepared and titrated under the same conditions. The amount of nitrogen in the sample was calculated using the formula below:

Calculation of Nitrogen percentage:

$$\%N = (1.4007 \times (Va - Vb) \times N)/W$$

Given that:

Va is volume of acid used for sample titration.

Vb is volume of acid used for the blank.

N is the Normality of acid

W is the sample weight in grams.

1.4007 is the conversion factor milliequivalent weight of nitrogen and N percentage

Calculation percent crude protein (CP):

$$\text{Crude Protein (Dry matter basis)} = \%\ \text{normality dry matter basis(N) X F;}$$

where F = 6.25 (AOAC, 1990).

3.3.2.7 Determination of Carbohydrates

The carbohydrate content was determined by subtracting the summed-up percentage compositions of moisture, ash, protein, crude fat and crude fibre contents from 100% (Otitoju, 2009).

3.4 Data Analysis

The analysis was conducted using SPSS Statistics version 26, which provides robust tools for both descriptive and inferential statistical analysis suitable for scientific research. Descriptive statistics was used to summarize and describe the central tendency and variability of the nutrient and heavy metal concentration data across the vegetable species and study locations. To determine whether significant differences exist among the mean values of the various parameters measured (micronutrients, heavy metals, proximate content), a One-Way Analysis of Variance (ANOVA) was conducted. This will allow comparison of chemical properties across different vegetable species and sampling blocks (locations). A Tukey's Honest Significant Difference (HSD) post hoc test was applied to identify specific group differences.

3.5 Ethical Consideration

Permission to conduct the study was granted by the Chuka University Ethics Review Committee, ensuring that the research complied with the institution's ethical standards as attached in the appendices. In addition, a research license was issued by the National Commission for Science, Technology and Innovation (NACOSTI) (Appendix VII) to conduct this study as attached in the appendices.

CHAPTER FOUR

RESULTS

4.1 Atomic Absorption Spectrometry (AAS)

The following shows the mean concentration of four minerals (Fe, Zn, Ca &Mg) and two heavy minerals (Cd & Pb) analyzed using AAS in three different areas (Kiandai, Kianyaga & Karumande).

4.1.1 Concentration of Iron (Fe)

Calibration of the atomic absorption spectrometer was performed using a series of iron standard solutions prepared in accordance with approved method. Absorbance values were plotted against known concentrations to generate a calibration curve, which exhibited excellent linearity ($R^2 = 0.9999$) within the analytical range as shown in appendix IV(a). The slope of the curve reflected the method sensitivity, while the intercept corresponded to baseline absorbance. The calibration curve served as the basis for quantitative determination of analyte concentrations in unknown samples, ensuring measurement accuracy and traceability

4.1.1.1 Concentration Levels of Iron in African Nightshade

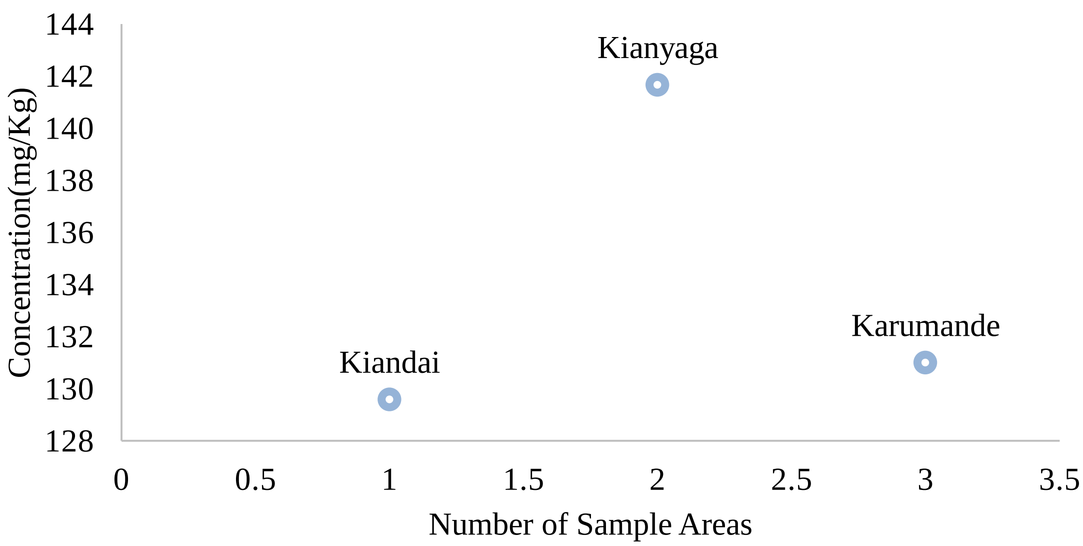

Figure 8: Mean concentration of iron in African Nightshade.

The mean concentration of Fe was highest in Kianyaga area (141.66mg/kg) and lowest in Kiandai area (129.58 mg/kg) as shown in Table 2.

Table 2: Concentration of Fe in African nightshade in Kianyaga, Kiandai & Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A - B	Volume of sample	Conc. Mg/kg	Mean
African Night shade (Kiandai)	2	0.3173	2.6358284	0	2.6358284	2	131.79142	
African Night shade (Kiandai)	2	0.3068	2.5475189	0	2.5475189	2	127.37595	
African Night shade (Kiandai)	2	0.312	2.5912532	0	2.5912532	2	129.56266	129.5767
African Night shade (Kianyaga)	3	0.3411	2.8359966	0	2.8359966	2	141.79983	
African Night shade (Kianyaga)	3	0.3404	2.8301093	0	2.8301093	2	141.50547	
African Night shade (Kianyaga)	3	0.3408	2.8334735	0	2.8334735	2	141.67368	141.6597
African Night Shade(Karumande)	11	0.3147	2.6139613	0	2.6139613	2	130.69807	
African Night Shade(Karumande)	11	0.3161	2.6257359	0	2.6257359	2	131.2868	
African Night Shade(Karumande)	11	0.3154	2.6198486	0	2.6198486	2	130.99243	130.9924

4.1.1.2 Concentration of iron in Spider Plant

The mean concentration of Fe was highest in Kianyaga area (233.53 mg/kg) and lowest in Kiandai area (123.17 mg/kg) as shown in table 3.

Table 3: Concentration of Iron in Spider Plant in Kianyaga, Kiandai & Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Spider plant (Kianyaga)	5	0.5581	4.6610597	0	4.6610597	2	233.05299	
Spider plant (Kianyaga)	5	0.5604	4.6804037	0	4.6804037	2	234.02019	
Spider plant (Kianyaga)	5	0.5592	4.6703112	0	4.6703112	2	233.51556	233.5296

Table 3: Concentration of Iron in Spider Plant in Kianyaga, Kiandai & Karumande. (Continued)

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Spider plant(Karumande)	7	0.3749	3.1202691	0	3.1202691	2	156.01346	
Spider plant(Karumande)	7	0.3743	3.1152229	0	3.1152229	2	155.76114	
Spider plant(Karumande)	7	0.3746	3.117746	0	3.117746	2	155.8873	155.8873
Spider plant (Kiandai)	9	0.294	2.4398654	0	2.4398654	2	121.99327	
Spider plant (Kiandai)	9	0.2996	2.4869638	0	2.4869638	2	124.34819	
Spider plant (Kiandai)	9	0.2968	2.4634146	0	2.4634146	2	123.17073	123.1707

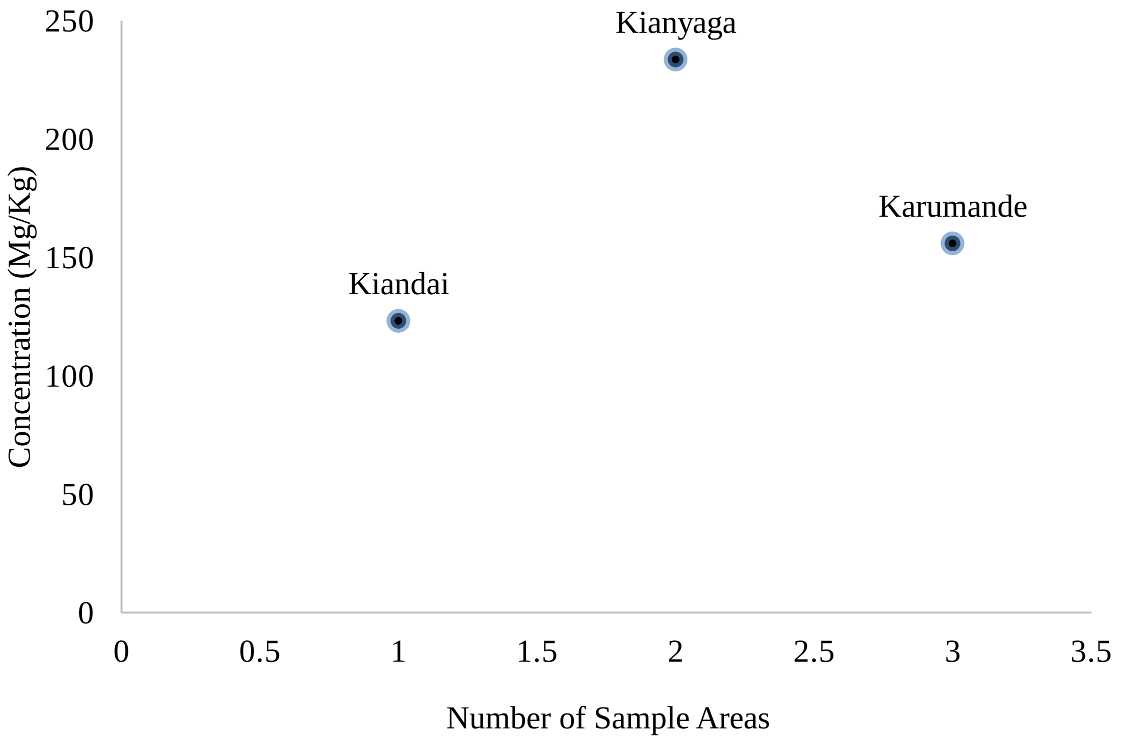

Figure 9: Mean concentration of iron in Spider Plant

4.1.1.3 Concentration of Iron in Vine Spinach

The mean concentration of Fe was highest in Karumande area (135.72 mg/kg) and lowest in Kiandai area (98.65 mg/kg) as shown in Table 4.

Table 4: Concentration of Iron in Vine Spinach in Kianyaga, Kiandai & Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A - B	Volume of sample	Conc. Mg/kg	Mean
Vine spinach (Kianyaga)	4	0.2802	2.3238015	0	2.3238015	2	116.19008	
Vine spinach (Kianyaga)	4	0.2784	2.3086627	0	2.3086627	2	115.43314	
Vine spinach (Kianyaga)	4	0.2793	2.3162321	0	2.3162321	2	115.81161	115.8116
Vine spinach (Kiandai)	8	0.2385	1.9730866	0	1.9730866	2	98.654331	
Vine spinach (Kiandai)	8	0.2385	1.9730866	0	1.9730866	2	98.654331	
Vine spinach (Kiandai)	8	0.2385	1.9730866	0	1.9730866	2	98.654331	98.65433
Vine spinach(Karumande)	10	0.3249	2.6997477	0	2.6997477	2	134.98738	
Vine spinach(Karumande)	10	0.3284	2.7291842	0	2.7291842	2	136.45921	
Vine spinach(Karumande)	10	0.3266	2.7140454	0	2.7140454	2	135.70227	135.7163

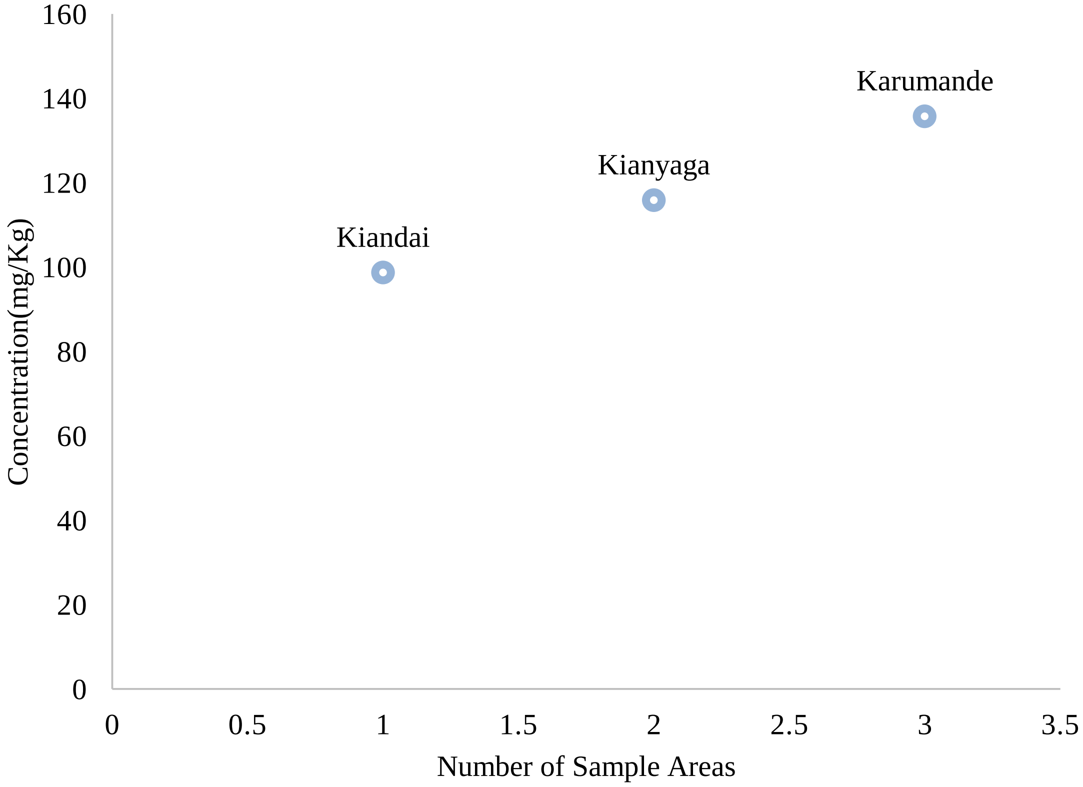

Figure 10: Mean concentration of iron in Vine Spinach

4.1.1.4 Concentration of iron in Pumpkin leaves

The mean concentration of Fe was highest in Kiandai area (175.02 mg/kg) and lowest in Kianyaga area (129.30 mg/kg) as shown in Table 5.

Table 5: Concentration of Iron in Pumpkin Leaves in Kianyaga, Kiandai & Karumande.

Sample Location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A - B	Volume of sample	Conc. Mg/kg	Mean
Pumpkin Leaves (Kianyaga)	12	0.3063	2.5433137	0	2.5433137	2	127.16569	
Pumpkin Leaves (Kianyaga)	12	0.3164	2.628259	0	2.628259	2	131.41295	
Pumpkin Leaves (Kianyaga)	12	0.3114	2.5862069	0	2.5862069	2	129.31034	129.2963
Pumpkin leaves(Kiandai)	6	0.4175	3.4785534	0	3.4785534	2	173.92767	
Pumpkin leaves(Kiandai)	6	0.4227	3.5222876	0	3.5222876	2	176.11438	
Pumpkin leaves(Kiandai)	6	0.4201	3.5004205	0	3.5004205	2	175.02103	175.021
Pumpkin Leaves(Karumande)	13	0.342	2.843566	0	2.843566	2	142.1783	
Pumpkin Leaves(Karumande)	13	0.3399	2.8259041	0	2.8259041	2	141.29521	
Pumpkin Leaves(Karumande)	13	0.341	2.8351556	0	2.8351556	2	141.75778	141.7438

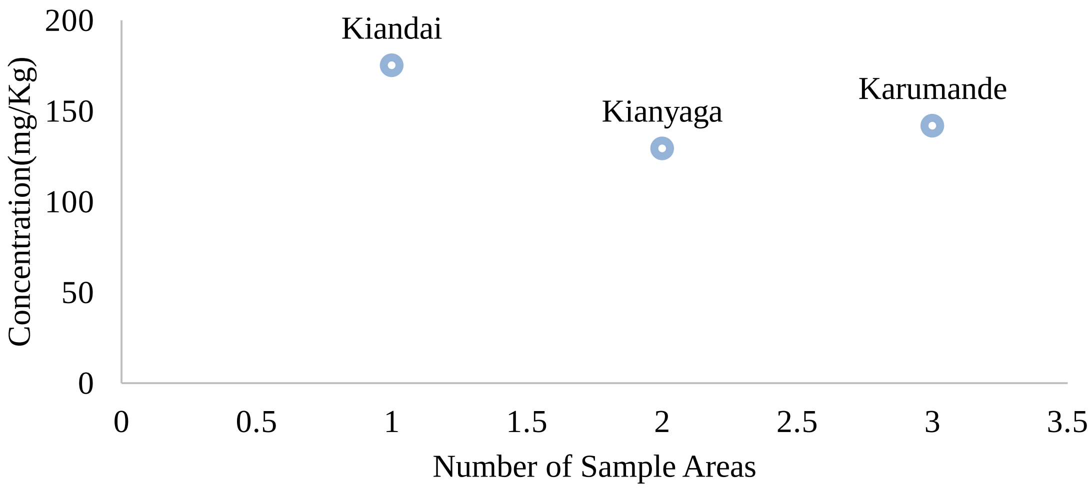

Figure 11: Mean concentration of iron in Pumpkin Leaves.

4.1.2 Concentration of Zinc (Zn)

The calibration curve for Zinc standards demonstrated excellent linearity (R^2= 0.9975), indicating that the atomic absorption spectrometer responded proportionally across the tested concentration range as shown in appendix IV(b). This strong correlation between absorbance and concentration confirmed the suitability of the method for accurate zinc quantification. Consequently, the zinc concentrations obtained for the analyzed samples can be considered reliable, with minimal likelihood of systematic bias arising from instrument calibration.

4.1.2.1 Concentration of Zinc in African Nightshade

The mean concentration of Zinc was highest in Kiandai (483.33 mg/kg) and lowest in Karumande (436.88 mg/kg) as shown in Table 6.

Table 6: Concentration of Zinc in African Nightshade in Kiandai Kianyaga & Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A - B	Volume of sample	Conc. Mg/kg	Mean
African Night shade (Kiandai)	2	0.3052	9.8920635	0.215873	9.6761905	2	483.80952	
African Night shade (Kiandai)	2	0.3046	9.8730159	0.215873	9.6571429	2	482.85714	
African Night shade (Kiandai)	2	0.3049	9.8825397	0.215873	9.6666667	2	483.33333	483.3333
African Night shade (Kianyaga)	3	0.305	9.8857143	0.215873	9.6698413	2	483.49206	
African Night shade (Kianyaga)	3	0.3039	9.8507937	0.215873	9.6349206	2	481.74603	
African Night shade (Kianyaga)	3	0.3044	9.8666667	0.215873	9.6507937	2	482.53968	482.5926
African Night Shade(Karumande)	11	0.2754	8.9460317	0.215873	8.7301587	2	436.50794	
African Night Shade(Karumande)	11	0.2759	8.9619048	0.215873	8.7460317	2	437.30159	
African Night Shade(Karumande)	11	0.2756	8.952381	0.215873	8.7365079	2	436.8254	436.8783

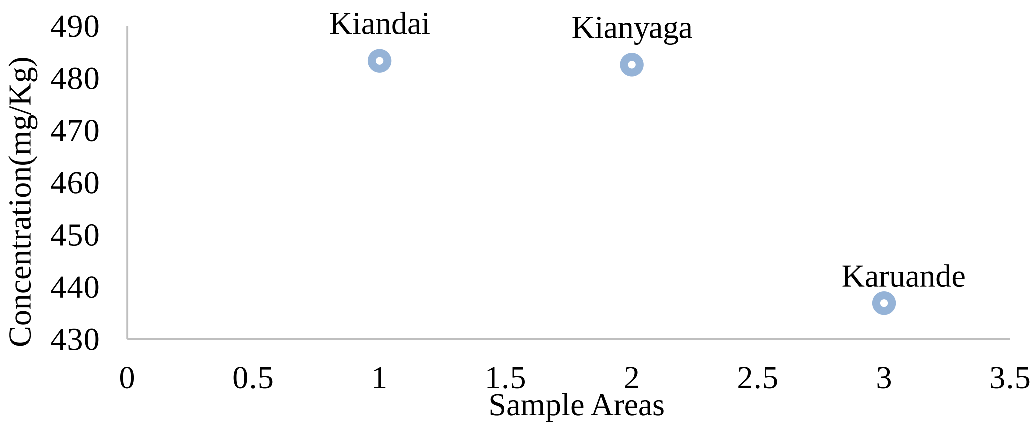

Figure 12: Mean concentration of zinc in African nightshade

4.1.2.2 Concentration of Zinc in Spider Plant

The mean concentration of Zinc was highest in Karumande (746.03 mg/kg) and lowest in Kiandai (710.53 mg/kg) as shown in Table 7.

Table 7: Concentration of Zinc in Spider plant in Kiandai Kianyaga & Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Spider plant (Kianyaga)	5	0.4677	15.050794	0.215873	14.834921	2	741.74603	
Spider plant (Kianyaga)	5	0.4647	14.955556	0.215873	14.739683	2	736.98413	
Spider plant (Kianyaga)	5	0.4662	15.003175	0.215873	14.787302	2	739.36508	739.3651
Spider plant(Karumande)	7	0.4693	15.101587	0.215873	14.885714	2	744.28571	
Spider plant(Karumande)	7	0.4715	15.171429	0.215873	14.955556	2	747.77778	
Spider plant(Karumande)	7	0.4704	15.136508	0.215873	14.920635	2	746.03175	746.0317
Spider plant (Kiandai)	9	0.4503	14.498413	0.215873	14.28254	2	714.12698	
Spider plant (Kiandai)	9	0.4458	14.355556	0.215873	14.139683	2	706.98413	
Spider plant (Kiandai)	9	0.448	14.425397	0.215873	14.209524	2	710.47619	710.5291

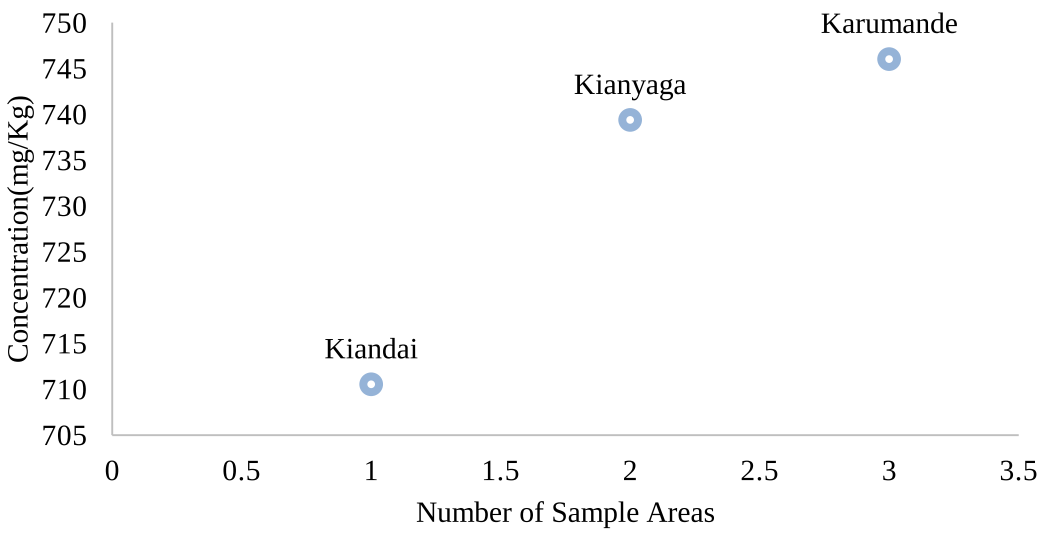

Figure 13: Mean concentration of Zinc in Spider Plant.

4.1.2.3 Concentration of Zinc in Vine Spinach

The mean concentration of Zinc was highest in Kianyaga (534.76 mg/kg) and lowest in Kiandai (513.02 mg/kg) as shown in Table 8.

Table 8: Concentration of Zinc in Vine spinach in Kiandai Kianyaga & Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Vine spinach (Kianyaga)	4	0.3386	10.952381	0.215873	10.736508	2	536.8254	
Vine spinach (Kianyaga)	4	0.336	10.869841	0.215873	10.653968	2	532.69841	
Vine spinach (Kianyaga)	4	0.3373	10.911111	0.215873	10.695238	2	534.7619	534.7619
Vine spinach (Kiandai)	8	0.3242	10.495238	0.215873	10.279365	2	513.96825	
Vine spinach (Kiandai)	8	0.323	10.457143	0.215873	10.24127	2	512.06349	
Vine spinach (Kiandai)	8	0.3236	10.47619	0.215873	10.260317	2	513.01587	513.0159
Vine spinach(Karumande)	10	0.3249	10.51746	0.215873	10.301587	2	515.07937	
Vine spinach(Karumande)	10	0.3271	10.587302	0.215873	10.371429	2	518.57143	
Vine spinach(Karumande)	10	0.326	10.552381	0.215873	10.336508	2	516.8254	516.8254

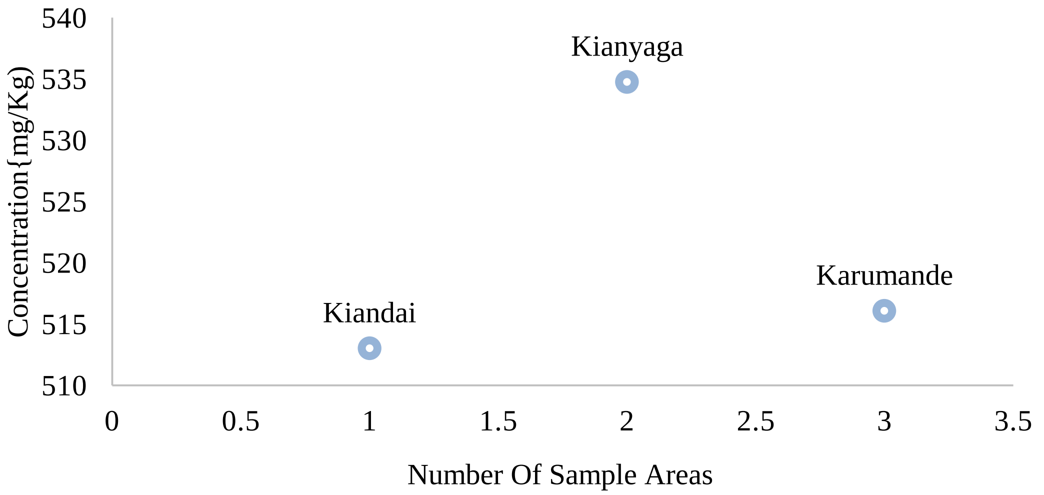

Figure 14: Mean concentration of zinc in Spider Plant

4.1.2.4 Concentration of Zinc in Pumpkin Leaves

The mean concentration of Zinc was highest in Kiandai (538.99 mg/kg) and lowest in Kianyaga (495.71 mg/kg) as shown in Table 9.

Table 9: Concentration of Zinc in pumpkin leaves in Kiandai Kianyaga & Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Pumpkin Leaves (Kianyaga)	12	0.3136	10.15873	0.215873	9.9428571	2	497.14286	
Pumpkin Leaves (Kianyaga)	12	0.3118	10.101587	0.215873	9.8857143	2	494.28571	
Pumpkin Leaves (Kianyaga)	12	0.3127	10.130159	0.215873	9.9142857	2	495.71429	495.7143
Pumpkin leaves(Kiandai)	6	0.342	11.060317	0.215873	10.844444	2	542.22222	
Pumpkin leaves(Kiandai)	6	0.3379	10.930159	0.215873	10.714286	2	535.71429	
Pumpkin leaves(Kiandai)	6	0.34	10.996825	0.215873	10.780952	2	539.04762	538.9947
Pumpkin Leaves(Karumande)	13	0.3243	10.498413	0.215873	10.28254	2	514.12698	
Pumpkin Leaves(Karumande)	13	0.3266	10.571429	0.215873	10.355556	2	517.77778	
Pumpkin Leaves(Karumande)	13	0.3254	10.533333	0.215873	10.31746	2	515.87302	515.9259

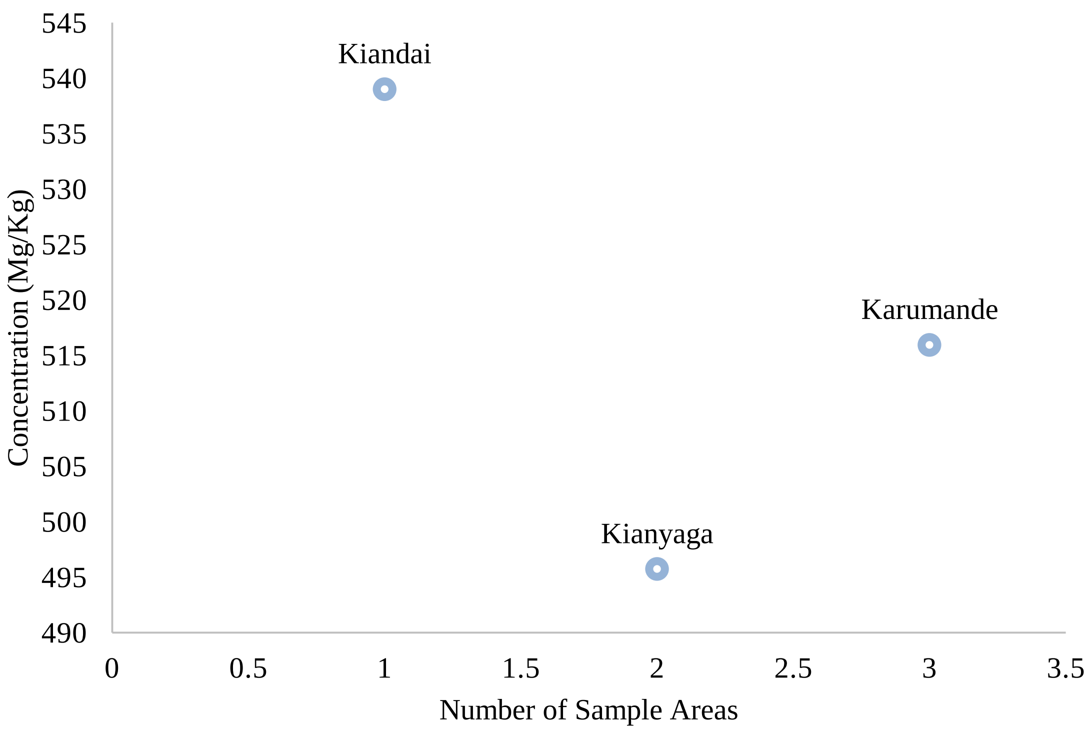

Figure 15: Mean concentration of zinc in Pumpkin Leaves

4.1.3 Concentration of Calcium (Ca)

The calibration curve achieved during atomic absorption analysis showed a well-defined linear trend across the concentration range tested, with an R^2 value of 0.9985 as shown in appendix IV(c). The relatively steep slope indicated high instrument sensitivity for calcium detection, while the minimal deviation from the regression line confirmed excellent precision. These characteristics suggest that the calibration model was highly effective for translating absorbance measurements into accurate calcium concentrations, thereby providing confidence in the reported values for all calcium-containing samples.

4.1.3.1 Concentration of Calcium in African Nightshade

The Mean concentration of calcium was higher in Karumande (8218.21 mg/kg) and lowest in Kiandai (7136.80 mg/kg) as shown in Table 10.

Table 10: Concentration of calcium in African nightshade Kiandai, Kianyaga and Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
African Night shade (Kiandai)	2	0.5221	15.517341	1.367052	14.150289	2	7075.1445	
African Night shade (Kiandai)	2	0.5306	15.763006	1.367052	14.395954	2	7197.9769	
African Night shade (Kiandai)	2	0.5264	15.641618	1.367052	14.274566	2	7137.2832	7136.802
African Night shade (Kianyaga)	3	0.5708	16.924855	1.367052	15.557803	2	7778.9017	
African Night shade (Kianyaga)	3	0.5685	16.858382	1.367052	15.491329	2	7745.6647	
African Night shade (Kianyaga)	3	0.5696	16.890173	1.367052	15.523121	2	7761.5607	7762.042
African Night Shade(Karumande)	11	0.6017	17.817919	1.367052	16.450867	2	8225.4335	
African Night Shade(Karumande)	11	0.6007	17.789017	1.367052	16.421965	2	8210.9827	
African Night Shade(Karumande)	11	0.6012	17.803468	1.367052	16.436416	2	8218.2081	8218.208

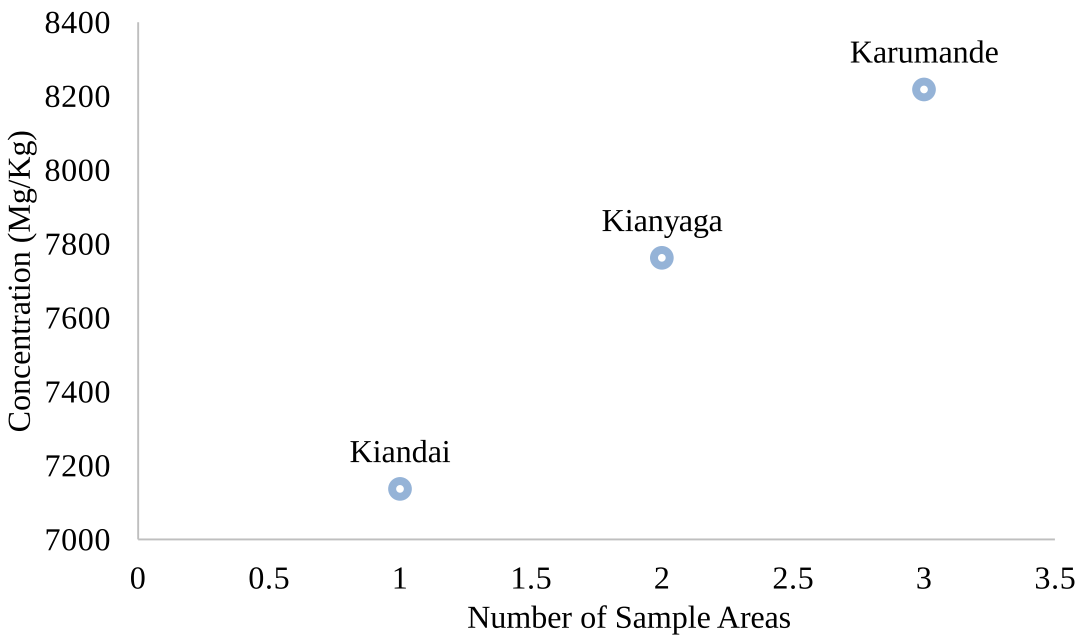

Figure 16: Mean concentration of Calcium in African Nightshade.

4.1.3.2 Concentration of Calcium in Spider Plant

The Mean concentration of calcium was higher in Kiandai (8995.18 mg/kg) and lowest in Karumande (8521.68 mg/kg) as shown in Table 11.

Table 11: Concentration of calcium in Spider plant in Kiandai, Kianyaga and Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Spider plant (Kianyaga)	5	0.6519	19.268786	1.367052	17.901734	2	8950.8671	
Spider plant (Kianyaga)	5	0.6447	19.060694	1.367052	17.693642	2	8846.8208	
Spider plant (Kianyaga)	5	0.6483	19.16474	1.367052	17.797688	2	8898.8439	8898.844
Spider plant(Karumande)	7	0.6244	18.473988	1.367052	17.106936	2	8553.4682	
Spider plant(Karumande)	7	0.62	18.346821	1.367052	16.979769	2	8489.8844	
Spider plant(Karumande)	7	0.6222	18.410405	1.367052	17.043353	2	8521.6763	8521.676
Spider plant (Kiandai)	9	0.6546	19.346821	1.367052	17.979769	2	8989.8844	
Spider plant (Kiandai)	9	0.6553	19.367052	1.367052	18	2	9000	
Spider plant (Kiandai)	9	0.655	19.358382	1.367052	17.991329	2	8995.6647	8995.183

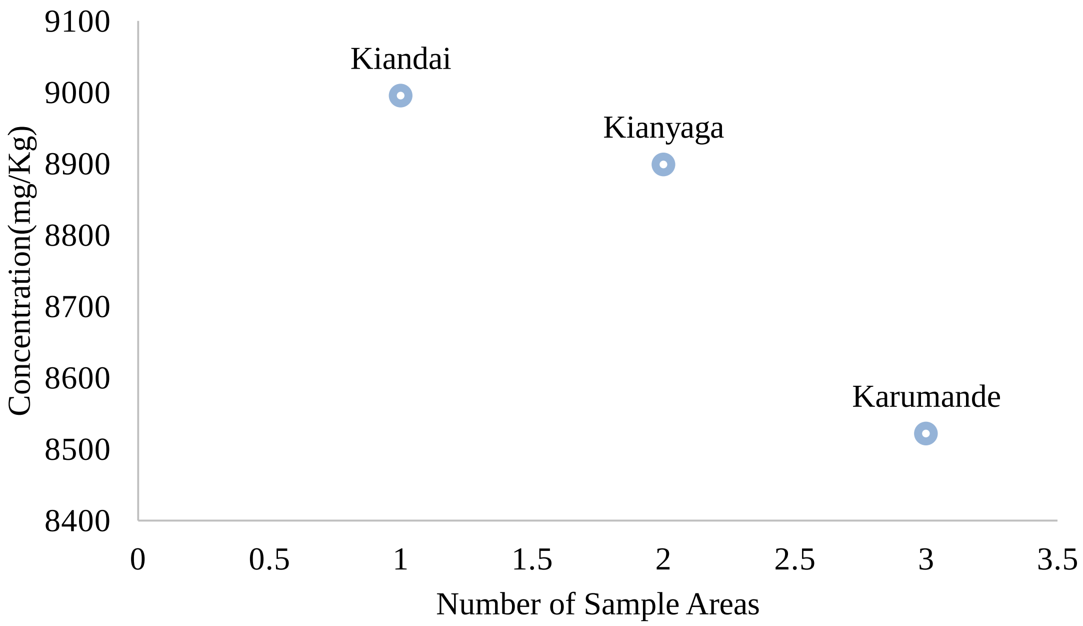

Figure 17: Mean concentration of calcium in Spider Plant

4.1.3.3 Concentration of Calcium in Vine Spinach

The mean concentration of calcium was higher in Karumande (9024.57 mg/kg) and lowest in Kiandai (8543.35 mg/kg) as shown in Table 12.

Table 12:Concentration of Vine spinach in Kiandai, Kianyaga and Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Vine spinach (Kianyaga)	4	0.6362	18.815029	1.367052	17.447977	2	8723.9884	
Vine spinach (Kianyaga)	4	0.6286	18.595376	1.367052	17.228324	2	8614.1618	
Vine spinach (Kianyaga)	4	0.6324	18.705202	1.367052	17.33815	2	8669.0751	8669.075
Vine spinach (Kiandai)	8	0.6232	18.439306	1.367052	17.072254	2	8536.1272	
Vine spinach (Kiandai)	8	0.6242	18.468208	1.367052	17.101156	2	8550.578	
Vine spinach (Kiandai)	8	0.6237	18.453757	1.367052	17.086705	2	8543.3526	8543.353
Vine spinach(Karumande)	10	0.6579	19.442197	1.367052	18.075145	2	9037.5723	
Vine spinach(Karumande)	10	0.6561	19.390173	1.367052	18.023121	2	9011.5607	
Vine spinach(Karumande)	10	0.657	19.416185	1.367052	18.049133	2	9024.5665	9024.566

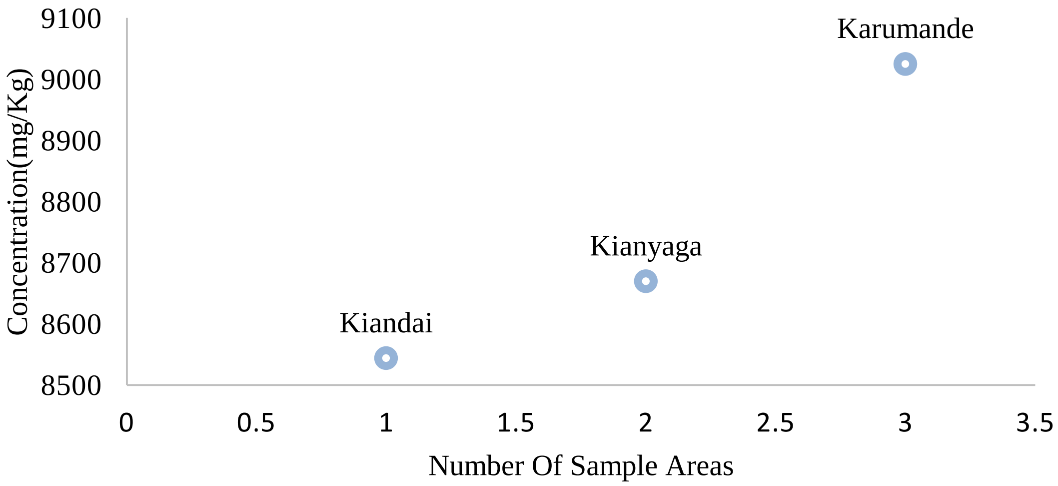

Figure 18: Mean concentration of calcium in Vine Spinach.

4.1.3.4 Concentration of Calcium in Pumpkin Leaves

The mean concentration of calcium was higher in Karumande (14070.81 mg/kg) and lowest in Kiandai (13789.02 mg/kg) as shown in Table 13.

Table 13: Concentration of calcium in pumpkin leaves in Kiandai, Kianyaga and Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Pumpkin Leaves (Kianyaga)	12	0.9698	28.456647	1.367052	27.089595	2	13544.798	
Pumpkin Leaves (Kianyaga)	12	0.9697	28.453757	1.367052	27.086705	2	13543.353	
Pumpkin Leaves (Kianyaga)	12	0.9698	28.456647	1.367052	27.089595	2	13544.798	13544.32
Pumpkin leaves(Kiandai)	6	0.9882	28.988439	1.367052	27.621387	2	13810.694	
Pumpkin leaves(Kiandai)	6	0.9852	28.901734	1.367052	27.534682	2	13767.341	
Pumpkin leaves(Kiandai)	6	0.9867	28.945087	1.367052	27.578035	2	13789.017	13789.02
Pumpkin Leaves(Karumande)	13	1.0071	29.534682	1.367052	28.16763	2	14083.815	
Pumpkin Leaves(Karumande)	13	1.0053	29.482659	1.367052	28.115607	2	14057.803	
Pumpkin Leaves(Karumande)	13	1.0062	29.508671	1.367052	28.141618	2	14070.809	14070.81

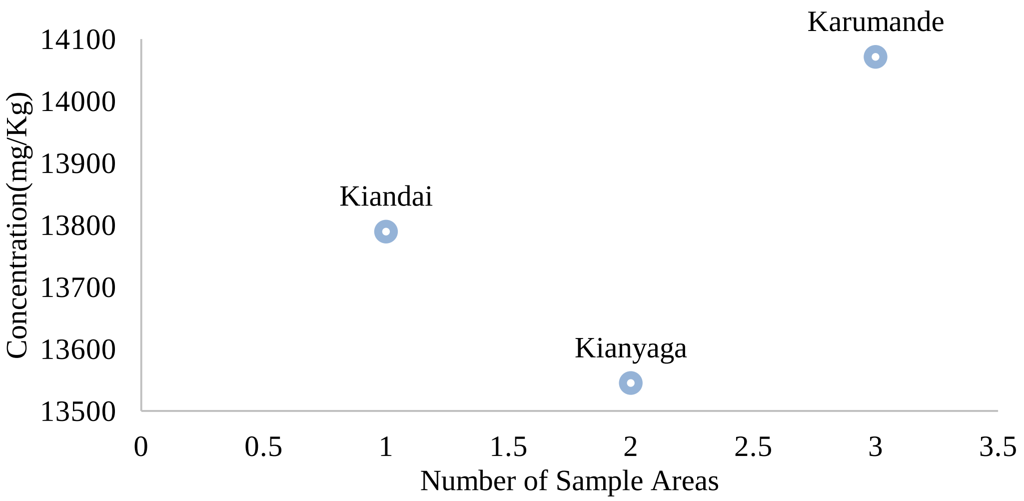

Figure 19: Mean concentration of calcium in Pumpkin Leaves.

4.1.4 Concentration of Magnesium (Mg)

The calibration curve achieved during atomic absorption analysis showed a well-defined linear trend across the concentration range tested, with an R^2 value of 0.9998 as shown in appendix IV(d). The relatively steep slope indicated high instrument sensitivity for magnesium detection, while the minimal deviation from the regression line confirmed excellent precision. These characteristics suggest that the calibration model was highly effective for translating absorbance measurements into accurate magnesium concentrations, thereby providing confidence in the reported values for all magnesium-containing samples.

4.1.4.1Concentration of Magnesium in African Nightshade

The mean concentration of magnesum was higher in Kianyaga (360.43mg/kg) and lowest in Karumande (343.89 mg/kg) as shown in Table 14.

Table 14: Concentration of magnesium in Kiandai, Kianyaga and Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
African Night shade (Kiandai)	2	0.6115	1.1265267	0.4314885	0.6950382	2	347.51908	
African Night shade (Kiandai)	2	0.6207	1.144084	0.4314885	0.7125954	2	356.29771	
African Night shade (Kiandai)	2	0.6161	1.1353053	0.4314885	0.7038168	2	351.9084	351.9084
African Night shade (Kianyaga)	3	0.6269	1.155916	0.4314885	0.7244275	2	362.21374	
African Night shade (Kianyaga)	3	0.6232	1.148855	0.4314885	0.7173664	2	358.68321	
African Night shade (Kianyaga)	3	0.625	1.1522901	0.4314885	0.7208015	2	360.40076	360.4326
African Night Shade(Karumande)	11	0.6081	1.1200382	0.4314885	0.6885496	2	344.27481	
African Night Shade(Karumande)	11	0.6073	1.1185115	0.4314885	0.6870229	2	343.51145	
African Night Shade(Karumande)	11	0.6077	1.1192748	0.4314885	0.6877863	2	343.89313	343.8931

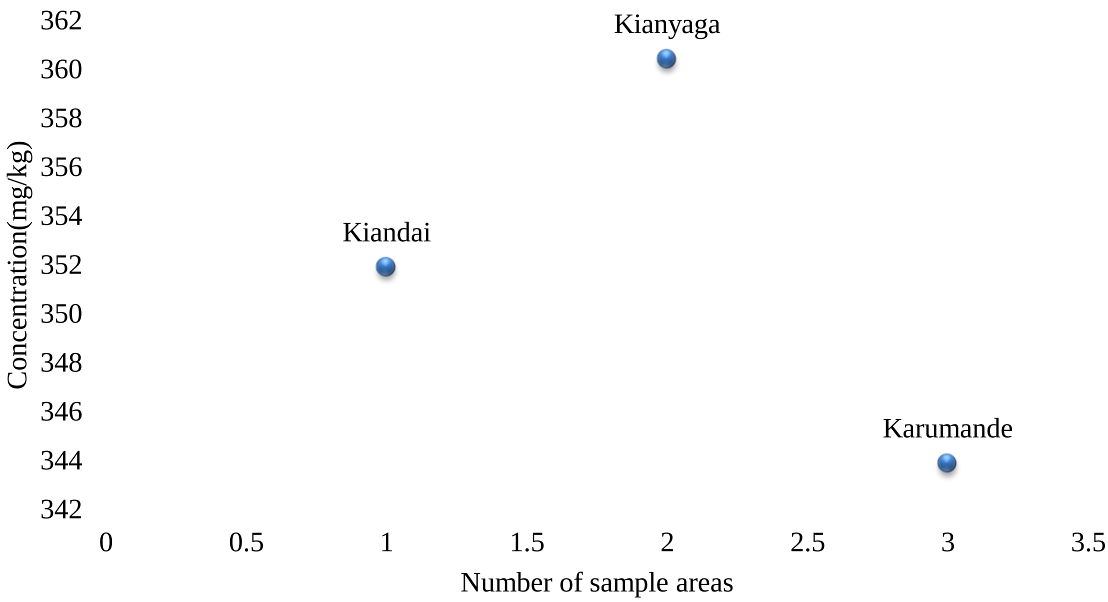

Figure 20: Mean concentration of magnesium in African Nightshade

4.1.4.2 Concentration of Magnesium in Spider Plant

The mean concentration of magnesum was higher in kiandai (470.87mg/kg) and lowest in Karumande (454.77mg/kg) as shown in Table 15.

Table 15: Concentration of magnesium in Kiandai, Kianyaga and Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A - B	Volume of sample	Conc. Mg/kg	Mean
Spider plant (Kianyaga)	5	0.7388	1.3694656	0.4314885	0.9379771	2	468.98855	
Spider plant (Kianyaga)	5	0.7419	1.3753817	0.4314885	0.9438931	2	471.94656	
Spider plant (Kianyaga)	5	0.7404	1.3725191	0.4314885	0.9410305	2	470.51527	470.4835
Spider plant(Karumande)	7	0.7253	1.3437023	0.4314885	0.9122137	2	456.10687	
Spider plant(Karumande)	7	0.7225	1.3383588	0.4314885	0.9068702	2	453.43511	
Spider plant(Karumande)	7	0.7239	1.3410305	0.4314885	0.909542	2	454.77099	454.771
Spider plant (Kiandai)	9	0.74	1.3717557	0.4314885	0.9402672	2	470.13359	
Spider plant (Kiandai)	9	0.7415	1.3746183	0.4314885	0.9431298	2	471.56489	
Spider plant (Kiandai)	9		0.7408	1.3732824	0.4314885	0.9417939	2	470.89695

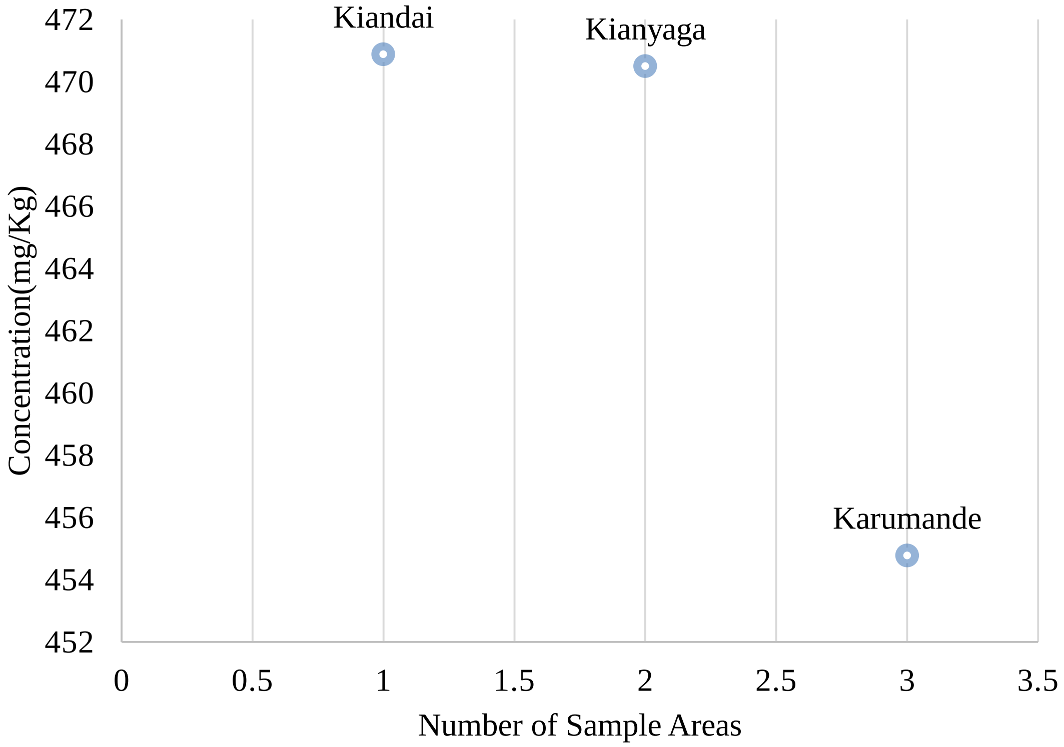

Figure 21: Mean concentration of magnesium in Spider Plant

4.1.4.3 Concentration of Magnesium in Vine Spinach

The mean concentration of magnesum was higher in Karumande (570.87mg/kg) and lowest in Kiandai (563.17 mg/kg) as shown in table 16.

Table 16: Concentration of magnesium in vine spinach in Kiandai, Kianyaga and Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Vine spinach (Kianyaga)	4	0.846	1.5740458	0.4314885	1.1425573	2	571.27863	
Vine spinach (Kianyaga)	4	0.8402	1.5629771	0.4314885	1.1314885	2	565.74427	
Vine spinach (Kianyaga)	4	0.8431	1.5685115	0.4314885	1.1370229	2	568.51145	568.5115
Vine spinach (Kiandai)	8	0.8377	1.5582061	0.4314885	1.1267176	2	563.35878	
Vine spinach (Kiandai)	8	0.8373	1.5574427	0.4314885	1.1259542	2	562.9771	
Vine spinach (Kiandai)	8	0.8375	1.5578244	0.4314885	1.1263359	2	563.16794	563.1679
Vine spinach(Karumande)	10	0.8449	1.5719466	0.4314885	1.140458	2	570.22901	
Vine spinach(Karumande)	10	0.8462	1.5744275	0.4314885	1.1429389	2	571.46947	
Vine spinach(Karumande)	10	0.8456	1.5732824	0.4314885	1.1417939	2	570.89695	570.8651

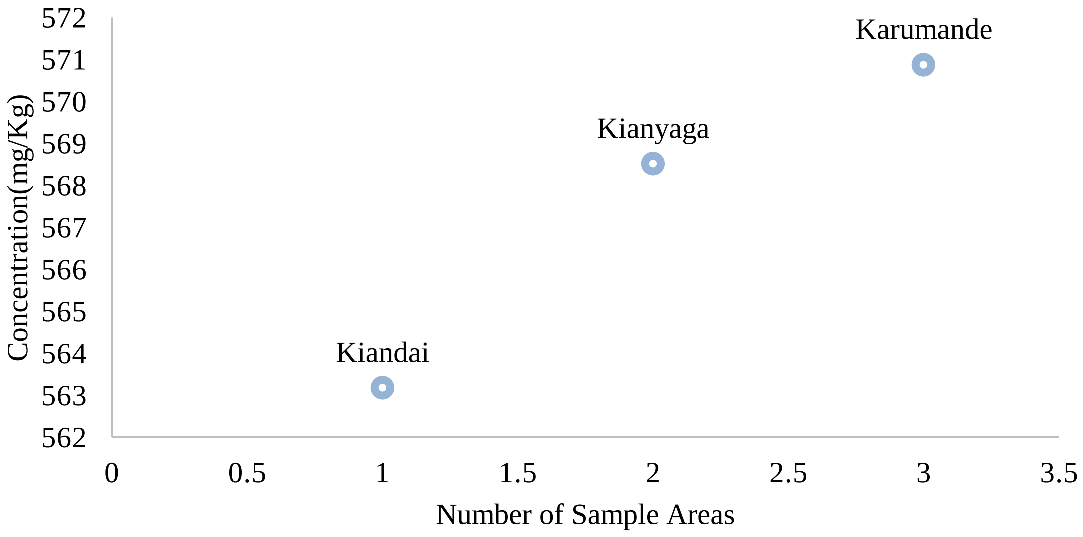

Figure 22: Mean concentration of magnesium in vine spinach

4.1.4.4 Concentration of Magnesium in Pumpkin Leaves

The mean concentration of magnesum was higher in Karumande (548.72mg/kg) and lowest in Kianyaga (536.39 mg/kg) as shown in table 17.

Table 17: Concentration of magnesium in pumpkin leaves in Kiandai, Kianyaga and Karumande.

Sample location	Sample ID	Abs.	Actual Conc.	Blank Conc (B)	A – B	Volume of sample	Conc. Mg/kg	Mean
Pumpkin Leaves (Kianyaga)	12	0.8102	1.5057252	0.4314885	1.0742366	2	537.11832	
Pumpkin Leaves (Kianyaga)	12	0.8087	1.5028626	0.4314885	1.071374	2	535.68702	
Pumpkin Leaves (Kianyaga)	12	0.8094	1.5041985	0.4314885	1.0727099	2	536.35496	536.3868
Pumpkin leaves(Kiandai)	6	0.818	1.5206107	0.4314885	1.0891221	2	544.56107	
Pumpkin leaves(Kiandai)	6	0.8158	1.5164122	0.4314885	1.0849237	2	542.46183	
Pumpkin leaves(Kiandai)	6	0.8169	1.5185115	0.4314885	1.0870229	2	543.51145	543.5115
Pumpkin Leaves(Karumande)	13	0.8234	1.530916	0.4314885	1.0994275	2	549.71374	
Pumpkin Leaves(Karumande)	13	0.8213	1.5269084	0.4314885	1.0954198	2	547.70992	
Pumpkin Leaves(Karumande)	13	0.8224	1.5290076	0.4314885	1.0975191	2	548.75954	548.7277

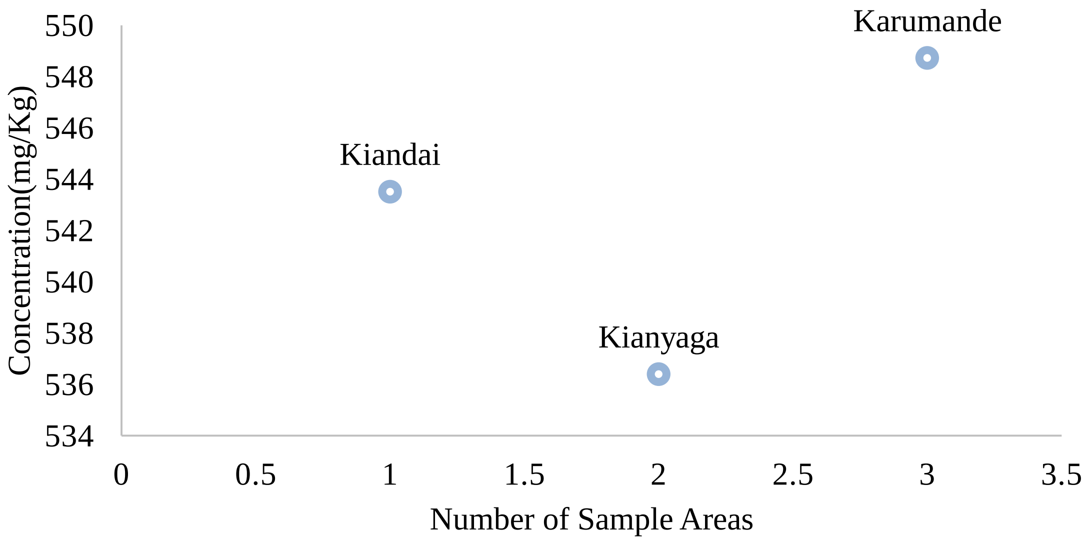

Figure 23: Mean concentration of magnesium in Pumpkin Leaves.

4.1.5 Concentration of Cadmium (Cd)

The calibration curve for cadmium standards demonstrated excellent linearity (R^2= 0.9998), indicating that the atomic absorption spectrometer responded proportionally across the tested concentration range as shown in appendix IV(e). This strong correlation between absorbance and concentration confirmed the suitability of the method for accurate cadmium quantification. Consequently, the cadmium concentrations obtained for the analyzed samples can be considered reliable, with minimal likelihood of systematic bias arising from instrument calibration.

4.1.5.1 Concentration of Cadmium in African Nightshade

The mean concentration of cadmium was higher in Kianyaga (0.062069mg/kg) and lowest in Kiandai (0.024302 mg/kg) as shown in Table 18.

Table 18: A Summary of Mean Concentration of Kiandai, Kianyaga and Karumande.

Samples areas	Concentration(mg/kg)
Kiandai	0.024302
Kianyaga	0.062069
Karumande	0.030194

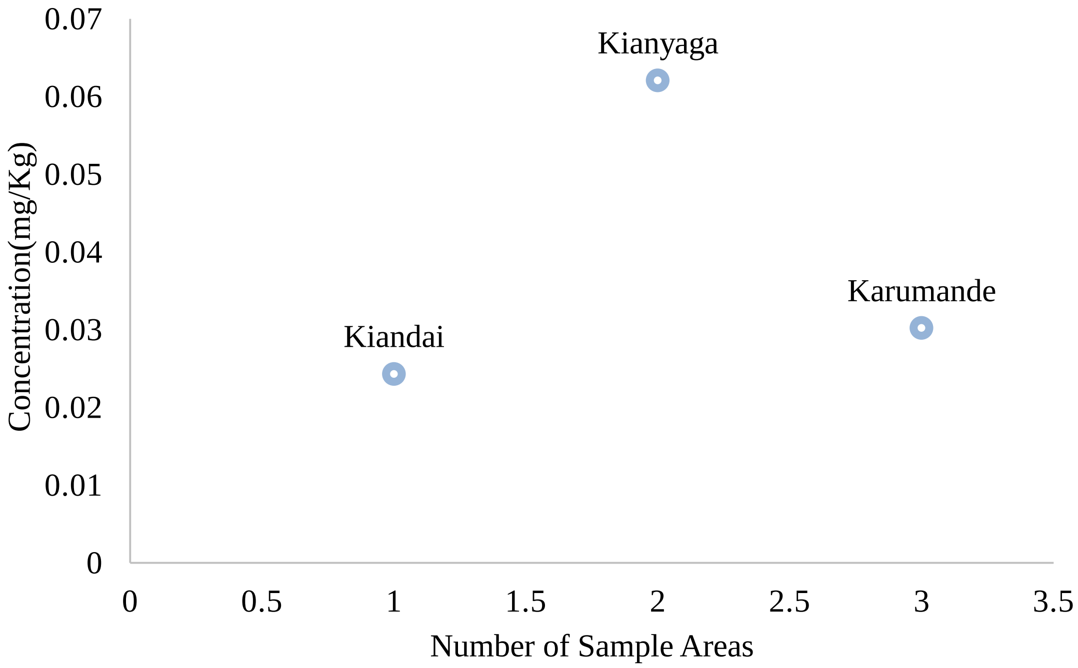

Figure 24: Mean concentration of cadmium in African Nightshade

4.1.5.2 Concentration of Cadmium in Spiderplant

The mean concentration of cadmium was higher in Kiandai (0.100155mg/kg) and lowest in Karumande (0.006376mg/kg) as shown in table 19.

Table 19: A Summary of Mean Concentration of Kiandai, Kianyaga and Karumande.

Samples areas	Concentration(mg/kg)
Kiandai	0.100155
Kianyaga	0.078798
Karumande	0.006376

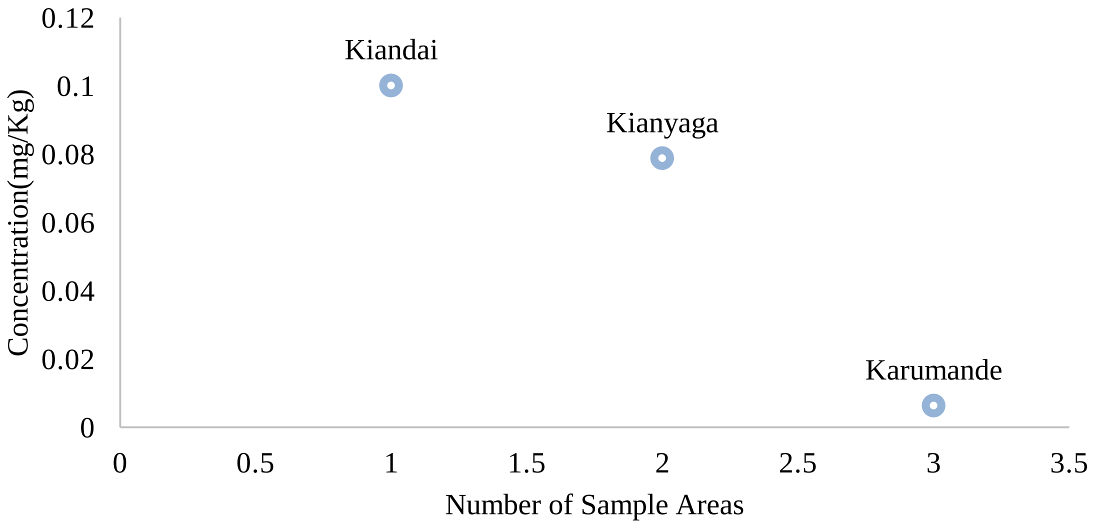

Figure 25: Mean concentration of cadmium in Spider Plant

4.1.5.3 Concentration of cadmium in Vine Spinach

The mean concentration of cadmium was higher in Kianyaga(0.06186mg/kg) and lowest in Kiandai (0.03038 mg/kg) as shown in Table 20.

Table 20: A Summary of Mean Concentration of Kiandai, Kianyaga and Karumande.

Samples areas	Concentration(mg/kg)
Kiandai	0.03038
Kianyaga	0.06186
Karumande	0.05252

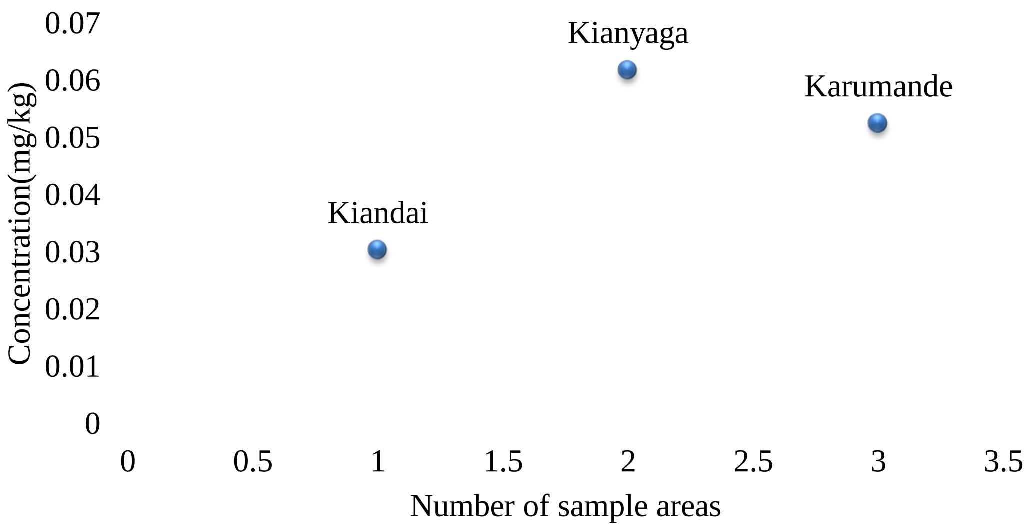

Figure 26: Mean concentration of cadmium in Vine spinach

4.1.5.4 Concentration of cadmium in Pumpkin leaves

The mean concentration of cadmium was higher in Kiandai(0.03609mg/kg) and lowest in Karumande(0.02855mg/kg) as shown in Table 21.

Table 21: A Summary of Mean Concentration of Kiandai, Kianyaga and Karumande.

Samples areas	Concentration(mg/kg)
Kiandai	0.03609
Kianyaga	0.03338
Karumande	0.02855

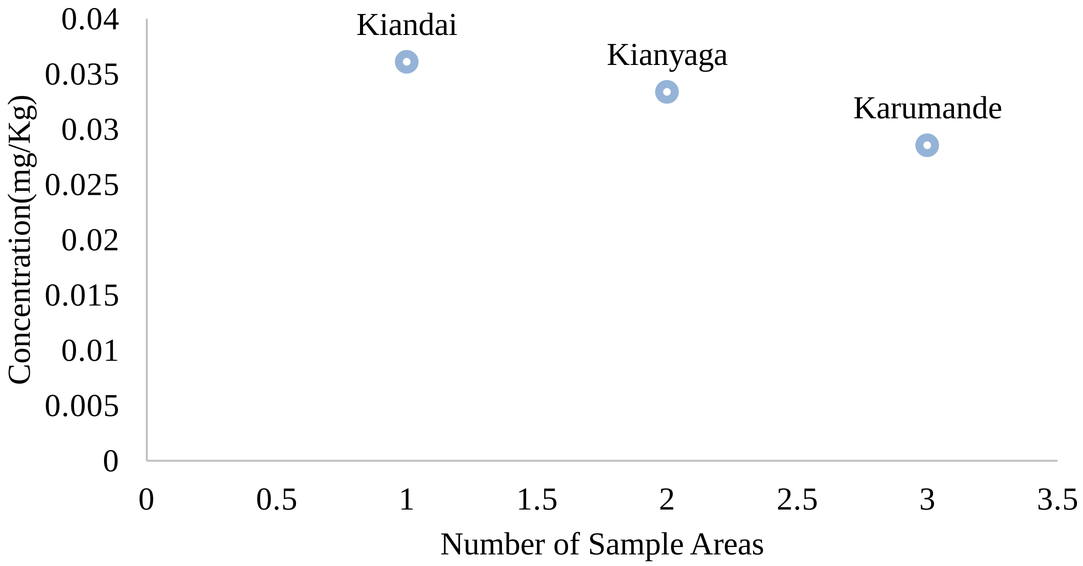

Figure 27: Mean concentration of cadmium in Pumpkin Leaves

4.1.6 Concentration of Lead (Pb)

Calibration of the atomic absorption spectrometer was performed using a series of lead standard solutions prepared in accordance with approved method. Absorbance values were plotted against known concentrations to generate a calibration curve, which exhibited excellent linearity ($R^2 = 0.9975$) within the analytical range as shown in appendix IV(f). The slope of the curve reflected the method sensitivity, while the intercept corresponded to baseline absorbance. The calibration curve served as the basis for quantitative determination of analyte concentrations in unknown samples, ensuring measurement accuracy and traceability.

4.1.6.1Concentration of lead in African Nightshade

The mean concentration of lead was higher in Karumande (0.09235mg/kg) and lowest in Kiandai (0 mg/kg) as shown in Table 22.

Table 22: A Summary of Mean Concentration of Kiandai, Kianyaga and Karumande.

Samples areas	Concentration(mg/kg)
Kiandai	0
Kianyaga	0.08014
Karumande	0.09235

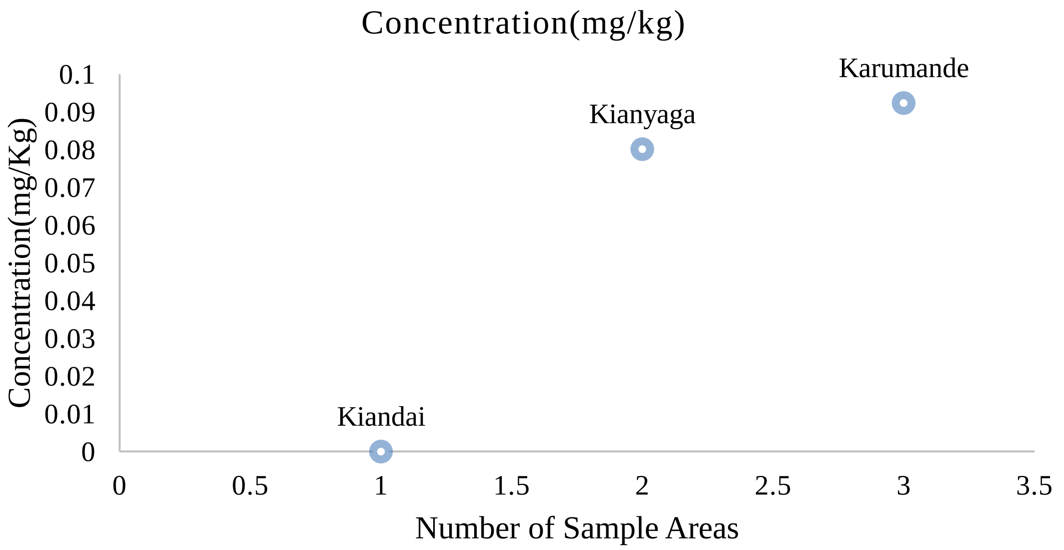

Figure 28: Mean concentration of lead in African Nightshade

4.1.6.2 Concentration of lead in Spider Plant

The mean concentration of lead for Kianyaga, Kiandai & Karumande was 0mg/kg as shown in table 23.

Table 23: A Summary of Mean Concentration of Kiandai, Kianyaga and Karumande.

Samples areas	Concentration(mg/kg)
Kiandai	0
Kianyaga	0
Karumande	0

4.1.6.3 Concentration of lead in Vine Spinach

The mean concentration of lead was higher in Kianyaga(0.08032mg/kg) and lowest in Kiandai (0 mg/kg) as shown in table 24.

Table 24: A Summary of Mean Concentration of Kiandai, Kianyaga and Karumande.

Samples areas	Concentration(mg/kg)
Kiandai	0
Kianyaga	0.08032
Karumande	0.07652

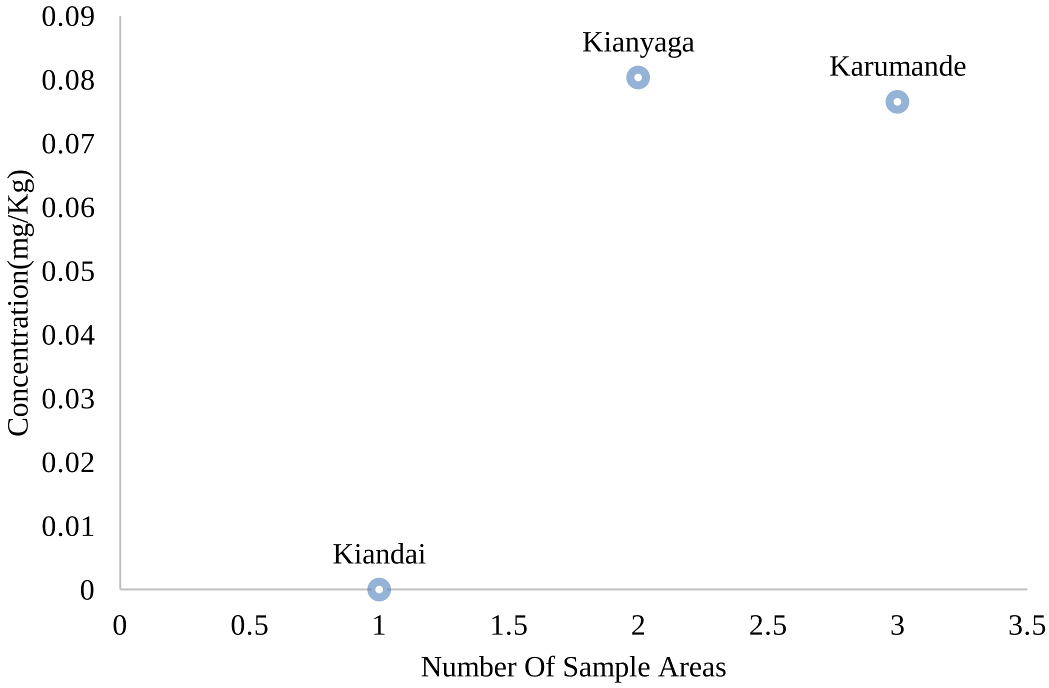

Figure 29: Mean concentration of lead in Vine Spinach

4.1.6.4 Concentration of lead in pumpkin leaves

The mean concentration of lead was higher in Karumande (0.05771 mg/kg) and lowest in Kiandai (0 mg/kg) as shown in Table 25.

Table 25: A Summary of Mean Concentration of Kiandai, Kianyaga and Karumande.

Samples areas	Concentration(mg/kg)
Kiandai	0
Kianyaga	0.05667
Karumande	0.05771

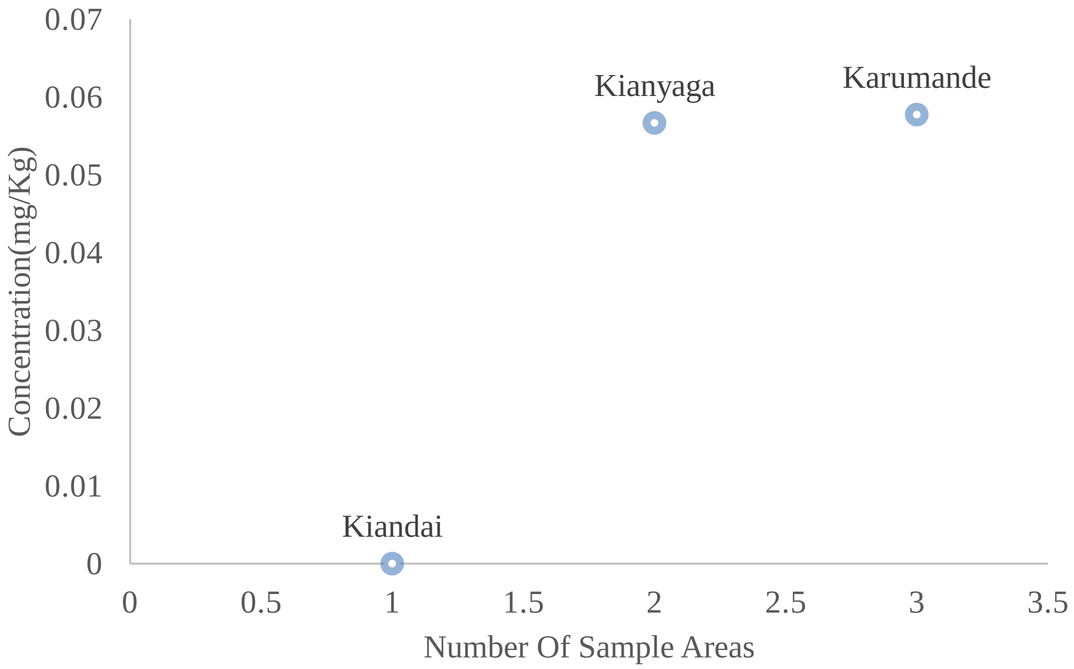

Figure 30: Mean concentration of lead in Pumpkin Leaves.

4.2 Proximate Analysis

The proximate analysis of the twelve vegetable samples analyzed on dry and wet weight basis, revealed significant variation in moisture content, crude protein, fat/oil content, ash, crude fiber, and carbohydrate levels, both on a dry weight and fresh weight basis.

4.2.1 Dry Weight Basis

4.2.1.1 Moisture (%)

Since all samples had a moisture content of 0% (dry weight), the nutrient values reflect the true composition of the solid matter without dilution by water.

4.2.1.2 Crude Protein (%)

Protein content varied across samples, with the highest levels recorded in pumpkin varieties particularly in kianyaga (29.81%) and kiandai (28.69%), followed closely by karumande (28.21%). Among the leafy vegetables, Managu varieties showed moderate protein levels ranging from 23.22–24.71%, while Nderema samples contained slightly lower values (19.96–23.03%). Sagaa varieties had the lowest protein content overall, ranging from 18.03–21.13%. This trend indicates that pumpkin leaves could be a superior source of dietary protein compared to the other vegetables examined.

4.2.1.3 Crude Fat/Oils (%)

Fat content was generally low across all samples, with the exception of Nderema, which had higher levels (4.07–4.20%). Pumpkin and Managu varieties contained approximately 0.81–1.25% fat, while Sagaa samples ranged between 1.98–2.30%. The higher lipid content in Nderema could contribute to increased caloric density and may influence palatability.

4.2.1.4 Total Ash (%)

Ash content, representing total mineral matter, was highest in Sagaa samples, peaking at 31.17% (Sagaa kianyaga), followed closely by Saga kiandai (30.50%) and Saga kamande (28.70%). Pumpkin varieties had moderate ash content (15.32–18.65%), while Managu and Nderema recorded higher values (24.87–28.68% and 26.69–26.97%, respectively). This suggests that Saga, Nderema, and Managu are particularly rich in mineral nutrients compared to pumpkin leaves.

4.2.1.5 Crude Fiber (%)

Fiber content ranged from 8.65% to 11.20%, with Sagaa from kiandai showing the highest value (11.20%), closely followed by Sagaa from karumande (11.14%) and Sagaa in Kianyaga (10.98%). The pumpkin varieties had slightly lower fiber content (9.25–10.52%), and Nderema showed the lowest levels (8.65–9.05%). High fiber content in Sagaa may contribute to improved digestive health and satiety.

4.2.1.6 Carbohydrates (%)

Carbohydrate levels were highest in pumpkin varieties, particularly Pumpkin from Kianyaga (43.24%) and Pumpkin from Kiandai (42.89%), indicating their potential as energy-rich leafy vegetables. Managu and Nderema varieties had moderate carbohydrate levels (37.15–41.30%), whereas Saga recorded the lowest (35.32–38.29%). This suggests that pumpkin leaves are better suited for energy provision compared to other leafy greens in this study.

Table 26: Results of Proximate Analysis on Dry Weight Basis

S/No.	Sample type	Moisture content (%)	Dry matter (%)	Crude Protein (%)	Crude Fat/Oils (%)	Total ash (%)	Crude fiber (%)	Carbohydrates (%)
1.	S1(Pumpkin kamande)	0	100	28.21	1.25	18.65	10.52	41.37
2.	S2(Pumpkin kiandai)	0	100	28.69	1.09	18.08	9.25	42.89
3.	S3(Pumpkin kianyaga)	0	100	29.81	1.23	15.32	10.4	43.24
4.	S4(Managu kamande)	0	100	24.56	0.98	28.68	9.71	36.07
5.	S5(Managu kiandai)	0	100	24.71	1.25	24.87	9.45	39.72
6.	S6(Managu kianyaga)	0	100	23.22	0.81	25	9.67	41.3
7.	S7(Nderema kiandai)	0	100	19.96	4.07	26.69	8.78	40.5
8.	S8R1(Nderema kianyaga)	0	100	21.29	4.18	26.94	9.05	38.54
9.	S9(Nderema kamande)	0	100	23.03	4.2	26.97	8.65	37.15
10.	S10(Saga kiandai)	0	100	18.03	1.98	30.5	11.2	38.29
11.	S11(Saga kamande)	0	100	21.13	2.3	28.7	11.14	36.73
12.	S12(Saga kianyaga)	0	100	20.39	2.14	31.17	10.98	35.32

4.2.2 Fresh Weight Basis

4.2.2.1 Moisture Content (%)

Moisture content ranged from 82.07% in managu (Kiandai) to 90.60% in nderema (Kiandai). Generally, leafy vegetables exhibited high moisture content, which is consistent with previous findings that fresh vegetables typically contain over 80% water. Pumpkin leaves had slightly lower moisture content (85.35–85.76%), while nderema and saga had the highest values (>88%). Correspondingly, dry matter content was inversely related to moisture content, ranging from 9.40% in nderema (Kiandai) to 17.93% in managu (Kiandai). This trend indicates that vegetables with lower moisture content may provide a more concentrated source of nutrients on a fresh weight basis.

4.2.2.2 Crude Protein (%)

Crude protein content varied significantly among the species. Managu recorded the highest values, with 4.43% in Kiandai samples, while sagaa and nderema had lower levels, averaging 1.75–2.54%. Pumpkin leaves also showed relatively high protein content (4.02–4.37%), comparable to managu. These results suggest that pumpkin leaves and managu could serve as valuable plant-based protein sources in local diets, aligning with previous reports highlighting African nightshade as a protein-rich leafy vegetable.

4.2.2.3 Crude Fat/Oils (%)

Crude fat content was generally low across all samples, ranging between 0.14% in managu (Kianyaga) and 0.46% in nderema (Kamande). Nderema consistently had higher fat values compared to the other vegetables, suggesting the presence of slightly more lipid content, though still within the typical low-fat range for leafy greens.

4.2.2.4 Total Ash (%)

Total ash, an indicator of total mineral content, was highest in managu (up to 5.10% in Kamande samples) and lowest in pumpkin leaves (as low as 2.24% in kianyaga samples). This suggests that managu could be a better source of minerals compared to the other vegetables studied.

4.2.2.5 Crude Fiber (%)

Crude fiber content ranged from 0.82% in nderema (Kiandai) to 1.73% in managu (Kamande). Generally, managu and pumpkin leaves recorded higher fiber levels than nderema and saga, supporting their role in aiding digestion and promoting gut health.

4.2.2.6 Carbohydrates (%)

Carbohydrate content was highest in managu (up to 7.13% in Kiandai samples) and pumpkin leaves (5.89–6.34%), while nderema and saga exhibited lower levels (3.71–4.11%). The differences may be attributed to species-specific metabolic compositions and environmental growth conditions.

Table 27: Results of Proximate Analysis on Dry Weight Basis

S/No.	Sample type	Moisture content (%)	Dry matter (%)	Crude Protein (%)	Crude Fat/Oils (%)	Total ash (%)	Crude fiber (%)	Carbohydrates (%)
1.	S1(Pumpkin kamande)	85.76	14.24	4.02	0.18	2.66	1.49	5.89
2.	S2(Pumpkin kiandai)	85.5	14.5	4.16	0.15	2.62	1.34	6.23
3.	S3(Pumpkin kianyaga)	85.35	14.65	4.37	0.18	2.24	1.52	6.34
4.	S4(Managu kamande)	82.21	17.79	4.37	0.17	5.1	1.73	6.42
5.	S5(Managu kiandai)	82.07	17.93	4.43	0.22	4.46	1.69	7.13
6.	S6(Managu kianyaga)	82.8	17.2	3.99	0.14	4.3	1.66	7.11
7.	S7(Nderema kiandai)	90.6	9.4	1.88	0.38	2.51	0.82	3.81
8.	S8R1(Nderema kianyaga)	89.76	10.24	2.18	0.43	2.76	0.93	3.94
9.	S9(Nderema kamande)	88.96	11.04	2.54	0.46	2.98	0.95	4.11
10.	S10(Saga kiandai)	90.29	9.71	1.75	0.19	2.96	1.09	3.72
11.	S11(Saga kamande)	88.92	11.08	2.34	0.25	3.18	1.23	4.08
12.	S12(Saga kianyaga)	85.76	14.24	4.02	0.18	2.66	1.49	5.89

4.3 Variation in Micronutrient Composition, Heavy Metal Accumulation, and Proximate Relationships across Locations

To establish whether the observed variations in micronutrient concentrations and heavy metal levels among the four selected indigenous vegetables (African nightshade, spider plant, vine spinach, and pumpkin leaves) and across the three sampling locations (Kiandai, Kianyaga, Karumande) were statistically significant, a One-Way Analysis of Variance (ANOVA) was conducted for each parameter. For proximate Pearson correlation analysis was employed to assess relationships among proximate components.

4.3.1 Micronutrient Composition Across Locations

Micronutrient concentrations (Fe, Mg, Ca, and Zn) varied significantly among the 12 vegetable–location groups, according to the one-way ANOVA ($p < 0.001$). The F-statistic for iron (Fe) was highly significant ($F=3235.06$, $p < 0.001$), indicating significant variation between species and locations. According to post-hoc Tukey HSD tests, the spider plant at Kianyaga had Fe levels that were roughly 104 mg/kg higher than those of the African nightshade at Kiandai ($p<0.001$). Additionally, spider plants from all three sites consistently differed from other vegetable–site combinations in magnesium (Mg) ($F = 7370.93$, $p< 0.001$). These results indicate that the micronutrient composition of the vegetables is significantly influenced by both plant species and location.

4.3.2 Heavy Metal Accumulation Across Locations

Cadmium (Cd) and lead (Pb) concentrations were detected in all the vegetables studied, with variations observed across species and locations. African nightshade and vine spinach generally recorded relatively higher concentrations of cadmium and lead compared to spider plant and pumpkin leaves. However, the mean values for both cadmium and lead across all samples were within the FAO/WHO permissible limits of 0.2 mg/kg and 0.3 mg/kg, respectively, for leafy vegetables.

The ANOVA and Tukey post-hoc tests confirmed that differences in cadmium and lead concentrations across sites and species were statistically significant ($p < 0.05$), reflecting the influence of both environmental conditions and species-specific uptake capacity. Despite this variation, the results indicate that the vegetables studied remain safe for human consumption with respect to cadmium and lead contamination. These findings suggest that while location and species affect the uptake of heavy metals the concentrations do not pose immediate food safety risks.

4.3.3 Proximate Composition and Pearson Correlation Relationships

To evaluate the relationships between the proximate components, a Pearson correlation analysis was performed. Moisture and dry matter ($r = -1.000^{**}$), protein ($r = -0.938^{**}$), fiber ($r = -0.949^{**}$), and carbohydrates ($r = -0.968^{**}$) all exhibited a significant negative correlation, according to the results. On the other hand, dry matter had a positive correlation with carbohydrates ($r = 0.968^{**}$), protein ($r = 0.938^{**}$), and fiber ($r = 0.949^{**}$). Ash had a positive correlation with fiber ($r = 0.636^{*}$), whereas crude fat had a negative correlation with both fiber ($r=-0.776^{**}$) and carbohydrates (r=−0.632*). These correlations show that while higher moisture content tends to dilute nutrient concentrations on a fresh-weight basis, higher dry matter content is linked to greater nutrient density.

CHAPTER FIVE

DISCUSSION

5.1 Micronutrient Concentrations in Indigenous Vegetables

The concentrations of calcium, iron, magnesium, and zinc across African nightshade, spider plant, vine spinach, and pumpkin leaves revealed substantial variation both among the species and across the three sampling sites (Kianyaga, Karumande & Kiandai). These results reaffirm the nutritional potential of African Indigenous Vegetables (AIVs) as significant reservoirs of essential minerals, supporting earlier reports by Abukutsa (2010) and Kamga (2013) that such vegetables can help address micronutrient deficiencies in African diets.

5.1.1 Concentration levels of Iron (Fe)

Iron concentrations were highest in spider plant (up to 233.53 mg/kg in Kianyaga) and pumpkin leaves (175.02 mg/kg in Kiandai). According to this study, spider plant had the highest concentration of iron (233.53 mg/kg). These results align with the findings of (Oyango *et al*.,2013), who noted the spider plant's high iron content and its significance in preventing iron deficiency anemia. (Abukutsa,2010) also highlighted the superiority of native African vegetables over exotic ones as sources of bioavailable iron. As noted by (Kamga ,2013), soil and agronomic variations may be the cause of the variations in iron concentration across study locations The higher iron values in Kianyaga may be linked to soil fertility and organic matter, which influence bioavailability. These results agree with previous findings that organic inputs improve micronutrient uptake in leafy vegetables (Semagn *et al*., 2023).

5.1.2 Concentration levels of Zinc (Zn)

African nightshade recorded the highest zinc content (483.33 mg/kg in Kiandai), this finding is consistent with (Abukutsa,2010), who found that African nightshade species are especially high in zinc, which is necessary for immune response, enzymatic activity, and reproduction. (Bhowmik *et al*., 2010) identified zinc as a crucial micronutrient in leafy vegetables and the current findings support their findings. The high zinc content of African nightshade found in this study highlights the plant's potential to treat illnesses linked to zinc deficiency. The differences in zinc across sites, with generally lower levels in Karumande, may be due to soil pH and texture variations, which influence zinc solubility and uptake. These results indicate that promoting African indigenous vegetable consumption could reduce reliance on costly zinc supplementation programs

5.1.3 Concentration levels of Calcium (Ca)

Pumpkin leaves had the highest calcium content (14,070.81 mg/kg in Karumande), confirming their reputation as excellent dietary sources of calcium. The observed levels exceed the daily requirements, meaning even moderate intake could contribute significantly to the Recommended Dietary Allowance (RDA). This reinforces the role of pumpkin leaves in preventing rickets, osteoporosis and other calcium-deficiency conditions. High calcium levels in pumpkin leaves and other leafy vegetables were also reported by (Kamga ,2013) and (Abukutsa ,2010), underscoring their importance for bone and dental health. (Saris *et al*.,2005) also reaffirmed that because of their high chlorophyll and cell wall content, leafy vegetables are important dietary sources of calcium. The influence of regional environmental conditions and soil fertility may be reflected in the higher values found in this study.

5.1.4 Concentration levels of Magnesium (Mg)

Magnesium levels ranged between 343.89 mg/kg in African nightshade (Karumande) and 570.87 mg/kg in vine spinach (Karumande). The high magnesium levels in vine spinach confirm its importance as a restorative food and align with (Saris *et al*..2000), who noted that green leafy vegetables are rich sources of magnesium due to their chlorophyll content. Magnesium's role in enzymatic activation and neuromuscular functions further highlights the nutritional significance of these vegetables.

In summary all four vegetables demonstrated nutritionally important mineral profiles. Variations across sites highlight the influence of agro-ecological factors, underscoring the need for locally tailored dietary recommendations.

5.2 Proximate Composition of Indigenous Vegetables

Proximate analysis results showed differences in moisture, protein, fat, ash, fiber, and carbohydrate contents across the sampled vegetables.

5.2.1 Moisture Content

Moisture ranged from 82–91%, aligning with values typical of fresh leafy vegetables (Mibei, 2011). While high moisture enhances palatability and digestibility, it reduces shelf life due to microbial susceptibility (Jay *et al.,* 2005). Thus, preservation techniques such as drying or fermentation are essential.

5.2.2 Crude Protein

Spider plant and African nightshade recorded higher protein contents (up to 17.9% in managu from Kiandai). This confirms their potential as alternative protein sources, especially in low-income households. The findings align with (Oyango *et al*.,2013), who reported that spider plant is rich in essential amino acids. These vegetables can help reduce protein-energy malnutrition among children.

5.2.3 Crude Fat

Crude fat levels were consistently low, typical of leafy vegetables. This agrees with (Jay *et al*.,2005), who reported that indigenous vegetables are nutrient-dense but energy-light, making them ideal foods for reducing the risk of obesity and cardiovascular diseases. The low-fat content enhances their suitability as health-promoting foods.

5.2.4 Ash Content

Ash values (up to 4.46% in African nightshade from Kiandai) reflected high mineral densities. This demonstrates the mineral richness of African indigenous vegetables and supports their nutritional relevance.

5.2.5 Crude Fiber

Fiber ranged between 1.66% and 1.69% for African nightshade and 0.93–0.95% for vine spinach. Adequate fiber intake aids in digestion, controls blood sugar, and lowers cholesterol (McSweeney *et al*., 2005). African nightshade’s higher fiber content highlights its role in promoting gastrointestinal health.

5.2.6 Carbohydrates

Carbohydrate contents ranged from 3–7%. This moderate contribution to energy complements the already carbohydrate-heavy African diets, offering essential nutrients without contributing to excessive calorie intake. Proximate analysis confirms that these vegetables are nutrient-dense but energy-light, ideal for combating both malnutrition and lifestyle-related diseases.

5.3 Heavy Metal Concentrations

5.3.1 Concentration levels of Cadmium (Cd)

The study's findings demonstrated that the levels of cadmium in indigenous African vegetables differed by species and geographical location. The highest mean levels were found in African nightshade, followed by vine spinach and spider plant, while the lowest concentrations were typically found in pumpkin leaves. The concentrations found were all within the WHO/FAO permissible limit of 0.2 mg/kg for leafy vegetables, despite notable variations between sites. This implies that the vegetables are still safe for human consumption in terms of cadmium contamination, even with the variations associated with soil and environmental conditions. Cadmium levels in vegetables from non-industrial areas frequently fall below international thresholds, reflecting limited anthropogenic pollution, according to similar findings (Gupta *et al*.2019) and (Prasad *et al*.,2021). The findings therefore highlight the nutritional advantage of consuming African indigenous vegetables without the risk of cadmium toxicity.

5.3.2 Concentration levels of Lead (Pb)

Lead concentrations also differed between the vegetables and regions sampled African nightshade and vine spinach had comparatively higher mean values than spider plant and pumpkin leaves. All of the measured concentrations, nevertheless, fell below the 0.3 mg/kg maximum limit for leafy vegetables that the WHO and FAO recommend. This suggests that, in terms of lead contamination, the vegetables evaluated in this study are safe to eat. According to previous research (Omambia & Simiyu, 2014) & (Sharma *et al*., 2007), vegetables grown away from major roads and industrial discharges frequently have Pb levels within acceptable international standards. Given that lead exposure is associated with serious health risks such as neurological and developmental impairments, the results of this study provide reassurance that the consumption of these African indigenous vegetables does not pose immediate Pb related health hazards.

5.4 The Effects of Location Related Variation in Micronutrients, Heavy Metals, and Proximate Composition on Nutrition and Safety.

5.4.1 Micronutrient Variation and Nutritional Implications

The notable differences in micronutrient concentrations between species and geographical areas show the impact of both environmental factors and crop health. For instance, vine spinach showed high magnesium levels, but spider plants frequently showed higher iron contents, especially in Kianyaga. These results imply that the observed variations were probably caused by site specific soil properties and agronomic techniques. This variation is significant from a nutritional point because it shows how some vegetable site pairings may be promoted as better providers of vital minerals in regional diets. According to earlier research e.g., (Abukutsa, 2010), (Kamga, 2013) & (Semagn *et al*., 2023), the mineral content of African indigenous vegetables (AIVs) varies by species and geographic location. The uptake of iron, zinc, calcium, and magnesium is significantly influenced by pH, organic matter, and soil fertility. This confirms your conclusion that nutrient density was influenced by location (Kianyaga, Kiandai, Karumande).

5.4.2 Heavy Metal Accumulation and Food Safety Risks

The current study found that the levels of lead and cadmium in native African vegetables differed greatly between species and geographical areas. Pumpkin leaves consistently displayed the lowest levels of lead and cadmium, while African nightshade and vine spinach tended to record relatively higher concentrations. Notwithstanding these differences, every concentration found in leafy vegetables was within the WHO/FAO allowable limits of 0.2 mg/kg for cadmium and 0.3 mg/kg for lead. This suggests that, in terms of heavy metal contamination, the vegetables under study are safe for ingestion. The results are in line with previous studies (Gupta *et al*., 2019) & (Prasad *et al*., 2021), which pointed out that heavy metal concentrations in vegetables grown in regions with little industrial activity and regulated agricultural inputs are frequently lower than those found internationally. Variations in soil properties, fertilizer use, and water quality all affect the bioavailability of trace elements, which explains the location-related differences found in this study. However, the fact that every concentration was within safe bounds indicates that there was little anthropogenic pollution at the study locations. The levels found in this study do not immediately threaten food safety, despite the fact that lead and cadmium are toxic elements that, when consumed in high amounts, can cause long-term health problems like kidney damage, neurological impairments, and cancer. These results are therefore encouraging because they show that Kirinyaga East's native African vegetables not only offer vital micronutrients but also satisfy global safety regulations regarding lead and cadmium contamination. However, ongoing observation is still required to make sure that upcoming modifications to farming methods or environmental circumstances do not result in dangerous accumulation levels.

5.4.3 Proximate Relationships and Nutrient Concentration Patterns

The Pearson correlation results provided important insights into the internal balance of proximate components. The strong negative association between moisture and nutrients such as protein, fiber and carbohydrates reflects the water dilution effect, where high water content reduces nutrient density per unit of fresh weight. On the other hand, the positive correlations among dry matter, protein, fiber and carbohydrates highlight that lower moisture samples are more nutrient-dense. These relationships help explain the variability observed across locations and species and suggest that environmental conditions influencing moisture levels may indirectly affect nutrient availability. Extension services should educate farmers on safer agronomic practices, safer post-harvesting practices while policymakers should strengthen monitoring of environmental contaminants. According to literature (Mibei, 2011), (McSweeney *et al*., 2005) & (Jay *et al*., 2005), dry matter raises the concentration of protein, fiber, and carbohydrates while high moisture dilutes nutrient density. This demonstrates how site factors that impact water retention also have an indirect impact on nutrition.

CHAPTER SIX
SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary of Key Findings

This study established that African indigenous vegetables (AIVs) cultivated in Kirinyaga East Sub-County are nutritionally rich though their composition varies significantly across species and locations. Micronutrient analysis revealed that spider plant consistently had the highest iron concentrations (up to 233.53 mg/kg), African nightshade recorded the highest zinc levels (483.33 mg/kg), pumpkin leaves were richest in calcium (14,070.81 mg/kg), and vine spinach contained the most magnesium (570.87 mg/kg).

Proximate analysis further showed that spider plant and African nightshade contained the highest protein levels (up to 17.9%), while African nightshade also had high ash and fiber contents, confirming its mineral density. Moisture levels were high across all species (82–91%), consistent with fresh vegetables but Pearson correlation analysis revealed that higher moisture reduced nutrient density while dry matter correlated positively with protein, fiber and carbohydrates. These results underscore that both species type and site conditions strongly influence the nutritional potential of African indigenous vegetables.

Heavy metal analysis demonstrated that cadmium and lead concentrations varied significantly across locations and species, with African nightshade and vine spinach showing relatively higher levels compared to spider plant and pumpkin leaves. However, all observed concentrations of cadmium and lead were within the WHO/FAO permissible limits of 0.2 mg/kg and 0.3 mg/kg, respectively for leafy vegetables.

6.2 Conclusion

In conclusion, this study established that African indigenous vegetables (African nightshade, spider plant, vine spinach and pumpkin leaves) are rich sources of essential micronutrients and proximate nutrients, making them valuable components of a balanced diet. The findings revealed high concentrations of key minerals such as calcium, iron, zinc, and magnesium across the selected species, with pumpkin leaves showing the highest calcium levels, spider plant exhibiting the highest iron concentration, vine spinach containing the highest magnesium levels and African nightshade having the highest zinc content. Proximate analysis further indicated that these vegetables are nutrient-dense but low in crude fat, confirming their suitability for promoting good health and preventing diet-related diseases.

The study also found that the concentrations of heavy metals (lead and cadmium) in all the vegetable samples were below the permissible limits set by WHO/FAO, indicating that the vegetables analyzed from Kirinyaga East Sub-County are safe for human consumption. However, slight variations in nutrient and heavy metal levels across sampling locations suggest that environmental factors such as soil type, farming practices and local agro-ecological conditions influence the nutritional and safety profiles of these vegetables.

Overall, the study concludes that African indigenous vegetables are nutritionally beneficial, safe and can serve as affordable dietary sources of essential minerals for combating malnutrition in Kenya. Promoting their production and consumption can contribute significantly to improving community health, enhancing food security and supporting sustainable agricultural systems.

6.3 Recommendations

i. Encourage African indigenous vegetables for Food Security and Nutrition by integrating them into hospital diets and school feeding programs.

ii. Make food safety monitoring more robust by checking for heavy metals in vegetables and soils on a regular basis. And limiting farming in areas with wastewater, industries, and roadsides.

iii. Farmers should be assisted with extension and training to teach people how to use pesticides and fertilizers safely in order to lessen the uptake of metals, encourage organic soil management.

iv. Make research and innovation investments by examining the minerals' bioavailability in African indigenous vegetables to help with agricultural zoning, map heavy metal hotspots.

6.4 Recommendations for Further Study

i. While this study quantified mineral concentrations (Fe, Zn, Ca, Mg), further research should examine their bioavailability after cooking, processing, and digestion. This will give a clearer picture of actual nutritional benefits.

ii. Further studies should be conducted on communities regularly consuming African Indigenous Vegetables (AIVs) to establish their long-term health impacts on reducing malnutrition, anemia, stunting, and lifestyle diseases.

iii. More detailed research is needed to understand how soil properties (pH, organic matter, fertilizer type) influence cadmium and lead uptake in African indigenous vegetables, and to develop strategies to minimize accumulation.

iv. Extend sampling to other counties and across different seasons to determine how regional agro-ecological conditions affect nutrient density and contamination levels as a result of geographical and seasonal variations.

v. Investigate how different post-harvest handling, storage, and processing methods affect both nutrient retention and contaminant levels in African indigenous vegetables.

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APPENDICES

Appendix I: ANOVA Analysis for Minerals (Zn,Mg,Fe & Ca)

Fe (mg/kg)

ANOVA					
FeConcMgkg					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39157.593	11	3559.781	3235.058	.000
Within Groups	26.409	24	1.100		
Total	39184.002	35			

Post HOC Tests

Multiple Comparisons						
Dependent Variable: FeConcMgkg						
Tukey HSD						
(I) Locationvegetablecode	(J) Locationvegetablecode	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
African Night shade (Kiandai)	African Night shade (Kianyaga)	-12.0829829*	.8564953	.000	-15.171187	-8.994778
	African Night Shade(Karumande)	-1.4157555	.8564953	.872	-4.503960	1.672449
	Pumpkin Leaves (Kianyaga)	.2803476	.8564953	1.000	-2.807857	3.368552
	Pumpkin Leaves(Karumande)	-12.1670872*	.8564953	.000	-15.255292	-9.078883
	Pumpkin leaves(Kiandai)	-45.4443510*	.8564953	.000	-48.532555	-42.356147
	Spider plant (Kiandai)	6.4059434*	.8564953	.000	3.317739	9.494148
	Spider plant (Kianyaga)	-103.9529016*	.8564953	.000	-107.041106	-100.864697
	Spider plant(Karumande)	-26.3106252*	.8564953	.000	-29.398830	-23.222421
	Vine spinach (Kiandai)	30.9223437*	.8564953	.000	27.834139	34.010548
	Vine spinach (Kianyaga)	13.7650687*	.8564953	.000	10.676864	16.853273
	Vine spinach(Karumande)	-6.1396131*	.8564953	.000	-9.227818	-3.051409
African Night shade (Kianyaga)	African Night shade (Kiandai)	12.0829829*	.8564953	.000	8.994778	15.171187
	African Night Shade(Karumande)	10.6672274*	.8564953	.000	7.579023	13.755432
	Pumpkin Leaves (Kianyaga)	12.3633305*	.8564953	.000	9.275126	15.451535
	Pumpkin Leaves(Karumande)	-.0841043	.8564953	1.000	-3.172309	3.004100
	Pumpkin leaves(Kiandai)	-33.3613681*	.8564953	.000	-36.449573	-30.273164
	Spider plant (Kiandai)	18.4889263*	.8564953	.000	15.400722	21.577131
	Spider plant (Kianyaga)	-91.8699187*	.8564953	.000	-94.958123	-88.781714
	Spider plant(Karumande)	-14.2276423*	.8564953	.000	-17.315847	-11.139438
	Vine spinach (Kiandai)	43.0053266*	.8564953	.000	39.917122	46.093531
	Vine spinach (Kianyaga)	25.8480516*	.8564953	.000	22.759847	28.936256
	Vine spinach(Karumande)	5.9433698*	.8564953	.000	2.855165	9.031574
African Night Shade(Karumande)	African Night shade (Kiandai)	1.4157555	.8564953	.872	-1.672449	4.503960
	African Night shade (Kianyaga)	-10.6672274*	.8564953	.000	-13.755432	-7.579023
	Pumpkin Leaves (Kianyaga)	1.6961032	.8564953	.701	-1.392101	4.784308
	Pumpkin Leaves(Karumande)	-10.7513317*	.8564953	.000	-13.839536	-7.663127
	Pumpkin leaves(Kiandai)	-44.0285955*	.8564953	.000	-47.116800	-40.940391
	Spider plant (Kiandai)	7.8216989*	.8564953	.000	4.733494	10.909903
	Spider plant (Kianyaga)	-102.5371461*	.8564953	.000	-105.625351	-99.448942
	Spider plant(Karumande)	-24.8948696*	.8564953	.000	-27.983074	-21.806665
	Vine spinach (Kiandai)	32.3380992*	.8564953	.000	29.249895	35.426304
	Vine spinach (Kianyaga)	15.1808242*	.8564953	.000	12.092620	18.269029
	Vine spinach(Karumande)	-4.7238576*	.8564953	.001	-7.812062	-1.635653
Pumpkin Leaves (Kianyaga)	African Night shade (Kiandai)	-.2803476	.8564953	1.000	-3.368552	2.807857
	African Night shade (Kianyaga)	-12.3633305*	.8564953	.000	-15.451535	-9.275126
	African Night Shade(Karumande)	-1.6961032	.8564953	.701	-4.784308	1.392101
	Pumpkin Leaves(Karumande)	-12.4474348*	.8564953	.000	-15.535639	-9.359230
	Pumpkin leaves(Kiandai)	-45.7246986*	.8564953	.000	-48.812903	-42.636494
	Spider plant (Kiandai)	6.1255957*	.8564953	.000	3.037391	9.213800
	Spider plant (Kianyaga)	-104.2332492*	.8564953	.000	-107.321454	-101.145045
	Spider plant(Karumande)	-26.5909728*	.8564953	.000	-29.679177	-23.502768
	Vine spinach (Kiandai)	30.6419961*	.8564953	.000	27.553792	33.730201
	Vine spinach (Kianyaga)	13.4847211*	.8564953	.000	10.396517	16.572926
	Vine spinach(Karumande)	-6.4199608*	.8564953	.000	-9.508165	-3.331756
Pumpkin Leaves(Karumande)	African Night shade (Kiandai)	12.1670872*	.8564953	.000	9.078883	15.255292
	African Night shade (Kianyaga)	.0841043	.8564953	1.000	-3.004100	3.172309
	African Night Shade(Karumande)	10.7513317*	.8564953	.000	7.663127	13.839536

	Pumpkin Leaves (Kianyaga)	12.4474348*	.8564953	.000	9.359230	15.535639
	Pumpkin leaves(Kiandai)	-33.2772638*	.8564953	.000	-36.365468	-30.189059
	Spider plant (Kiandai)	18.5730306*	.8564953	.000	15.484826	21.661235
	Spider plant (Kianyaga)	-91.7858144*	.8564953	.000	-94.874019	-88.697610
	Spider plant(Karumande)	-14.1435380*	.8564953	.000	-17.231742	-11.055334
	Vine spinach (Kiandai)	43.0894309*	.8564953	.000	40.001226	46.177635
	Vine spinach (Kianyaga)	25.9321559*	.8564953	.000	22.843951	29.020360
	Vine spinach(Karumande)	6.0274741*	.8564953	.000	2.939270	9.115679
Pumpkin leaves(Kiandai)	African Night shade (Kiandai)	45.4443510*	.8564953	.000	42.356147	48.532555
	African Night shade (Kianyaga)	33.3613681*	.8564953	.000	30.273164	36.449573
	African Night Shade(Karumande)	44.0285955*	.8564953	.000	40.940391	47.116800
	Pumpkin Leaves (Kianyaga)	45.7246986*	.8564953	.000	42.636494	48.812903
	Pumpkin Leaves(Karumande)	33.2772638*	.8564953	.000	30.189059	36.365468
	Spider plant (Kiandai)	51.8502944*	.8564953	.000	48.762090	54.938499
	Spider plant (Kianyaga)	-58.5085506*	.8564953	.000	-61.596755	-55.420346
	Spider plant(Karumande)	19.1337258*	.8564953	.000	16.045521	22.221930
	Vine spinach (Kiandai)	76.3666947*	.8564953	.000	73.278490	79.454899
	Vine spinach (Kianyaga)	59.2094197*	.8564953	.000	56.121215	62.297624
	Vine spinach(Karumande)	39.3047379*	.8564953	.000	36.216533	42.392942
Spider plant (Kiandai)	African Night shade (Kiandai)	-6.4059434*	.8564953	.000	-9.494148	-3.317739
	African Night shade (Kianyaga)	-18.4889263*	.8564953	.000	-21.577131	-15.400722
	African Night Shade(Karumande)	-7.8216989*	.8564953	.000	-10.909903	-4.733494
	Pumpkin Leaves (Kianyaga)	-6.1255957*	.8564953	.000	-9.213800	-3.037391
	Pumpkin Leaves(Karumande)	-18.5730306*	.8564953	.000	-21.661235	-15.484826
	Pumpkin leaves(Kiandai)	-51.8502944*	.8564953	.000	-54.938499	-48.762090
	Spider plant (Kianyaga)	-110.3588450*	.8564953	.000	-113.447049	-107.270641
	Spider plant(Karumande)	-32.7165685*	.8564953	.000	-35.804773	-29.628364
	Vine spinach (Kiandai)	24.5164003*	.8564953	.000	21.428196	27.604605
	Vine spinach (Kianyaga)	7.3591253*	.8564953	.000	4.270921	10.447330
	Vine spinach(Karumande)	-12.5455565*	.8564953	.000	-15.633761	-9.457352
Spider plant (Kianyaga)	African Night shade (Kiandai)	103.9529016*	.8564953	.000	100.864697	107.041106
	African Night shade (Kianyaga)	91.8699187*	.8564953	.000	88.781714	94.958123
	African Night Shade(Karumande)	102.5371461*	.8564953	.000	99.448942	105.625351
	Pumpkin Leaves (Kianyaga)	104.2332492*	.8564953	.000	101.145045	107.321454
	Pumpkin Leaves(Karumande)	91.7858144*	.8564953	.000	88.697610	94.874019
	Pumpkin leaves(Kiandai)	58.5085506*	.8564953	.000	55.420346	61.596755
	Spider plant (Kiandai)	110.3588450*	.8564953	.000	107.270641	113.447049
	Spider plant(Karumande)	77.6422764*	.8564953	.000	74.554072	80.730481
	Vine spinach (Kiandai)	134.8752453*	.8564953	.000	131.787041	137.963450
	Vine spinach (Kianyaga)	117.7179703*	.8564953	.000	114.629766	120.806175
	Vine spinach(Karumande)	97.8132885*	.8564953	.000	94.725084	100.901493
Spider plant(Karumande)	African Night shade (Kiandai)	26.3106252*	.8564953	.000	23.222421	29.398830
	African Night shade (Kianyaga)	14.2276423*	.8564953	.000	11.139438	17.315847
	African Night Shade(Karumande)	24.8948696*	.8564953	.000	21.806665	27.983074
	Pumpkin Leaves (Kianyaga)	26.5909728*	.8564953	.000	23.502768	29.679177
	Pumpkin Leaves(Karumande)	14.1435380*	.8564953	.000	11.055334	17.231742
	Pumpkin leaves(Kiandai)	-19.1337258*	.8564953	.000	-22.221930	-16.045521
	Spider plant (Kiandai)	32.7165685*	.8564953	.000	29.628364	35.804773
	Spider plant (Kianyaga)	-77.6422764*	.8564953	.000	-80.730481	-74.554072
	Vine spinach (Kiandai)	57.2329689*	.8564953	.000	54.144764	60.321173
	Vine spinach (Kianyaga)	40.0756939*	.8564953	.000	36.987489	43.163898
	Vine spinach(Karumande)	20.1710121*	.8564953	.000	17.082808	23.259217
Vine spinach (Kiandai)	African Night shade (Kiandai)	-30.9223437*	.8564953	.000	-34.010548	-27.834139
	African Night shade (Kianyaga)	-43.0053266*	.8564953	.000	-46.093531	-39.917122
	African Night Shade(Karumande)	-32.3380992*	.8564953	.000	-35.426304	-29.249895
	Pumpkin Leaves (Kianyaga)	-30.6419961*	.8564953	.000	-33.730201	-27.553792
	Pumpkin Leaves(Karumande)	-43.0894309*	.8564953	.000	-46.177635	-40.001226
	Pumpkin leaves(Kiandai)	-76.3666947*	.8564953	.000	-79.454899	-73.278490
	Spider plant (Kiandai)	-24.5164003*	.8564953	.000	-27.604605	-21.428196
	Spider plant (Kianyaga)	-134.8752453*	.8564953	.000	-137.963450	-131.787041
	Spider plant(Karumande)	-57.2329689*	.8564953	.000	-60.321173	-54.144764
	Vine spinach (Kianyaga)	-17.1572750*	.8564953	.000	-20.245479	-14.069071
	Vine spinach(Karumande)	-37.0619568*	.8564953	.000	-40.150161	-33.973752
Vine spinach (Kianyaga)	African Night shade (Kiandai)	-13.7650687*	.8564953	.000	-16.853273	-10.676864
	African Night shade (Kianyaga)	-25.8480516*	.8564953	.000	-28.936256	-22.759847
	African Night Shade(Karumande)	-15.1808242*	.8564953	.000	-18.269029	-12.092620
	Pumpkin Leaves (Kianyaga)	-13.4847211*	.8564953	.000	-16.572926	-10.396517
	Pumpkin Leaves(Karumande)	-25.9321559*	.8564953	.000	-29.020360	-22.843951
	Pumpkin leaves(Kiandai)	-59.2094197*	.8564953	.000	-62.297624	-56.121215
	Spider plant (Kiandai)	-7.3591253*	.8564953	.000	-10.447330	-4.270921
	Spider plant (Kianyaga)	-117.7179703*	.8564953	.000	-120.806175	-114.629766
	Spider plant(Karumande)	-40.0756939*	.8564953	.000	-43.163898	-36.987489
	Vine spinach (Kiandai)	17.1572750*	.8564953	.000	14.069071	20.245479
	Vine spinach(Karumande)	-19.9046818*	.8564953	.000	-22.992886	-16.816477
Vine spinach(Karumande)	African Night shade (Kiandai)	6.1396131*	.8564953	.000	3.051409	9.227818

	African Night shade (Kianyaga)	-5.9433698*	.8564953	.000	-9.031574	-2.855165
	African Night Shade(Karumande)	4.7238576*	.8564953	.001	1.635653	7.812062
	Pumpkin Leaves (Kianyaga)	6.4199608*	.8564953	.000	3.331756	9.508165
	Pumpkin Leaves(Karumande)	-6.0274741*	.8564953	.000	-9.115679	-2.939270
	Pumpkin leaves(Kiandai)	-39.3047379*	.8564953	.000	-42.392942	-36.216533
	Spider plant (Kiandai)	12.5455565*	.8564953	.000	9.457352	15.633761
	Spider plant (Kianyaga)	-97.8132885*	.8564953	.000	-100.901493	-94.725084
	Spider plant(Karumande)	-20.1710121*	.8564953	.000	-23.259217	-17.082808
	Vine spinach (Kiandai)	37.0619568*	.8564953	.000	33.973752	40.150161
	Vine spinach (Kianyaga)	19.9046818*	.8564953	.000	16.816477	22.992886

*. The mean difference is significant at the 0.05 level.

Zn (mg/kg)

ANOVA

ZnConcMgkg

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	383067.515	11	34824.320	8928.473	.000
Within Groups	93.609	24	3.900		
Total	383161.124	35			

Post HOC Tests

Multiple Comparisons

Dependent Variable: ZnConcMgkg

Tukey HSD

(I) Locationvegetablecode	(J) Locationvegetablecode	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
African Night shade (Kiandai)	African Night shade (Kianyaga)	.7407407	1.6125274	1.000	-5.073435	6.554917
	African Night Shade(Karumande)	46.4550265*	1.6125274	.000	40.640851	52.269202
	Pumpkin Leaves (Kianyaga)	-12.3809524*	1.6125274	.000	-18.195128	-6.566776
	Pumpkin Leaves(Karumande)	-32.5925926*	1.6125274	.000	-38.406768	-26.778417
	Pumpkin leaves(Kiandai)	-55.6613757*	1.6125274	.000	-61.475552	-49.847200
	Spider plant (Kiandai)	-227.1957672*	1.6125274	.000	-233.009943	-221.381591
	Spider plant (Kianyaga)	-256.0317460*	1.6125274	.000	-261.845922	-250.217570
	Spider plant(Karumande)	-262.6984127*	1.6125274	.000	-268.512589	-256.884237
	Vine spinach (Kiandai)	-29.6825397*	1.6125274	.000	-35.496716	-23.868364
	Vine spinach (Kianyaga)	-51.4285714*	1.6125274	.000	-57.242747	-45.614396
	Vine spinach(Karumande)	-33.4920635*	1.6125274	.000	-39.306239	-27.677888
African Night shade (Kianyaga)	African Night shade (Kiandai)	-.7407407	1.6125274	1.000	-6.554917	5.073435
	African Night Shade(Karumande)	45.7142857*	1.6125274	.000	39.900110	51.528462
	Pumpkin Leaves (Kianyaga)	-13.1216931*	1.6125274	.000	-18.935869	-7.307517
	Pumpkin Leaves(Karumande)	-33.3333333*	1.6125274	.000	-39.147509	-27.519157
	Pumpkin leaves(Kiandai)	-56.4021164*	1.6125274	.000	-62.216292	-50.587941
	Spider plant (Kiandai)	-227.9365079*	1.6125274	.000	-233.750684	-222.122332
	Spider plant (Kianyaga)	-256.7724868*	1.6125274	.000	-262.586663	-250.958311
	Spider plant(Karumande)	-263.4391534*	1.6125274	.000	-269.253329	-257.624978
	Vine spinach (Kiandai)	-30.4232804*	1.6125274	.000	-36.237456	-24.609105
	Vine spinach (Kianyaga)	-52.1693122*	1.6125274	.000	-57.983488	-46.355136
	Vine spinach(Karumande)	-34.2328042*	1.6125274	.000	-40.046980	-28.418628
African Night Shade(Karumande)	African Night shade (Kiandai)	-46.4550265*	1.6125274	.000	-52.269202	-40.640851
	African Night shade (Kianyaga)	-45.7142857*	1.6125274	.000	-51.528462	-39.900110
	Pumpkin Leaves (Kianyaga)	-58.8359788*	1.6125274	.000	-64.650155	-53.021803
	Pumpkin Leaves(Karumande)	-79.0476190*	1.6125274	.000	-84.861795	-73.233443
	Pumpkin leaves(Kiandai)	-102.1164021*	1.6125274	.000	-107.930578	-96.302226
	Spider plant (Kiandai)	-273.6507937*	1.6125274	.000	-279.464970	-267.836618
	Spider plant (Kianyaga)	-302.4867725*	1.6125274	.000	-308.300948	-296.672597

	Spider plant(Karumande)	-309.1534392*	1.6125274	.000	-314.967615	-303.339263
	Vine spinach (Kiandai)	-76.1375661*	1.6125274	.000	-81.951742	-70.323390
	Vine spinach (Kianyaga)	-97.8835979*	1.6125274	.000	-103.697774	-92.069422
	Vine spinach(Karumande)	-79.9470899*	1.6125274	.000	-85.761266	-74.132914
Pumpkin Leaves (Kianyaga)	African Night shade (Kiandai)	12.3809524*	1.6125274	.000	6.566776	18.195128
	African Night shade (Kianyaga)	13.1216931*	1.6125274	.000	7.307517	18.935869
	African Night Shade(Karumande)	58.8359788*	1.6125274	.000	53.021803	64.650155
	Pumpkin Leaves(Karumande)	-20.2116402*	1.6125274	.000	-26.025816	-14.397464
	Pumpkin leaves(Kiandai)	-43.2804233*	1.6125274	.000	-49.094599	-37.466247
	Spider plant (Kiandai)	-214.8148148*	1.6125274	.000	-220.628991	-209.000639
	Spider plant (Kianyaga)	-243.6507937*	1.6125274	.000	-249.464970	-237.836618
	Spider plant(Karumande)	-250.3174603*	1.6125274	.000	-256.131636	-244.503284
	Vine spinach (Kiandai)	-17.3015873*	1.6125274	.000	-23.115763	-11.487411
	Vine spinach (Kianyaga)	-39.0476190*	1.6125274	.000	-44.861795	-33.233443
	Vine spinach(Karumande)	-21.1111111*	1.6125274	.000	-26.925287	-15.296935
Pumpkin Leaves(Karumande)	African Night shade (Kiandai)	32.5925926*	1.6125274	.000	26.778417	38.406768
	African Night shade (Kianyaga)	33.3333333*	1.6125274	.000	27.519157	39.147509
	African Night Shade(Karumande)	79.0476190*	1.6125274	.000	73.233443	84.861795
	Pumpkin Leaves (Kianyaga)	20.2116402*	1.6125274	.000	14.397464	26.025816
	Pumpkin leaves(Kiandai)	-23.0687831*	1.6125274	.000	-28.882959	-17.254607
	Spider plant (Kiandai)	-194.6031746*	1.6125274	.000	-200.417350	-188.788999
	Spider plant (Kianyaga)	-223.4391534*	1.6125274	.000	-229.253329	-217.624978
	Spider plant(Karumande)	-230.1058201*	1.6125274	.000	-235.919996	-224.291644
	Vine spinach (Kiandai)	2.9100529	1.6125274	.801	-2.904123	8.724229
	Vine spinach (Kianyaga)	-18.8359788*	1.6125274	.000	-24.650155	-13.021803
	Vine spinach(Karumande)	-.8994709	1.6125274	1.000	-6.713647	4.914705
Pumpkin leaves(Kiandai)	African Night shade (Kiandai)	55.6613757*	1.6125274	.000	49.847200	61.475552
	African Night shade (Kianyaga)	56.4021164*	1.6125274	.000	50.587941	62.216292
	African Night Shade(Karumande)	102.1164021*	1.6125274	.000	96.302226	107.930578
	Pumpkin Leaves (Kianyaga)	43.2804233*	1.6125274	.000	37.466247	49.094599
	Pumpkin Leaves(Karumande)	23.0687831*	1.6125274	.000	17.254607	28.882959
	Spider plant (Kiandai)	-171.5343915*	1.6125274	.000	-177.348567	-165.720216
	Spider plant (Kianyaga)	-200.3703704*	1.6125274	.000	-206.184546	-194.556194
	Spider plant(Karumande)	-207.0370370*	1.6125274	.000	-212.851213	-201.222861
	Vine spinach (Kiandai)	25.9788360*	1.6125274	.000	20.164660	31.793012
	Vine spinach (Kianyaga)	4.2328042	1.6125274	.320	-1.581372	10.046980
	Vine spinach(Karumande)	22.1693122*	1.6125274	.000	16.355136	27.983488
Spider plant (Kiandai)	African Night shade (Kiandai)	227.1957672*	1.6125274	.000	221.381591	233.009943
	African Night shade (Kianyaga)	227.9365079*	1.6125274	.000	222.122332	233.750684
	African Night Shade(Karumande)	273.6507937*	1.6125274	.000	267.836618	279.464970
	Pumpkin Leaves (Kianyaga)	214.8148148*	1.6125274	.000	209.000639	220.628991
	Pumpkin Leaves(Karumande)	194.6031746*	1.6125274	.000	188.788999	200.417350
	Pumpkin leaves(Kiandai)	171.5343915*	1.6125274	.000	165.720216	177.348567
	Spider plant (Kianyaga)	-28.8359788*	1.6125274	.000	-34.650155	-23.021803
	Spider plant(Karumande)	-35.5026455*	1.6125274	.000	-41.316821	-29.688470
	Vine spinach (Kiandai)	197.5132275*	1.6125274	.000	191.699052	203.327403
	Vine spinach (Kianyaga)	175.7671958*	1.6125274	.000	169.953020	181.581372
	Vine spinach(Karumande)	193.7037037*	1.6125274	.000	187.889528	199.517880
Spider plant (Kianyaga)	African Night shade (Kiandai)	256.0317460*	1.6125274	.000	250.217570	261.845922
	African Night shade (Kianyaga)	256.7724868*	1.6125274	.000	250.958311	262.586663
	African Night Shade(Karumande)	302.4867725*	1.6125274	.000	296.672597	308.300948
	Pumpkin Leaves (Kianyaga)	243.6507937*	1.6125274	.000	237.836618	249.464970

	Pumpkin Leaves(Karumande)	223.4391534*	1.6125274	.000	217.624978	229.253329
	Pumpkin leaves(Kiandai)	200.3703704*	1.6125274	.000	194.556194	206.184546
	Spider plant (Kiandai)	28.8359788*	1.6125274	.000	23.021803	34.650155
	Spider plant(Karumande)	-6.6666667*	1.6125274	.015	-12.480843	-.852491
	Vine spinach (Kiandai)	226.3492063*	1.6125274	.000	220.535030	232.163382
	Vine spinach (Kianyaga)	204.6031746*	1.6125274	.000	198.788999	210.417350
	Vine spinach(Karumande)	222.5396825*	1.6125274	.000	216.725507	228.353858
Spider plant(Karumande)	African Night shade (Kiandai)	262.6984127*	1.6125274	.000	256.884237	268.512589
	African Night shade (Kianyaga)	263.4391534*	1.6125274	.000	257.624978	269.253329
	African Night Shade(Karumande)	309.1534392*	1.6125274	.000	303.339263	314.967615
	Pumpkin Leaves (Kianyaga)	250.3174603*	1.6125274	.000	244.503284	256.131636
	Pumpkin Leaves(Karumande)	230.1058201*	1.6125274	.000	224.291644	235.919996
	Pumpkin leaves(Kiandai)	207.0370370*	1.6125274	.000	201.222861	212.851213
	Spider plant (Kiandai)	35.5026455*	1.6125274	.000	29.688470	41.316821
	Spider plant (Kianyaga)	6.6666667*	1.6125274	.015	.852491	12.480843
	Vine spinach (Kiandai)	233.0158730*	1.6125274	.000	227.201697	238.830049
	Vine spinach (Kianyaga)	211.2698413*	1.6125274	.000	205.455665	217.084017
	Vine spinach(Karumande)	229.2063492*	1.6125274	.000	223.392173	235.020525
Vine spinach (Kiandai)	African Night shade (Kiandai)	29.6825397*	1.6125274	.000	23.868364	35.496716
	African Night shade (Kianyaga)	30.4232804*	1.6125274	.000	24.609105	36.237456
	African Night Shade(Karumande)	76.1375661*	1.6125274	.000	70.323390	81.951742
	Pumpkin Leaves (Kianyaga)	17.3015873*	1.6125274	.000	11.487411	23.115763
	Pumpkin Leaves(Karumande)	-2.9100529	1.6125274	.801	-8.724229	2.904123
	Pumpkin leaves(Kiandai)	-25.9788360*	1.6125274	.000	-31.793012	-20.164660
	Spider plant (Kiandai)	-197.5132275*	1.6125274	.000	-203.327403	-191.699052
	Spider plant (Kianyaga)	-226.3492063*	1.6125274	.000	-232.163382	-220.535030
	Spider plant(Karumande)	-233.0158730*	1.6125274	.000	-238.830049	-227.201697
	Vine spinach (Kianyaga)	-21.7460317*	1.6125274	.000	-27.560208	-15.931856
	Vine spinach(Karumande)	-3.8095238	1.6125274	.464	-9.623700	2.004652
Vine spinach (Kianyaga)	African Night shade (Kiandai)	51.4285714*	1.6125274	.000	45.614396	57.242747
	African Night shade (Kianyaga)	52.1693122*	1.6125274	.000	46.355136	57.983488
	African Night Shade(Karumande)	97.8835979*	1.6125274	.000	92.069422	103.697774
	Pumpkin Leaves (Kianyaga)	39.0476190*	1.6125274	.000	33.233443	44.861795
	Pumpkin Leaves(Karumande)	18.8359788*	1.6125274	.000	13.021803	24.650155
	Pumpkin leaves(Kiandai)	-4.2328042	1.6125274	.320	-10.046980	1.581372
	Spider plant (Kiandai)	-175.7671958*	1.6125274	.000	-181.581372	-169.953020
	Spider plant (Kianyaga)	-204.6031746*	1.6125274	.000	-210.417350	-198.788999
	Spider plant(Karumande)	-211.2698413*	1.6125274	.000	-217.084017	-205.455665
	Vine spinach (Kiandai)	21.7460317*	1.6125274	.000	15.931856	27.560208
	Vine spinach(Karumande)	17.9365079*	1.6125274	.000	12.122332	23.750684
Vine spinach(Karumande)	African Night shade (Kiandai)	33.4920635*	1.6125274	.000	27.677888	39.306239
	African Night shade (Kianyaga)	34.2328042*	1.6125274	.000	28.418628	40.046980
	African Night Shade(Karumande)	79.9470899*	1.6125274	.000	74.132914	85.761266
	Pumpkin Leaves (Kianyaga)	21.1111111*	1.6125274	.000	15.296935	26.925287
	Pumpkin Leaves(Karumande)	.8994709	1.6125274	1.000	-4.914705	6.713647
	Pumpkin leaves(Kiandai)	-22.1693122*	1.6125274	.000	-27.983488	-16.355136
	Spider plant (Kiandai)	-193.7037037*	1.6125274	.000	-199.517880	-187.889528
	Spider plant (Kianyaga)	-222.5396825*	1.6125274	.000	-228.353858	-216.725507
	Spider plant(Karumande)	-229.2063492*	1.6125274	.000	-235.020525	-223.392173
	Vine spinach (Kiandai)	3.8095238	1.6125274	.464	-2.004652	9.623700
	Vine spinach (Kianyaga)	-17.9365079*	1.6125274	.000	-23.750684	-12.122332

*. The mean difference is significant at the 0.05 level.

Ca (mg/kg)

ANOVA					
CaConcMgkg					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	205374541.217	11	18670412.838	19116.303	.000
Within Groups	23440.197	24	976.675		
Total	205397981.415	35			

Post HOC Tests

Multiple Comparisons

Dependent Variable: CaConcMgkg

Tukey HSD

(I) Locationvegetablecode	(J) Locationvegetablecode	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
African Night shade (Kiandai)	African Night shade (Kianyaga)	-625.2408478*	25.5169864	.000	-717.245641	-533.236054
	African Night Shade(Karumande)	-1081.4065511*	25.5169864	.000	-1173.411345	-989.401758
	Pumpkin Leaves (Kianyaga)	-6407.5144509*	25.5169864	.000	-6499.519244	-6315.509657
	Pumpkin Leaves(Karumande)	-6934.0077071*	25.5169864	.000	-7026.012501	-6842.002914
	Pumpkin leaves(Kiandai)	-6652.2157996*	25.5169864	.000	-6744.220593	-6560.211006
	Spider plant (Kiandai)	-1858.3815029*	25.5169864	.000	-1950.386296	-1766.376709
	Spider plant (Kianyaga)	-1762.0423892*	25.5169864	.000	-1854.047183	-1670.037596
	Spider plant(Karumande)	-1384.8747592*	25.5169864	.000	-1476.879553	-1292.869966
	Vine spinach (Kiandai)	-1406.5510597*	25.5169864	.000	-1498.555853	-1314.546266
	Vine spinach (Kianyaga)	-1532.2736031*	25.5169864	.000	-1624.278397	-1440.268810
	Vine spinach(Karumande)	-1887.7649326*	25.5169864	.000	-1979.769726	-1795.760139
African Night shade (Kianyaga)	African Night shade (Kiandai)	625.2408478*	25.5169864	.000	533.236054	717.245641
	African Night Shade(Karumande)	-456.1657033*	25.5169864	.000	-548.170497	-364.160910
	Pumpkin Leaves (Kianyaga)	-5782.2736031*	25.5169864	.000	-5874.278397	-5690.268810
	Pumpkin Leaves(Karumande)	-6308.7668593*	25.5169864	.000	-6400.771653	-6216.762066
	Pumpkin leaves(Kiandai)	-6026.9749518*	25.5169864	.000	-6118.979745	-5934.970158
	Spider plant (Kiandai)	-1233.1406551*	25.5169864	.000	-1325.145449	-1141.135862
	Spider plant (Kianyaga)	-1136.8015414*	25.5169864	.000	-1228.806335	-1044.796748
	Spider plant(Karumande)	-759.6339114*	25.5169864	.000	-851.638705	-667.629118
	Vine spinach (Kiandai)	-781.3102119*	25.5169864	.000	-873.315005	-689.305418
	Vine spinach (Kianyaga)	-907.0327553*	25.5169864	.000	-999.037549	-815.027962
	Vine spinach(Karumande)	-1262.5240848*	25.5169864	.000	-1354.528878	-1170.519291
African Night Shade(Karumande)	African Night shade (Kiandai)	1081.4065511*	25.5169864	.000	989.401758	1173.411345
	African Night shade (Kianyaga)	456.1657033*	25.5169864	.000	364.160910	548.170497
	Pumpkin Leaves (Kianyaga)	-5326.1078998*	25.5169864	.000	-5418.112693	-5234.103106
	Pumpkin Leaves(Karumande)	-5852.6011561*	25.5169864	.000	-5944.605950	-5760.596363
	Pumpkin leaves(Kiandai)	-5570.8092486*	25.5169864	.000	-5662.814042	-5478.804455
	Spider plant (Kiandai)	-776.9749518*	25.5169864	.000	-868.979745	-684.970158
	Spider plant (Kianyaga)	-680.6358382*	25.5169864	.000	-772.640632	-588.631045
	Spider plant(Karumande)	-303.4682081*	25.5169864	.000	-395.473002	-211.463415

	Vine spinach (Kiandai)	-325.1445087*	25.5169864	.000	-417.149302	-233.139715
	Vine spinach (Kianyaga)	-450.8670520*	25.5169864	.000	-542.871846	-358.862259
	Vine spinach(Karumande)	-806.3583815*	25.5169864	.000	-898.363175	-714.353588
Pumpkin Leaves (Kianyaga)	African Night shade (Kiandai)	6407.5144509*	25.5169864	.000	6315.509657	6499.519244
	African Night shade (Kianyaga)	5782.2736031*	25.5169864	.000	5690.268810	5874.278397
	African Night Shade(Karumande)	5326.1078998*	25.5169864	.000	5234.103106	5418.112693
	Pumpkin Leaves(Karumande)	-526.4932563*	25.5169864	.000	-618.498050	-434.488463
	Pumpkin leaves(Kiandai)	-244.7013487*	25.5169864	.000	-336.706142	-152.696555
	Spider plant (Kiandai)	4549.1329480*	25.5169864	.000	4457.128154	4641.137741
	Spider plant (Kianyaga)	4645.4720617*	25.5169864	.000	4553.467268	4737.476855
	Spider plant(Karumande)	5022.6396917*	25.5169864	.000	4930.634898	5114.644485
	Vine spinach (Kiandai)	5000.9633911*	25.5169864	.000	4908.958598	5092.968185
	Vine spinach (Kianyaga)	4875.2408478*	25.5169864	.000	4783.236054	4967.245641
	Vine spinach(Karumande)	4519.7495183*	25.5169864	.000	4427.744725	4611.754312
Pumpkin Leaves(Karumande)	African Night shade (Kiandai)	6934.0077071*	25.5169864	.000	6842.002914	7026.012501
	African Night shade (Kianyaga)	6308.7668593*	25.5169864	.000	6216.762066	6400.771653
	African Night Shade(Karumande)	5852.6011561*	25.5169864	.000	5760.596363	5944.605950
	Pumpkin Leaves (Kianyaga)	526.4932563*	25.5169864	.000	434.488463	618.498050
	Pumpkin leaves(Kiandai)	281.7919075*	25.5169864	.000	189.787114	373.796701
	Spider plant (Kiandai)	5075.6262042*	25.5169864	.000	4983.621411	5167.630998
	Spider plant (Kianyaga)	5171.9653179*	25.5169864	.000	5079.960524	5263.970111
	Spider plant(Karumande)	5549.1329480*	25.5169864	.000	5457.128154	5641.137741
	Vine spinach (Kiandai)	5527.4566474*	25.5169864	.000	5435.451854	5619.461441
	Vine spinach (Kianyaga)	5401.7341040*	25.5169864	.000	5309.729311	5493.738898
	Vine spinach(Karumande)	5046.2427746*	25.5169864	.000	4954.237981	5138.247568
Pumpkin leaves(Kiandai)	African Night shade (Kiandai)	6652.2157996*	25.5169864	.000	6560.211006	6744.220593
	African Night shade (Kianyaga)	6026.9749518*	25.5169864	.000	5934.970158	6118.979745
	African Night Shade(Karumande)	5570.8092486*	25.5169864	.000	5478.804455	5662.814042
	Pumpkin Leaves (Kianyaga)	244.7013487*	25.5169864	.000	152.696555	336.706142
	Pumpkin Leaves(Karumande)	-281.7919075*	25.5169864	.000	-373.796701	-189.787114
	Spider plant (Kiandai)	4793.8342967*	25.5169864	.000	4701.829503	4885.839090
	Spider plant (Kianyaga)	4890.1734104*	25.5169864	.000	4798.168617	4982.178204
	Spider plant(Karumande)	5267.3410405*	25.5169864	.000	5175.336247	5359.345834
	Vine spinach (Kiandai)	5245.6647399*	25.5169864	.000	5153.659946	5337.669533
	Vine spinach (Kianyaga)	5119.9421965*	25.5169864	.000	5027.937403	5211.946990
	Vine spinach(Karumande)	4764.4508671*	25.5169864	.000	4672.446074	4856.455661
Spider plant (Kiandai)	African Night shade (Kiandai)	1858.3815029*	25.5169864	.000	1766.376709	1950.386296
	African Night shade (Kianyaga)	1233.1406551*	25.5169864	.000	1141.135862	1325.145449
	African Night Shade(Karumande)	776.9749518*	25.5169864	.000	684.970158	868.979745
	Pumpkin Leaves (Kianyaga)	-4549.1329480*	25.5169864	.000	-4641.137741	-4457.128154
	Pumpkin Leaves(Karumande)	-5075.6262042*	25.5169864	.000	-5167.630998	-4983.621411
	Pumpkin leaves(Kiandai)	-4793.8342967*	25.5169864	.000	-4885.839090	-4701.829503
	Spider plant (Kianyaga)	96.3391137*	25.5169864	.034	4.334320	188.343907

	Spider plant(Karumande)	473.5067437*	25.5169864	.000	381.501950	565.511537
	Vine spinach (Kiandai)	451.8304432*	25.5169864	.000	359.825650	543.835237
	Vine spinach (Kianyaga)	326.1078998*	25.5169864	.000	234.103106	418.112693
	Vine spinach(Karumande)	-29.3834297	25.5169864	.988	-121.388223	62.621364
Spider plant (Kianyaga)	African Night shade (Kiandai)	1762.0423892*	25.5169864	.000	1670.037596	1854.047183
	African Night shade (Kianyaga)	1136.8015414*	25.5169864	.000	1044.796748	1228.806335
	African Night Shade(Karumande)	680.6358382*	25.5169864	.000	588.631045	772.640632
	Pumpkin Leaves (Kianyaga)	-4645.4720617*	25.5169864	.000	-4737.476855	-4553.467268
	Pumpkin Leaves(Karumande)	-5171.9653179*	25.5169864	.000	-5263.970111	-5079.960524
	Pumpkin leaves(Kiandai)	-4890.1734104*	25.5169864	.000	-4982.178204	-4798.168617
	Spider plant (Kiandai)	-96.3391137*	25.5169864	.034	-188.343907	-4.334320
	Spider plant(Karumande)	377.1676301*	25.5169864	.000	285.162837	469.172424
	Vine spinach (Kiandai)	355.4913295*	25.5169864	.000	263.486536	447.496123
	Vine spinach (Kianyaga)	229.7687861*	25.5169864	.000	137.763993	321.773580
	Vine spinach(Karumande)	-125.7225434*	25.5169864	.002	-217.727337	-33.717750
Spider plant(Karumande)	African Night shade (Kiandai)	1384.8747592*	25.5169864	.000	1292.869966	1476.879553
	African Night shade (Kianyaga)	759.6339114*	25.5169864	.000	667.629118	851.638705
	African Night Shade(Karumande)	303.4682081*	25.5169864	.000	211.463415	395.473002
	Pumpkin Leaves (Kianyaga)	-5022.6396917*	25.5169864	.000	-5114.644485	-4930.634898
	Pumpkin Leaves(Karumande)	-5549.1329480*	25.5169864	.000	-5641.137741	-5457.128154
	Pumpkin leaves(Kiandai)	-5267.3410405*	25.5169864	.000	-5359.345834	-5175.336247
	Spider plant (Kiandai)	-473.5067437*	25.5169864	.000	-565.511537	-381.501950
	Spider plant (Kianyaga)	-377.1676301*	25.5169864	.000	-469.172424	-285.162837
	Vine spinach (Kiandai)	-21.6763006	25.5169864	.999	-113.681094	70.328493
	Vine spinach (Kianyaga)	-147.3988439*	25.5169864	.000	-239.403637	-55.394050
	Vine spinach(Karumande)	-502.8901734*	25.5169864	.000	-594.894967	-410.885380
Vine spinach (Kiandai)	African Night shade (Kiandai)	1406.5510597*	25.5169864	.000	1314.546266	1498.555853
	African Night shade (Kianyaga)	781.3102119*	25.5169864	.000	689.305418	873.315005
	African Night Shade(Karumande)	325.1445087*	25.5169864	.000	233.139715	417.149302
	Pumpkin Leaves (Kianyaga)	-5000.9633911*	25.5169864	.000	-5092.968185	-4908.958598
	Pumpkin Leaves(Karumande)	-5527.4566474*	25.5169864	.000	-5619.461441	-5435.451854
	Pumpkin leaves(Kiandai)	-5245.6647399*	25.5169864	.000	-5337.669533	-5153.659946
	Spider plant (Kiandai)	-451.8304432*	25.5169864	.000	-543.835237	-359.825650
	Spider plant (Kianyaga)	-355.4913295*	25.5169864	.000	-447.496123	-263.486536
	Spider plant(Karumande)	21.6763006	25.5169864	.999	-70.328493	113.681094
	Vine spinach (Kianyaga)	-125.7225434*	25.5169864	.002	-217.727337	-33.717750
	Vine spinach(Karumande)	-481.2138728*	25.5169864	.000	-573.218666	-389.209079
Vine spinach (Kianyaga)	African Night shade (Kiandai)	1532.2736031*	25.5169864	.000	1440.268810	1624.278397
	African Night shade (Kianyaga)	907.0327553*	25.5169864	.000	815.027962	999.037549
	African Night Shade(Karumande)	450.8670520*	25.5169864	.000	358.862259	542.871846
	Pumpkin Leaves (Kianyaga)	-4875.2408478*	25.5169864	.000	-4967.245641	-4783.236054
	Pumpkin Leaves(Karumande)	-5401.7341040*	25.5169864	.000	-5493.738898	-5309.729311
	Pumpkin leaves(Kiandai)	-5119.9421965*	25.5169864	.000	-5211.946990	-5027.937403

	Spider plant (Kiandai)	-326.1078998*	25.5169864	.000	-418.112693	-234.103106
	Spider plant (Kianyaga)	-229.7687861*	25.5169864	.000	-321.773580	-137.763993
	Spider plant(Karumande)	147.3988439*	25.5169864	.000	55.394050	239.403637
	Vine spinach (Kiandai)	125.7225434*	25.5169864	.002	33.717750	217.727337
	Vine spinach(Karumande)	-355.4913295*	25.5169864	.000	-447.496123	-263.486536
Vine spinach(Karumande)	African Night shade (Kiandai)	1887.7649326*	25.5169864	.000	1795.760139	1979.769726
	African Night shade (Kianyaga)	1262.5240848*	25.5169864	.000	1170.519291	1354.528878
	African Night Shade(Karumande)	806.3583815*	25.5169864	.000	714.353588	898.363175
	Pumpkin Leaves (Kianyaga)	-4519.7495183*	25.5169864	.000	-4611.754312	-4427.744725
	Pumpkin Leaves(Karumande)	-5046.2427746*	25.5169864	.000	-5138.247568	-4954.237981
	Pumpkin leaves(Kiandai)	-4764.4508671*	25.5169864	.000	-4856.455661	-4672.446074
	Spider plant (Kiandai)	29.3834297	25.5169864	.988	-62.621364	121.388223
	Spider plant (Kianyaga)	125.7225434*	25.5169864	.002	33.717750	217.727337
	Spider plant(Karumande)	502.8901734*	25.5169864	.000	410.885380	594.894967
	Vine spinach (Kiandai)	481.2138728*	25.5169864	.000	389.209079	573.218666
	Vine spinach (Kianyaga)	355.4913295*	25.5169864	.000	263.486536	447.496123

*. The mean difference is significant at the 0.05 level.

Mg (mg/kg)

ANOVA

MgConcMgkg

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	254812.911	11	23164.810	7370.933	.000
Within Groups	75.425	24	3.143		
Total	254888.336	35			

Post HOC Tests

Multiple Comparisons

Dependent Variable: MgConcMgkg

Tukey HSD

(I) Locationvegetablecode	(J) Locationvegetablecode	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
African Night shade (Kiandai)	African Night shade (Kianyaga)	-8.5241730*	1.4474631	.000	-13.743189	-3.305158
	African Night Shade(Karumande)	8.0152672*	1.4474631	.001	2.796252	13.234283
	Pumpkin Leaves (Kianyaga)	-184.4783715*	1.4474631	.000	-189.697387	-179.259356
	Pumpkin Leaves(Karumande)	-196.8193384*	1.4474631	.000	-202.038354	-191.600323
	Pumpkin leaves(Kiandai)	-191.6030534*	1.4474631	.000	-196.822069	-186.384038
	Spider plant (Kiandai)	-118.9567430*	1.4474631	.000	-124.175758	-113.737728
	Spider plant (Kianyaga)	-118.5750636*	1.4474631	.000	-123.794079	-113.356048
	Spider plant(Karumande)	-102.8625954*	1.4474631	.000	-108.081611	-97.643580
	Vine spinach (Kiandai)	-211.2595420*	1.4474631	.000	-216.478557	-206.040527
	Vine spinach (Kianyaga)	-216.6030534*	1.4474631	.000	-221.822069	-211.384038
	Vine spinach(Karumande)	-218.9567430*	1.4474631	.000	-224.175758	-213.737728

African Night shade (Kianyaga)	African Night shade (Kiandai)	8.5241730*	1.4474631	.000	3.305158	13.743189
	African Night Shade(Karumande)	16.5394402*	1.4474631	.000	11.320425	21.758456
	Pumpkin Leaves (Kianyaga)	-175.9541985*	1.4474631	.000	-181.173214	-170.735183
	Pumpkin Leaves(Karumande)	-188.2951654*	1.4474631	.000	-193.514181	-183.076150
	Pumpkin leaves(Kiandai)	-183.0788804*	1.4474631	.000	-188.297896	-177.859865
	Spider plant (Kiandai)	-110.4325700*	1.4474631	.000	-115.651585	-105.213554
	Spider plant (Kianyaga)	-110.0508906*	1.4474631	.000	-115.269906	-104.831875
	Spider plant(Karumande)	-94.3384224*	1.4474631	.000	-99.557438	-89.119407
	Vine spinach (Kiandai)	-202.7353690*	1.4474631	.000	-207.954384	-197.516353
	Vine spinach (Kianyaga)	-208.0788804*	1.4474631	.000	-213.297896	-202.859865
	Vine spinach(Karumande)	-210.4325700*	1.4474631	.000	-215.651585	-205.213554
African Night Shade(Karumande)	African Night shade (Kiandai)	-8.0152672*	1.4474631	.001	-13.234283	-2.796252
	African Night shade (Kianyaga)	-16.5394402*	1.4474631	.000	-21.758456	-11.320425
	Pumpkin Leaves (Kianyaga)	-192.4936387*	1.4474631	.000	-197.712654	-187.274623
	Pumpkin Leaves(Karumande)	-204.8346056*	1.4474631	.000	-210.053621	-199.615590
	Pumpkin leaves(Kiandai)	-199.6183206*	1.4474631	.000	-204.837336	-194.399305
	Spider plant (Kiandai)	-126.9720102*	1.4474631	.000	-132.191026	-121.752995
	Spider plant (Kianyaga)	-126.5903308*	1.4474631	.000	-131.809346	-121.371315
	Spider plant(Karumande)	-110.8778626*	1.4474631	.000	-116.096878	-105.658847
	Vine spinach (Kiandai)	-219.2748092*	1.4474631	.000	-224.493825	-214.055794
	Vine spinach (Kianyaga)	-224.6183206*	1.4474631	.000	-229.837336	-219.399305
	Vine spinach(Karumande)	-226.9720102*	1.4474631	.000	-232.191026	-221.752995
Pumpkin Leaves (Kianyaga)	African Night shade (Kiandai)	184.4783715*	1.4474631	.000	179.259356	189.697387
	African Night shade (Kianyaga)	175.9541985*	1.4474631	.000	170.735183	181.173214
	African Night Shade(Karumande)	192.4936387*	1.4474631	.000	187.274623	197.712654
	Pumpkin Leaves(Karumande)	-12.3409669*	1.4474631	.000	-17.559982	-7.121951
	Pumpkin leaves(Kiandai)	-7.1246819*	1.4474631	.002	-12.343697	-1.905666
	Spider plant (Kiandai)	65.5216285*	1.4474631	.000	60.302613	70.740644
	Spider plant (Kianyaga)	65.9033079*	1.4474631	.000	60.684292	71.122323
	Spider plant(Karumande)	81.6157761*	1.4474631	.000	76.396761	86.834792
	Vine spinach (Kiandai)	-26.7811705*	1.4474631	.000	-32.000186	-21.562155
	Vine spinach (Kianyaga)	-32.1246819*	1.4474631	.000	-37.343697	-26.905666
	Vine spinach(Karumande)	-34.4783715*	1.4474631	.000	-39.697387	-29.259356
Pumpkin Leaves(Karumande)	African Night shade (Kiandai)	196.8193384*	1.4474631	.000	191.600323	202.038354
	African Night shade (Kianyaga)	188.2951654*	1.4474631	.000	183.076150	193.514181
	African Night Shade(Karumande)	204.8346056*	1.4474631	.000	199.615590	210.053621
	Pumpkin Leaves (Kianyaga)	12.3409669*	1.4474631	.000	7.121951	17.559982

	Pumpkin leaves(Kiandai)	5.2162850	1.4474631	.050	-.002730	10.435300
	Spider plant (Kiandai)	77.8625954*	1.4474631	.000	72.643580	83.081611
	Spider plant (Kianyaga)	78.2442748*	1.4474631	.000	73.025259	83.463290
	Spider plant(Karumande)	93.9567430*	1.4474631	.000	88.737728	99.175758
	Vine spinach (Kiandai)	-14.4402036*	1.4474631	.000	-19.659219	-9.221188
	Vine spinach (Kianyaga)	-19.7837150*	1.4474631	.000	-25.002730	-14.564700
	Vine spinach(Karumande)	-22.1374046*	1.4474631	.000	-27.356420	-16.918389
Pumpkin leaves(Kiandai)	African Night shade (Kiandai)	191.6030534*	1.4474631	.000	186.384038	196.822069
	African Night shade (Kianyaga)	183.0788804*	1.4474631	.000	177.859865	188.297896
	African Night Shade(Karumande)	199.6183206*	1.4474631	.000	194.399305	204.837336
	Pumpkin Leaves (Kianyaga)	7.1246819*	1.4474631	.002	1.905666	12.343697
	Pumpkin Leaves(Karumande)	-5.2162850	1.4474631	.050	-10.435300	.002730
	Spider plant (Kiandai)	72.6463104*	1.4474631	.000	67.427295	77.865326
	Spider plant (Kianyaga)	73.0279898*	1.4474631	.000	67.808974	78.247005
	Spider plant(Karumande)	88.7404580*	1.4474631	.000	83.521443	93.959473
	Vine spinach (Kiandai)	-19.6564885*	1.4474631	.000	-24.875504	-14.437473
	Vine spinach (Kianyaga)	-25.0000000*	1.4474631	.000	-30.219015	-19.780985
	Vine spinach(Karumande)	-27.3536896*	1.4474631	.000	-32.572705	-22.134674
Spider plant (Kiandai)	African Night shade (Kiandai)	118.9567430*	1.4474631	.000	113.737728	124.175758
	African Night shade (Kianyaga)	110.4325700*	1.4474631	.000	105.213554	115.651585
	African Night Shade(Karumande)	126.9720102*	1.4474631	.000	121.752995	132.191026
	Pumpkin Leaves (Kianyaga)	-65.5216285*	1.4474631	.000	-70.740644	-60.302613
	Pumpkin Leaves(Karumande)	-77.8625954*	1.4474631	.000	-83.081611	-72.643580
	Pumpkin leaves(Kiandai)	-72.6463104*	1.4474631	.000	-77.865326	-67.427295
	Spider plant (Kianyaga)	.3816794	1.4474631	1.000	-4.837336	5.600695
	Spider plant(Karumande)	16.0941476*	1.4474631	.000	10.875132	21.313163
	Vine spinach (Kiandai)	-92.3027990*	1.4474631	.000	-97.521814	-87.083783
	Vine spinach (Kianyaga)	-97.6463104*	1.4474631	.000	-102.865326	-92.427295
	Vine spinach(Karumande)	-100.0000000*	1.4474631	.000	-105.219015	-94.780985
Spider plant (Kianyaga)	African Night shade (Kiandai)	118.5750636*	1.4474631	.000	113.356048	123.794079
	African Night shade (Kianyaga)	110.0508906*	1.4474631	.000	104.831875	115.269906
	African Night Shade(Karumande)	126.5903308*	1.4474631	.000	121.371315	131.809346
	Pumpkin Leaves (Kianyaga)	-65.9033079*	1.4474631	.000	-71.122323	-60.684292
	Pumpkin Leaves(Karumande)	-78.2442748*	1.4474631	.000	-83.463290	-73.025259
	Pumpkin leaves(Kiandai)	-73.0279898*	1.4474631	.000	-78.247005	-67.808974
	Spider plant (Kiandai)	-.3816794	1.4474631	1.000	-5.600695	4.837336
	Spider plant(Karumande)	15.7124682*	1.4474631	.000	10.493453	20.931484

	Vine spinach (Kiandai)	-92.6844784*	1.4474631	.000	-97.903494	-87.465463
	Vine spinach (Kianyaga)	-98.0279898*	1.4474631	.000	-103.247005	-92.808974
	Vine spinach(Karumande)	-100.3816794*	1.4474631	.000	-105.600695	-95.162664
Spider plant(Karumande)	African Night shade (Kiandai)	102.8625954*	1.4474631	.000	97.643580	108.081611
	African Night shade (Kianyaga)	94.3384224*	1.4474631	.000	89.119407	99.557438
	African Night Shade(Karumande)	110.8778626*	1.4474631	.000	105.658847	116.096878
	Pumpkin Leaves (Kianyaga)	-81.6157761*	1.4474631	.000	-86.834792	-76.396761
	Pumpkin Leaves(Karumande)	-93.9567430*	1.4474631	.000	-99.175758	-88.737728
	Pumpkin leaves(Kiandai)	-88.7404580*	1.4474631	.000	-93.959473	-83.521443
	Spider plant (Kiandai)	-16.0941476*	1.4474631	.000	-21.313163	-10.875132
	Spider plant (Kianyaga)	-15.7124682*	1.4474631	.000	-20.931484	-10.493453
	Vine spinach (Kiandai)	-108.3969466*	1.4474631	.000	-113.615962	-103.177931
	Vine spinach (Kianyaga)	-113.7404580*	1.4474631	.000	-118.959473	-108.521443
	Vine spinach(Karumande)	-116.0941476*	1.4474631	.000	-121.313163	-110.875132
Vine spinach (Kiandai)	African Night shade (Kiandai)	211.2595420*	1.4474631	.000	206.040527	216.478557
	African Night shade (Kianyaga)	202.7353690*	1.4474631	.000	197.516353	207.954384
	African Night Shade(Karumande)	219.2748092*	1.4474631	.000	214.055794	224.493825
	Pumpkin Leaves (Kianyaga)	26.7811705*	1.4474631	.000	21.562155	32.000186
	Pumpkin Leaves(Karumande)	14.4402036*	1.4474631	.000	9.221188	19.659219
	Pumpkin leaves(Kiandai)	19.6564885*	1.4474631	.000	14.437473	24.875504
	Spider plant (Kiandai)	92.3027990*	1.4474631	.000	87.083783	97.521814
	Spider plant (Kianyaga)	92.6844784*	1.4474631	.000	87.465463	97.903494
	Spider plant(Karumande)	108.3969466*	1.4474631	.000	103.177931	113.615962
	Vine spinach (Kianyaga)	-5.3435115*	1.4474631	.041	-10.562527	-.124496
	Vine spinach(Karumande)	-7.6972010*	1.4474631	.001	-12.916217	-2.478186
Vine spinach (Kianyaga)	African Night shade (Kiandai)	216.6030534*	1.4474631	.000	211.384038	221.822069
	African Night shade (Kianyaga)	208.0788804*	1.4474631	.000	202.859865	213.297896
	African Night Shade(Karumande)	224.6183206*	1.4474631	.000	219.399305	229.837336
	Pumpkin Leaves (Kianyaga)	32.1246819*	1.4474631	.000	26.905666	37.343697
	Pumpkin Leaves(Karumande)	19.7837150*	1.4474631	.000	14.564700	25.002730
	Pumpkin leaves(Kiandai)	25.0000000*	1.4474631	.000	19.780985	30.219015
	Spider plant (Kiandai)	97.6463104*	1.4474631	.000	92.427295	102.865326
	Spider plant (Kianyaga)	98.0279898*	1.4474631	.000	92.808974	103.247005
	Spider plant(Karumande)	113.7404580*	1.4474631	.000	108.521443	118.959473
	Vine spinach (Kiandai)	5.3435115*	1.4474631	.041	.124496	10.562527
	Vine spinach(Karumande)	-2.3536896	1.4474631	.883	-7.572705	2.865326
Vine spinach(Karumande)	African Night shade (Kiandai)	218.9567430*	1.4474631	.000	213.737728	224.175758

	African Night shade (Kianyaga)	210.4325700*	1.4474631	.000	205.213554	215.651585
	African Night Shade(Karumande)	226.9720102*	1.4474631	.000	221.752995	232.191026
	Pumpkin Leaves (Kianyaga)	34.4783715*	1.4474631	.000	29.259356	39.697387
	Pumpkin Leaves(Karumande)	22.1374046*	1.4474631	.000	16.918389	27.356420
	Pumpkin leaves(Kiandai)	27.3536896*	1.4474631	.000	22.134674	32.572705
	Spider plant (Kiandai)	100.0000000*	1.4474631	.000	94.780985	105.219015
	Spider plant (Kianyaga)	100.3816794*	1.4474631	.000	95.162664	105.600695
	Spider plant(Karumande)	116.0941476*	1.4474631	.000	110.875132	121.313163
	Vine spinach (Kiandai)	7.6972010*	1.4474631	.001	2.478186	12.916217
	Vine spinach (Kianyaga)	2.3536896	1.4474631	.883	-2.865326	7.572705

*. The mean difference is significant at the 0.05 level.

Appendix II: Anova Analysis for Heavy Metals (Cd & Pb)

Cadmium

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Cd Conc. Mg/kg	Based on Mean	8.673	11	24	.000
	Based on Median	.666	11	24	.756
	Based on Median and with adjusted df	.666	11	5.661	.735
	Based on trimmed mean	7.058	11	24	.000

ANOVA					
Cd Conc. Mg/kg					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.026	11	.002	6.269	.000
Within Groups	.009	24	.000		
Total	.035	35			

Post HOC

Multiple Comparisons						
Dependent Variable: Cd Conc. Mg/kg						
Tukey HSD						
(I) Borehole/Vegetable	(J) Borehole/Vegetable	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
African Night shade (Kiandai)	African Night shade (Kianyaga)	-.0545109	.0158551	.071	-.111679	.002657
	African Night Shade(Karumande)	.0006977	.0158551	1.000	-.056470	.057865
	Pumpkin Leaves (Kianyaga)	-.0024884	.0158551	1.000	-.059656	.054679
	Pumpkin Leaves(Karumande)	.0023450	.0158551	1.000	-.054823	.059513
	Pumpkin leaves(Kiandai)	-.0051938	.0158551	1.000	-.062361	.051974
	Spider plant (Kiandai)	-.0692636*	.0158551	.009	-.126431	-.012096
	Spider plant (Kianyaga)	-.0479070	.0158551	.162	-.105075	.009261
	Spider plant(Karumande)	.0245155	.0158551	.912	-.032652	.081683
	Vine spinach (Kiandai)	.0005116	.0158551	1.000	-.056656	.057679
	Vine spinach (Kianyaga)	-.0309690	.0158551	.717	-.088137	.026199
	Vine spinach(Karumande)	-.0216279	.0158551	.960	-.078796	.035540
African Night shade (Kianyaga)	African Night shade (Kiandai)	.0545109	.0158551	.071	-.002657	.111679
	African Night Shade(Karumande)	.0552086	.0158551	.065	-.001959	.112376
	Pumpkin Leaves (Kianyaga)	.0520226	.0158551	.098	-.005145	.109190
	Pumpkin Leaves(Karumande)	.0568559	.0158551	.052	-.000312	.114024
	Pumpkin leaves(Kiandai)	.0493171	.0158551	.137	-.007851	.106485
	Spider plant (Kiandai)	-.0147526	.0158551	.998	-.071920	.042415
	Spider plant (Kianyaga)	.0066039	.0158551	1.000	-.050564	.063772
	Spider plant(Karumande)	.0790264*	.0158551	.002	.021859	.136194
	Vine spinach (Kiandai)	.0550226	.0158551	.067	-.002145	.112190
	Vine spinach (Kianyaga)	.0235419	.0158551	.931	-.033626	.080710
	Vine spinach(Karumande)	.0328830	.0158551	.644	-.024285	.090051
African Night Shade(Karumande)	African Night shade (Kiandai)	-.0006977	.0158551	1.000	-.057865	.056470
	African Night shade (Kianyaga)	-.0552086	.0158551	.065	-.112376	.001959
	Pumpkin Leaves (Kianyaga)	-.0031860	.0158551	1.000	-.060354	.053982
	Pumpkin Leaves(Karumande)	.0016473	.0158551	1.000	-.055520	.058815
	Pumpkin leaves(Kiandai)	-.0058915	.0158551	1.000	-.063059	.051276
	Spider plant (Kiandai)	-.0699612*	.0158551	.008	-.127129	-.012794

	Spider plant (Kianyaga)	-.0486047	.0158551	.150	-.105772	.008563
	Spider plant(Karumande)	.0238178	.0158551	.926	-.033350	.080985
	Vine spinach (Kiandai)	-.0001860	.0158551	1.000	-.057354	.056982
	Vine spinach (Kianyaga)	-.0316667	.0158551	.691	-.088834	.025501
	Vine spinach(Karumande)	-.0223256	.0158551	.951	-.079493	.034842
Pumpkin Leaves (Kianyaga)	African Night shade (Kiandai)	.0024884	.0158551	1.000	-.054679	.059656
	African Night shade (Kianyaga)	-.0520226	.0158551	.098	-.109190	.005145
	African Night Shade(Karumande)	.0031860	.0158551	1.000	-.053982	.060354
	Pumpkin Leaves(Karumande)	.0048333	.0158551	1.000	-.052334	.062001
	Pumpkin leaves(Kiandai)	-.0027054	.0158551	1.000	-.059873	.054462
	Spider plant (Kiandai)	-.0667752*	.0158551	.013	-.123943	-.009608
	Spider plant (Kianyaga)	-.0454186	.0158551	.215	-.102586	.011749
	Spider plant(Karumande)	.0270039	.0158551	.850	-.030164	.084172
	Vine spinach (Kiandai)	.0030000	.0158551	1.000	-.054168	.060168
	Vine spinach (Kianyaga)	-.0284806	.0158551	.805	-.085648	.028687
	Vine spinach(Karumande)	-.0191395	.0158551	.983	-.076307	.038028
Pumpkin Leaves(Karumande)	African Night shade (Kiandai)	-.0023450	.0158551	1.000	-.059513	.054823
	African Night shade (Kianyaga)	-.0568559	.0158551	.052	-.114024	.000312
	African Night Shade(Karumande)	-.0016473	.0158551	1.000	-.058815	.055520
	Pumpkin Leaves (Kianyaga)	-.0048333	.0158551	1.000	-.062001	.052334
	Pumpkin leaves(Kiandai)	-.0075388	.0158551	1.000	-.064706	.049629
	Spider plant (Kiandai)	-.0716085*	.0158551	.006	-.128776	-.014441
	Spider plant (Kianyaga)	-.0502519	.0158551	.123	-.107420	.006916
	Spider plant(Karumande)	.0221705	.0158551	.953	-.034997	.079338
	Vine spinach (Kiandai)	-.0018333	.0158551	1.000	-.059001	.055334
	Vine spinach (Kianyaga)	-.0333140	.0158551	.627	-.090482	.023854
	Vine spinach(Karumande)	-.0239729	.0158551	.923	-.081141	.033195
Pumpkin leaves(Kiandai)	African Night shade (Kiandai)	.0051938	.0158551	1.000	-.051974	.062361
	African Night shade (Kianyaga)	-.0493171	.0158551	.137	-.106485	.007851
	African Night Shade(Karumande)	.0058915	.0158551	1.000	-.051276	.063059
	Pumpkin Leaves (Kianyaga)	.0027054	.0158551	1.000	-.054462	.059873
	Pumpkin Leaves(Karumande)	.0075388	.0158551	1.000	-.049629	.064706
	Spider plant (Kiandai)	-.0640698*	.0158551	.019	-.121237	-.006902
	Spider plant (Kianyaga)	-.0427132	.0158551	.287	-.099881	.014454
	Spider plant(Karumande)	.0297093	.0158551	.763	-.027458	.086877
	Vine spinach (Kiandai)	.0057054	.0158551	1.000	-.051462	.062873
	Vine spinach (Kianyaga)	-.0257752	.0158551	.883	-.082943	.031392
	Vine spinach(Karumande)	-.0164341	.0158551	.995	-.073602	.040734
Spider plant (Kiandai)	African Night shade (Kiandai)	.0692636*	.0158551	.009	.012096	.126431
	African Night shade (Kianyaga)	.0147526	.0158551	.998	-.042415	.071920
	African Night Shade(Karumande)	.0699612*	.0158551	.008	.012794	.127129
	Pumpkin Leaves (Kianyaga)	.0667752*	.0158551	.013	.009608	.123943
	Pumpkin Leaves(Karumande)	.0716085*	.0158551	.006	.014441	.128776
	Pumpkin leaves(Kiandai)	.0640698*	.0158551	.019	.006902	.121237
	Spider plant (Kianyaga)	.0213566	.0158551	.963	-.035811	.078524
	Spider plant(Karumande)	.0937791*	.0158551	.000	.036611	.150947
	Vine spinach (Kiandai)	.0697752*	.0158551	.008	.012608	.126943
	Vine spinach (Kianyaga)	.0382946	.0158551	.433	-.018873	.095462
	Vine spinach(Karumande)	.0476357	.0158551	.168	-.009532	.104803
Spider plant (Kianyaga)	African Night shade (Kiandai)	.0479070	.0158551	.162	-.009261	.105075
	African Night shade (Kianyaga)	-.0066039	.0158551	1.000	-.063772	.050564
	African Night Shade(Karumande)	.0486047	.0158551	.150	-.008563	.105772
	Pumpkin Leaves (Kianyaga)	.0454186	.0158551	.215	-.011749	.102586

	Pumpkin Leaves(Karumande)	.0502519	.0158551	.123	-.006916	.107420
	Pumpkin leaves(Kiandai)	.0427132	.0158551	.287	-.014454	.099881
	Spider plant (Kiandai)	-.0213566	.0158551	.963	-.078524	.035811
	Spider plant(Karumande)	.0724225*	.0158551	.006	.015255	.129590
	Vine spinach (Kiandai)	.0484186	.0158551	.153	-.008749	.105586
	Vine spinach (Kianyaga)	.0169380	.0158551	.993	-.040230	.074106
	Vine spinach(Karumande)	.0262791	.0158551	.870	-.030889	.083447
Spider plant(Karumande)	African Night shade (Kiandai)	-.0245155	.0158551	.912	-.081683	.032652
	African Night shade (Kianyaga)	-.0790264*	.0158551	.002	-.136194	-.021859
	African Night Shade(Karumande)	-.0238178	.0158551	.926	-.080985	.033350
	Pumpkin Leaves (Kianyaga)	-.0270039	.0158551	.850	-.084172	.030164
	Pumpkin Leaves(Karumande)	-.0221705	.0158551	.953	-.079338	.034997
	Pumpkin leaves(Kiandai)	-.0297093	.0158551	.763	-.086877	.027458
	Spider plant (Kiandai)	-.0937791*	.0158551	.000	-.150947	-.036611
	Spider plant (Kianyaga)	-.0724225*	.0158551	.006	-.129590	-.015255
	Vine spinach (Kiandai)	-.0240039	.0158551	.922	-.081172	.033164
	Vine spinach (Kianyaga)	-.0554845	.0158551	.063	-.112652	.001683
	Vine spinach(Karumande)	-.0461434	.0158551	.199	-.103311	.011024
Vine spinach (Kiandai)	African Night shade (Kiandai)	-.0005116	.0158551	1.000	-.057679	.056656
	African Night shade (Kianyaga)	-.0550226	.0158551	.067	-.112190	.002145
	African Night Shade(Karumande)	.0001860	.0158551	1.000	-.056982	.057354
	Pumpkin Leaves (Kianyaga)	-.0030000	.0158551	1.000	-.060168	.054168
	Pumpkin Leaves(Karumande)	.0018333	.0158551	1.000	-.055334	.059001
	Pumpkin leaves(Kiandai)	-.0057054	.0158551	1.000	-.062873	.051462
	Spider plant (Kiandai)	-.0697752*	.0158551	.008	-.126943	-.012608
	Spider plant (Kianyaga)	-.0484186	.0158551	.153	-.105586	.008749
	Spider plant(Karumande)	.0240039	.0158551	.922	-.033164	.081172
	Vine spinach (Kianyaga)	-.0314806	.0158551	.698	-.088648	.025687
	Vine spinach(Karumande)	-.0221395	.0158551	.953	-.079307	.035028
Vine spinach (Kianyaga)	African Night shade (Kiandai)	.0309690	.0158551	.717	-.026199	.088137
	African Night shade (Kianyaga)	-.0235419	.0158551	.931	-.080710	.033626
	African Night Shade(Karumande)	.0316667	.0158551	.691	-.025501	.088834
	Pumpkin Leaves (Kianyaga)	.0284806	.0158551	.805	-.028687	.085648
	Pumpkin Leaves(Karumande)	.0333140	.0158551	.627	-.023854	.090482
	Pumpkin leaves(Kiandai)	.0257752	.0158551	.883	-.031392	.082943
	Spider plant (Kiandai)	-.0382946	.0158551	.433	-.095462	.018873
	Spider plant (Kianyaga)	-.0169380	.0158551	.993	-.074106	.040230
	Spider plant(Karumande)	.0554845	.0158551	.063	-.001683	.112652
	Vine spinach (Kiandai)	.0314806	.0158551	.698	-.025687	.088648
	Vine spinach(Karumande)	.0093411	.0158551	1.000	-.047827	.066509
Vine spinach(Karumande)	African Night shade (Kiandai)	.0216279	.0158551	.960	-.035540	.078796
	African Night shade (Kianyaga)	-.0328830	.0158551	.644	-.090051	.024285
	African Night Shade(Karumande)	.0223256	.0158551	.951	-.034842	.079493
	Pumpkin Leaves (Kianyaga)	.0191395	.0158551	.983	-.038028	.076307
	Pumpkin Leaves(Karumande)	.0239729	.0158551	.923	-.033195	.081141
	Pumpkin leaves(Kiandai)	.0164341	.0158551	.995	-.040734	.073602
	Spider plant (Kiandai)	-.0476357	.0158551	.168	-.104803	.009532
	Spider plant (Kianyaga)	-.0262791	.0158551	.870	-.083447	.030889
	Spider plant(Karumande)	.0461434	.0158551	.199	-.011024	.103311
	Vine spinach (Kiandai)	.0221395	.0158551	.953	-.035028	.079307
	Vine spinach (Kianyaga)	-.0093411	.0158551	1.000	-.066509	.047827

*. The mean difference is significant at the 0.05 level.

Lead

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Pb Conc. Mg/kg	Based on Mean	8.673	11	24	.000
	Based on Median	.666	11	24	.756
	Based on Median and with adjusted df	.666	11	5.661	.735
	Based on trimmed mean	7.058	11	24	.000

ANOVA					
Pb Conc. Mg/kg					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.026	11	.002	6.269	.000
Within Groups	.009	24	.000		
Total	.035	35			

POST HOC

Multiple Comparisons						
Dependent Variable: Pb Conc. Mg/kg						
Tukey HSD						
(I) Borehole/ Vegetable	(J) Borehole/Vegetable	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
African Night shade (Kiandai)	African Night shade (Kianyaga)	-.0545109	.0158551	.071	-.111679	.002657
	African Night Shade(Karumande)	.0006977	.0158551	1.000	-.056470	.057865
	Pumpkin Leaves (Kianyaga)	-.0024884	.0158551	1.000	-.059656	.054679
	Pumpkin Leaves(Karumande)	.0023450	.0158551	1.000	-.054823	.059513
	Pumpkin leaves(Kiandai)	-.0051938	.0158551	1.000	-.062361	.051974
	Spider plant (Kiandai)	-.0692636*	.0158551	.009	-.126431	-.012096
	Spider plant (Kianyaga)	-.0479070	.0158551	.162	-.105075	.009261
	Spider plant(Karumande)	.0245155	.0158551	.912	-.032652	.081683
	Vine spinach (Kiandai)	.0005116	.0158551	1.000	-.056656	.057679
	Vine spinach (Kianyaga)	-.0309690	.0158551	.717	-.088137	.026199
	Vine spinach(Karumande)	-.0216279	.0158551	.960	-.078796	.035540
African Night shade (Kianyaga)	African Night shade (Kiandai)	.0545109	.0158551	.071	-.002657	.111679
	African Night Shade(Karumande)	.0552086	.0158551	.065	-.001959	.112376
	Pumpkin Leaves (Kianyaga)	.0520226	.0158551	.098	-.005145	.109190
	Pumpkin Leaves(Karumande)	.0568559	.0158551	.052	-.000312	.114024
	Pumpkin leaves(Kiandai)	.0493171	.0158551	.137	-.007851	.106485
	Spider plant (Kiandai)	-.0147526	.0158551	.998	-.071920	.042415
	Spider plant (Kianyaga)	.0066039	.0158551	1.000	-.050564	.063772
	Spider plant(Karumande)	.0790264*	.0158551	.002	.021859	.136194
	Vine spinach (Kiandai)	.0550226	.0158551	.067	-.002145	.112190
	Vine spinach (Kianyaga)	.0235419	.0158551	.931	-.033626	.080710
	Vine spinach(Karumande)	.0328830	.0158551	.644	-.024285	.090051
African Night Shade(Karumande)	African Night shade (Kiandai)	-.0006977	.0158551	1.000	-.057865	.056470
	African Night shade (Kianyaga)	-.0552086	.0158551	.065	-.112376	.001959
	Pumpkin Leaves (Kianyaga)	-.0031860	.0158551	1.000	-.060354	.053982
	Pumpkin Leaves(Karumande)	.0016473	.0158551	1.000	-.055520	.058815
	Pumpkin leaves(Kiandai)	-.0058915	.0158551	1.000	-.063059	.051276
	Spider plant (Kiandai)	-.0699612*	.0158551	.008	-.127129	-.012794
	Spider plant (Kianyaga)	-.0486047	.0158551	.150	-.105772	.008563
	Spider plant(Karumande)	.0238178	.0158551	.926	-.033350	.080985
	Vine spinach (Kiandai)	-.0001860	.0158551	1.000	-.057354	.056982
	Vine spinach (Kianyaga)	-.0316667	.0158551	.691	-.088834	.025501
	Vine spinach(Karumande)	-.0223256	.0158551	.951	-.079493	.034842
Pumpkin Leaves (Kianyaga)	African Night shade (Kiandai)	.0024884	.0158551	1.000	-.054679	.059656
	African Night shade (Kianyaga)	-.0520226	.0158551	.098	-.109190	.005145
	African Night Shade(Karumande)	.0031860	.0158551	1.000	-.053982	.060354

	Pumpkin Leaves(Karumande)	.0048333	.0158551	1.000	-.052334	.062001
	Pumpkin leaves(Kiandai)	-.0027054	.0158551	1.000	-.059873	.054462
	Spider plant (Kiandai)	-.0667752*	.0158551	.013	-.123943	-.009608
	Spider plant (Kianyaga)	-.0454186	.0158551	.215	-.102586	.011749
	Spider plant(Karumande)	.0270039	.0158551	.850	-.030164	.084172
	Vine spinach (Kiandai)	.0030000	.0158551	1.000	-.054168	.060168
	Vine spinach (Kianyaga)	-.0284806	.0158551	.805	-.085648	.028687
	Vine spinach(Karumande)	-.0191395	.0158551	.983	-.076307	.038028
Pumpkin Leaves(Karumande)	African Night shade (Kiandai)	-.0023450	.0158551	1.000	-.059513	.054823
	African Night shade (Kianyaga)	-.0568559	.0158551	.052	-.114024	.000312
	African Night Shade(Karumande)	-.0016473	.0158551	1.000	-.058815	.055520
	Pumpkin Leaves (Kianyaga)	-.0048333	.0158551	1.000	-.062001	.052334
	Pumpkin leaves(Kiandai)	-.0075388	.0158551	1.000	-.064706	.049629
	Spider plant (Kiandai)	-.0716085*	.0158551	.006	-.128776	-.014441
	Spider plant (Kianyaga)	-.0502519	.0158551	.123	-.107420	.006916
	Spider plant(Karumande)	.0221705	.0158551	.953	-.034997	.079338
	Vine spinach (Kiandai)	-.0018333	.0158551	1.000	-.059001	.055334
	Vine spinach (Kianyaga)	-.0333140	.0158551	.627	-.090482	.023854
	Vine spinach(Karumande)	-.0239729	.0158551	.923	-.081141	.033195
Pumpkin leaves(Kiandai)	African Night shade (Kiandai)	.0051938	.0158551	1.000	-.051974	.062361
	African Night shade (Kianyaga)	-.0493171	.0158551	.137	-.106485	.007851
	African Night Shade(Karumande)	.0058915	.0158551	1.000	-.051276	.063059
	Pumpkin Leaves (Kianyaga)	.0027054	.0158551	1.000	-.054462	.059873
	Pumpkin Leaves(Karumande)	.0075388	.0158551	1.000	-.049629	.064706
	Spider plant (Kiandai)	-.0640698*	.0158551	.019	-.121237	-.006902
	Spider plant (Kianyaga)	-.0427132	.0158551	.287	-.099881	.014454
	Spider plant(Karumande)	.0297093	.0158551	.763	-.027458	.086877
	Vine spinach (Kiandai)	.0057054	.0158551	1.000	-.051462	.062873
	Vine spinach (Kianyaga)	-.0257752	.0158551	.883	-.082943	.031392
	Vine spinach(Karumande)	-.0164341	.0158551	.995	-.073602	.040734
Spider plant (Kiandai)	African Night shade (Kiandai)	.0692636*	.0158551	.009	.012096	.126431
	African Night shade (Kianyaga)	.0147526	.0158551	.998	-.042415	.071920
	African Night Shade(Karumande)	.0699612*	.0158551	.008	.012794	.127129
	Pumpkin Leaves (Kianyaga)	.0667752*	.0158551	.013	.009608	.123943
	Pumpkin Leaves(Karumande)	.0716085*	.0158551	.006	.014441	.128776
	Pumpkin leaves(Kiandai)	.0640698*	.0158551	.019	.006902	.121237
	Spider plant (Kianyaga)	.0213566	.0158551	.963	-.035811	.078524
	Spider plant(Karumande)	.0937791*	.0158551	.000	.036611	.150947
	Vine spinach (Kiandai)	.0697752*	.0158551	.008	.012608	.126943
	Vine spinach (Kianyaga)	.0382946	.0158551	.433	-.018873	.095462
	Vine spinach(Karumande)	.0476357	.0158551	.168	-.009532	.104803
Spider plant (Kianyaga)	African Night shade (Kiandai)	.0479070	.0158551	.162	-.009261	.105075
	African Night shade (Kianyaga)	-.0066039	.0158551	1.000	-.063772	.050564
	African Night Shade(Karumande)	.0486047	.0158551	.150	-.008563	.105772
	Pumpkin Leaves (Kianyaga)	.0454186	.0158551	.215	-.011749	.102586
	Pumpkin Leaves(Karumande)	.0502519	.0158551	.123	-.006916	.107420
	Pumpkin leaves(Kiandai)	.0427132	.0158551	.287	-.014454	.099881
	Spider plant (Kiandai)	-.0213566	.0158551	.963	-.078524	.035811
	Spider plant(Karumande)	.0724225*	.0158551	.006	.015255	.129590
	Vine spinach (Kiandai)	.0484186	.0158551	.153	-.008749	.105586
	Vine spinach (Kianyaga)	.0169380	.0158551	.993	-.040230	.074106
	Vine spinach(Karumande)	.0262791	.0158551	.870	-.030889	.083447
Spider plant(Karumande)	African Night shade (Kiandai)	-.0245155	.0158551	.912	-.081683	.032652
	African Night shade (Kianyaga)	-.0790264*	.0158551	.002	-.136194	-.021859
	African Night Shade(Karumande)	-.0238178	.0158551	.926	-.080985	.033350
	Pumpkin Leaves (Kianyaga)	-.0270039	.0158551	.850	-.084172	.030164
	Pumpkin Leaves(Karumande)	-.0221705	.0158551	.953	-.079338	.034997
	Pumpkin leaves(Kiandai)	-.0297093	.0158551	.763	-.086877	.027458
	Spider plant (Kiandai)	-.0937791*	.0158551	.000	-.150947	-.036611
	Spider plant (Kianyaga)	-.0724225*	.0158551	.006	-.129590	-.015255
	Vine spinach (Kiandai)	-.0240039	.0158551	.922	-.081172	.033164
	Vine spinach (Kianyaga)	-.0554845	.0158551	.063	-.112652	.001683
	Vine spinach(Karumande)	-.0461434	.0158551	.199	-.103311	.011024
Vine spinach (Kiandai)	African Night shade (Kiandai)	-.0005116	.0158551	1.000	-.057679	.056656
	African Night shade (Kianyaga)	-.0550226	.0158551	.067	-.112190	.002145
	African Night Shade(Karumande)	.0001860	.0158551	1.000	-.056982	.057354
	Pumpkin Leaves (Kianyaga)	-.0030000	.0158551	1.000	-.060168	.054168
	Pumpkin Leaves(Karumande)	.0018333	.0158551	1.000	-.055334	.059001
	Pumpkin leaves(Kiandai)	-.0057054	.0158551	1.000	-.062873	.051462
	Spider plant (Kiandai)	-.0697752*	.0158551	.008	-.126943	-.012608
	Spider plant (Kianyaga)	-.0484186	.0158551	.153	-.105586	.008749
	Spider plant(Karumande)	.0240039	.0158551	.922	-.033164	.081172
	Vine spinach (Kianyaga)	-.0314806	.0158551	.698	-.088648	.025687
	Vine spinach(Karumande)	-.0221395	.0158551	.953	-.079307	.035028
	African Night shade (Kiandai)	.0309690	.0158551	.717	-.026199	.088137

Vine spinach (Kianyaga)	African Night shade (Kianyaga)	-.0235419	.0158551	.931	-.080710	.033626
	African Night Shade(Karumande)	.0316667	.0158551	.691	-.025501	.088834
	Pumpkin Leaves (Kianyaga)	.0284806	.0158551	.805	-.028687	.085648
	Pumpkin Leaves(Karumande)	.0333140	.0158551	.627	-.023854	.090482
	Pumpkin leaves(Kiandai)	.0257752	.0158551	.883	-.031392	.082943
	Spider plant (Kiandai)	-.0382946	.0158551	.433	-.095462	.018873
	Spider plant (Kianyaga)	-.0169380	.0158551	.993	-.074106	.040230
	Spider plant(Karumande)	.0554845	.0158551	.063	-.001683	.112652
	Vine spinach (Kiandai)	.0314806	.0158551	.698	-.025687	.088648
	Vine spinach(Karumande)	.0093411	.0158551	1.000	-.047827	.066509
Vine spinach(Karumande)	African Night shade (Kiandai)	.0216279	.0158551	.960	-.035540	.078796
	African Night shade (Kianyaga)	-.0328830	.0158551	.644	-.090051	.024285
	African Night Shade(Karumande)	.0223256	.0158551	.951	-.034842	.079493
	Pumpkin Leaves (Kianyaga)	.0191395	.0158551	.983	-.038028	.076307
	Pumpkin Leaves(Karumande)	.0239729	.0158551	.923	-.033195	.081141
	Pumpkin leaves(Kiandai)	.0164341	.0158551	.995	-.040734	.073602
	Spider plant (Kiandai)	-.0476357	.0158551	.168	-.104803	.009532
	Spider plant (Kianyaga)	-.0262791	.0158551	.870	-.083447	.030889
	Spider plant(Karumande)	.0461434	.0158551	.199	-.011024	.103311
	Vine spinach (Kiandai)	.0221395	.0158551	.953	-.035028	.079307
	Vine spinach (Kianyaga)	-.0093411	.0158551	1.000	-.066509	.047827
*. The mean difference is significant at the 0.05 level.						

Appendix III: Pearson's Correlation Coefficient

Dry Basis

Descriptive Statistics				
	Mean	Std. Deviation	CV (%)	N
Crude Protein (%)	23.585833	3.7460342	15.88%	12
Crude Fat/Oils (%)	2.123333	1.3075747	61.58%	12
Total ash (%)	25.130833	5.1148153	20.35%	12
Crude fiber (%)	9.9	0.9185859	9.28%	12
Carbohydrates (%)	39.26	2.652480828	6.76%	12

Correlations						
		Crude Protein (%)	Crude Fat/Oils (%)	Total ash (%)	Crude fiber (%)	Carbohydrates (%)
Crude Protein (%)	Pearson Correlation	1	-.540	-.914**	-.131	.661*
	Sig. (2-tailed)		.070	.000	.685	.019
	N	12	12	12	12	12
Crude Fat/Oils (%)	Pearson Correlation	-.540	1	.389	-.445	-.325
	Sig. (2-tailed)	.070		.212	.147	.302
	N	12	12	12	12	12
Total ash (%)	Pearson Correlation	-.914**	.389	1	.145	-.880**
	Sig. (2-tailed)	.000	.212		.654	.000
	N	12	12	12	12	12
Crude fiber (%)	Pearson Correlation	-.131	-.445	.145	1	-.221
	Sig. (2-tailed)	.685	.147	.654		.490
	N	12	12	12	12	12
Carbohydrates (%)	Pearson Correlation	.661*	-.325	-.880**	-.221	1
	Sig. (2-tailed)	.019	.302	.000	.490	
	N	12	12	12	12	12
**. Correlation is significant at the 0.01 level (2-tailed).						
*. Correlation is significant at the 0.05 level (2-tailed).						

Fresh Basis

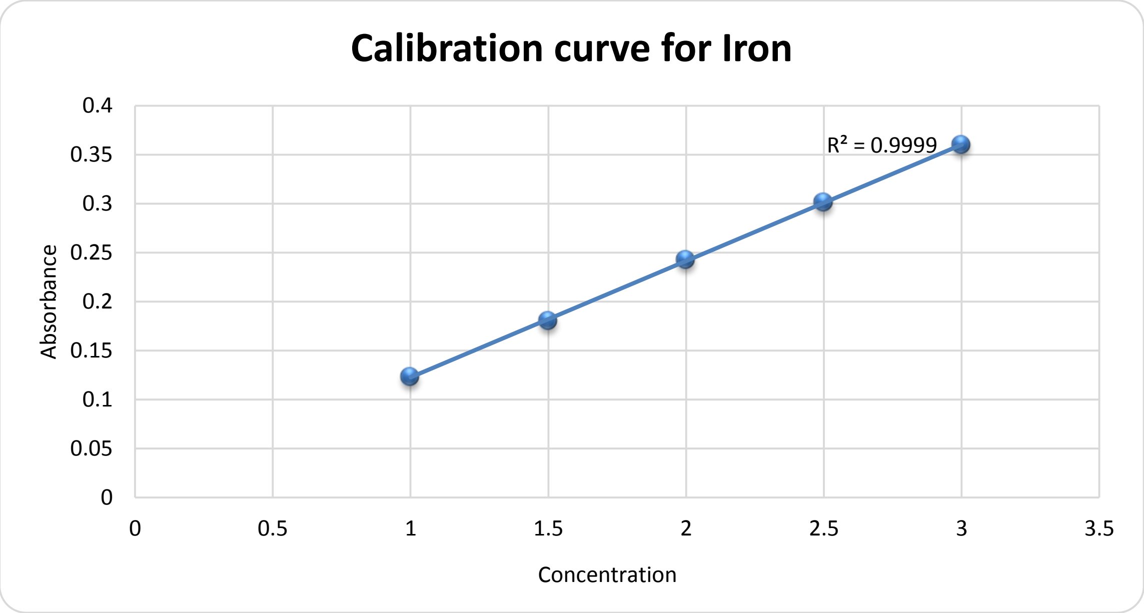
Descriptive Statistics				
	Mean	Std. Deviation	CV (%)	N
Moisture content (%)	86.814167	3.2532067	3.75%	12
Dry matter (%)	13.185833	3.2532067	24.67%	12
Crude Protein (%)	3.18	1.1147523	35.06%	12
Crude Fat/Oils (%)	0.2475	0.1116101	45.09%	12
Total ash (%)	3.251667	0.8895232	27.36%	12
Crude fiber (%)	1.299167	0.3186751	24.53%	12
Carbohydrates (%)	5.2075	1.4164625	27.20%	12

Correlations							
	Moisture content (%)	Dry matter (%)	Crude Protein (%)	Crude Fat/Oils (%)	Total ash (%)	Crude fiber (%)	Carbohydrates (%)

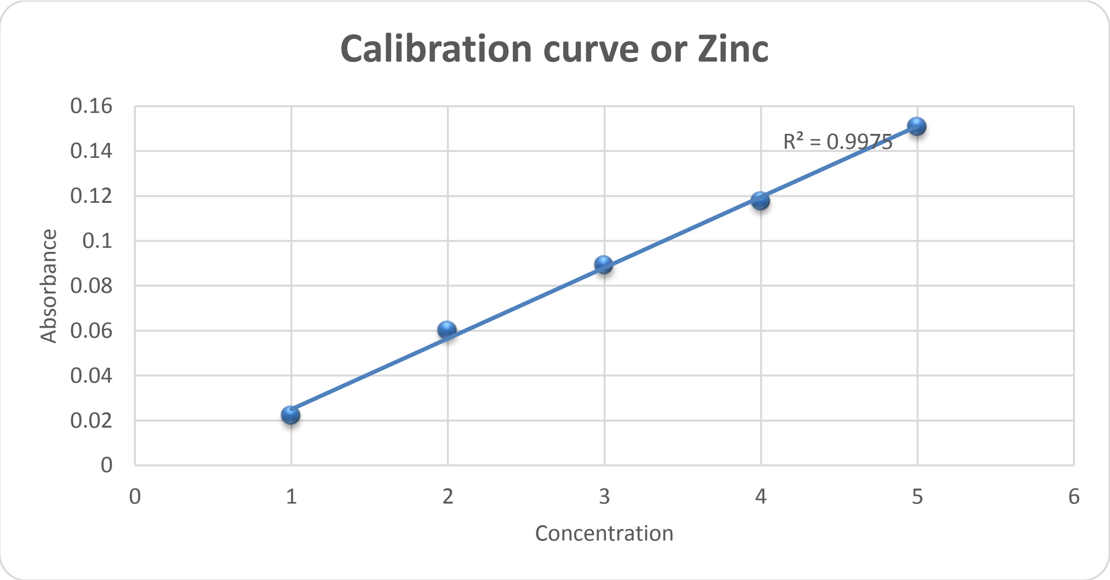
Moisture content (%)	Pearson Correlation	1	-1.000**	-.938**	.611*	-.676*	-.949**	-.968**
	Sig. (2-tailed)		.000	.000	.035	.016	.000	.000
	N	12	12	12	12	12	12	12
Dry matter (%)	Pearson Correlation	-1.000**	1	.938**	-.611*	.676*	.949**	.968**
	Sig. (2-tailed)	.000		.000	.035	.016	.000	.000
	N	12	12	12	12	12	12	12
Crude Protein (%)	Pearson Correlation	-.938**	.938**	1	-.605*	.399	.895**	.964**
	Sig. (2-tailed)	.000	.000		.037	.199	.000	.000
	N	12	12	12	12	12	12	12
Crude Fat/Oils (%)	Pearson Correlation	.611*	-.611*	-.605*	1	-.319	-.776**	-.632*
	Sig. (2-tailed)	.035	.035	.037		.312	.003	.027
	N	12	12	12	12	12	12	12
Total ash (%)	Pearson Correlation	-.676*	.676*	.399	-.319	1	.636*	.493
	Sig. (2-tailed)	.016	.016	.199	.312		.026	.103
	N	12	12	12	12	12	12	12
Crude fiber (%)	Pearson Correlation	-.949**	.949**	.895**	-.776**	.636*	1	.912**
	Sig. (2-tailed)	.000	.000	.000	.003	.026		.000
	N	12	12	12	12	12	12	12
Carbohydrates (%)	Pearson Correlation	-.968**	.968**	.964**	-.632*	.493	.912**	1
	Sig. (2-tailed)	.000	.000	.000	.027	.103	.000	
	N	12	12	12	12	12	12	12
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

Appendix IV: Calibration cuves

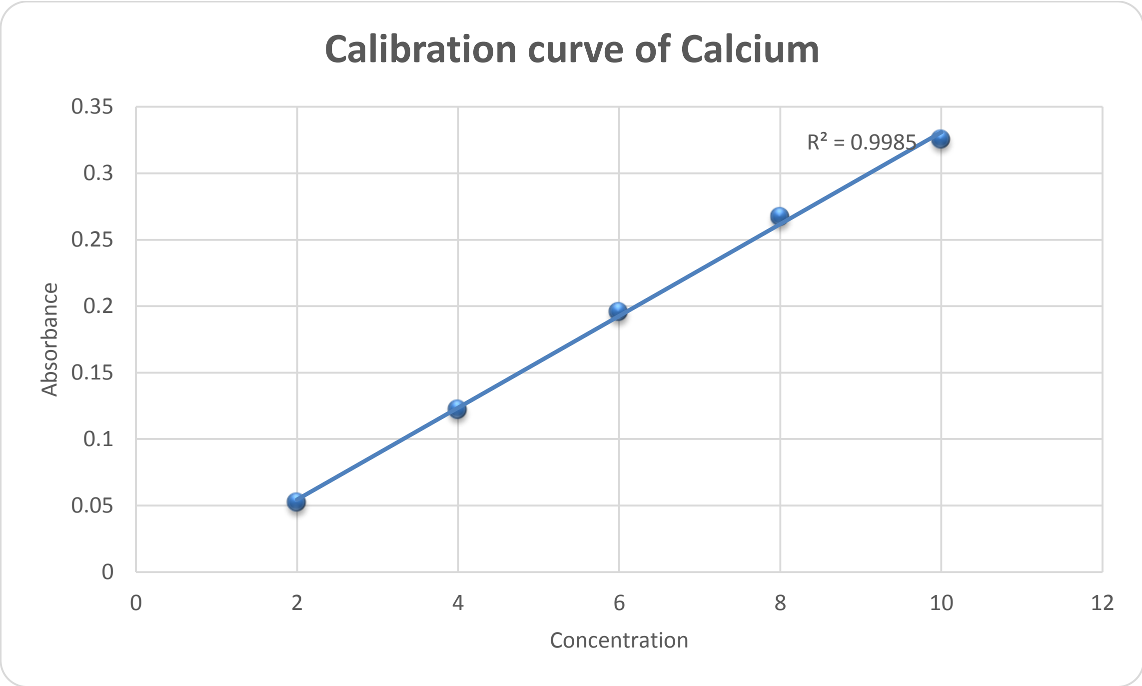
a) **Calibration curve for iron**



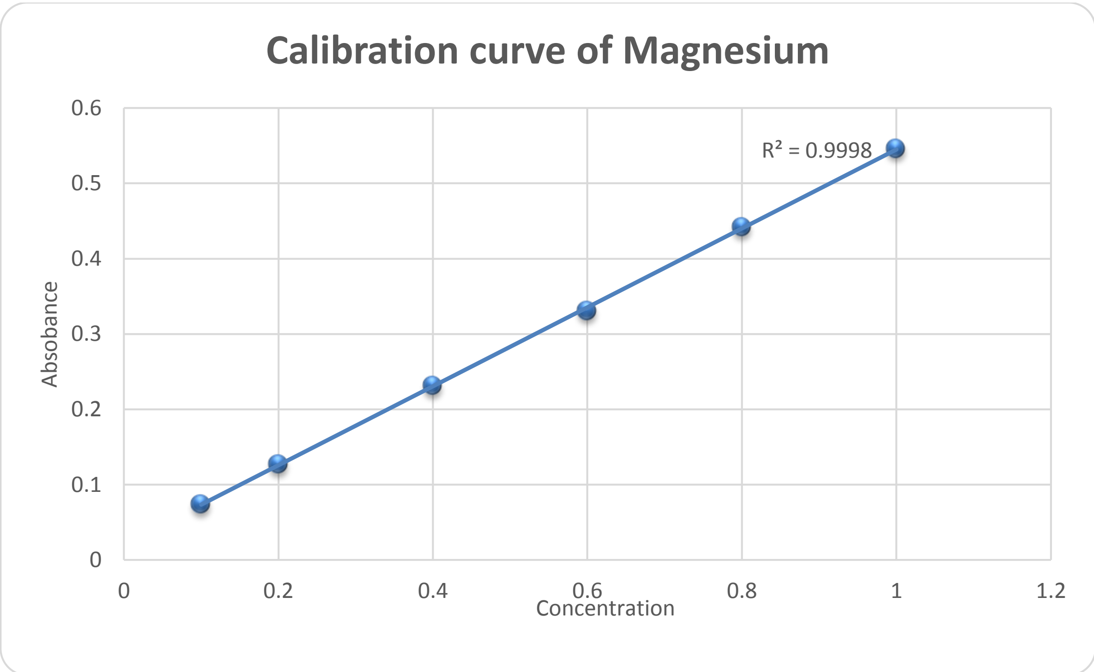
b) **Calibration curve for Zinc**



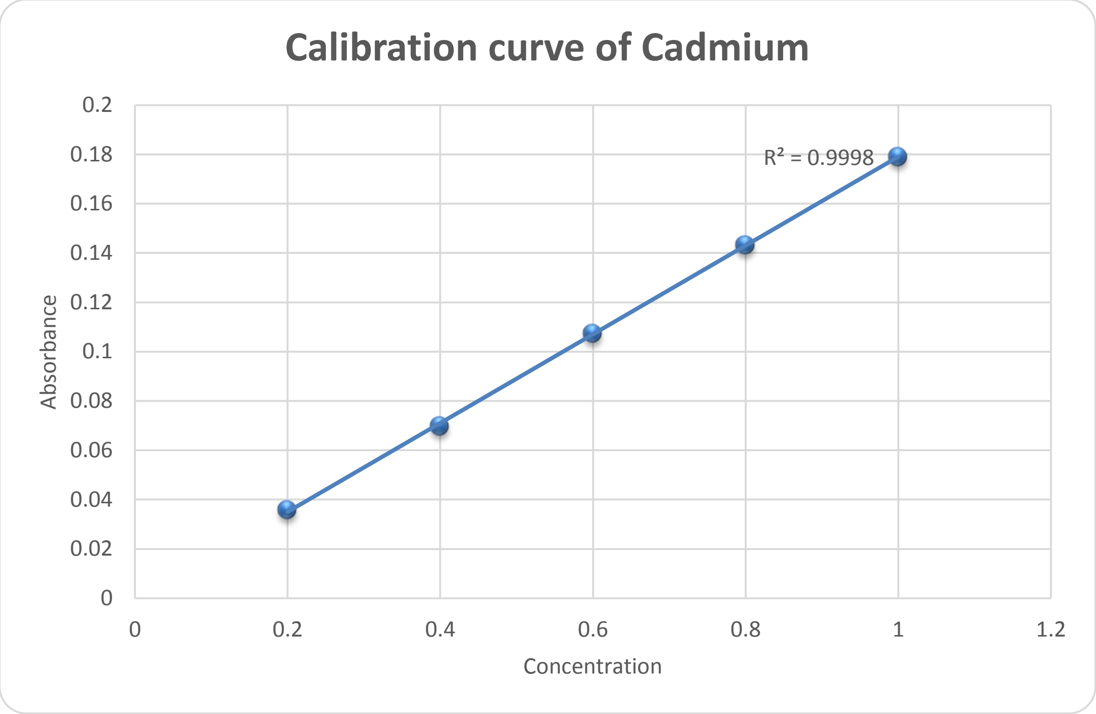
c) Calibration curve of Calcium



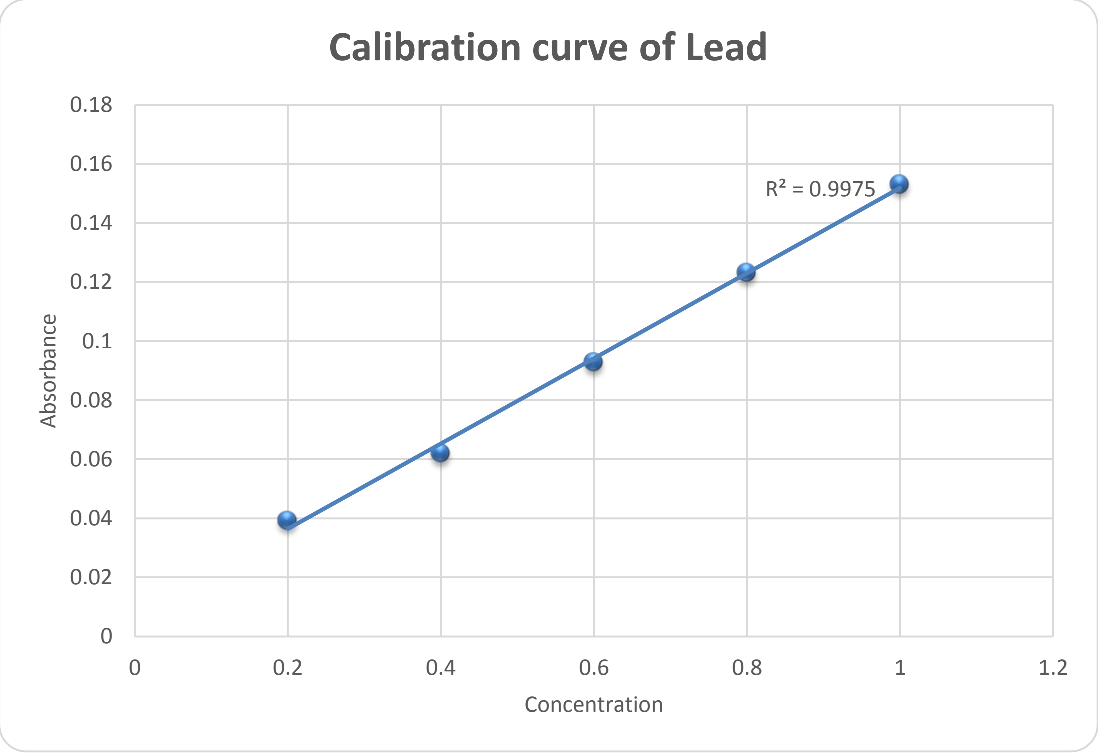
d) Calibration curve of Magnesium



Calibration of Cadmium



Calibration of Lead



Appendix V: Approval Letter from the Ethical Committee

CHUKA UNIVERSITY

Knowledge is Wealth *(Sapientia divitia est)* Akili ni Mali

CHUKA UNIVERSITY INSTITUTIONAL ETHICS REVIEW COMMITTEE

Telephones: 020-2310512/18
P. O. Box 109-60400, Chuka
Direct Line: 0772894438
Email: info@chuka.ac.ke,
Website: www.chuka.ac.ke

19th November, 2024

REF: CUIERC/ NACOSTI/662
TO: **Janet Njeri Maina**

RE: **Determination of Micronutrients, Heavy Metals and Proximate Analysis of Selected Indigenous Vegetables in Kirinyaga East Sub County, Kirinyaga County.**

This is to inform you that *Chuka University IERC* has reviewed and approved your above research proposal. Your application approval number is *NACOSTI/NBC/AC-0812.* The approval period is 19th November, 2024 – 19th November, 2025.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used

ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by *Chuka University IERC.*

iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to *Chuka University IERC* within 72 hours of notification

iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to *Chuka University IERC* within 72 hours

v. Clearance for export of biological specimens must be obtained from relevant institutions.

vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

vii. Submission of an executive summary report within 90 days upon completion of the study to *Chuka University IERC.*

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely

Dr. Benjamin Kanga
SECRETARY

INSTITUTIONAL ETHICS REVIEW COMMITTEE
19 NOV 2024
P. O. Box 109-60400, CHUKA
CHUKA UNIVERSITY

Appendix VI: Approval Letter from Board of Post Graduate Studies

CHUKA UNIVERSITY

Knowledge is Wealth *(Sapientia divitia est)* Akili ni Mali

OFFICE OF THE DIRECTOR

BOARD OF POSTGRADUATE STUDIES

Telephones: 020-2310512/18
Direct Line: 020-268 7625
postgraduate@chuka.ac.ke
P. O. Box 109-60400, Chuka
Website: www.chuka.ac.ke

REF: SM11/58104/22 **4th April, 2025**

Director
National Commission for Science Technology and Innovation
Off Waiyaki Way, Upper Kabete
P O Box 30623, 00100
Nairobi.

Dear Sir / Madam,

RE: JANET NJERI MAINA

The above-named person is a *bona fide* student of Chuka University pursuing MSC in Chemistry proposal titled: **Determination of Micronutrients, Heavy Metals and Proximate Analysis of Selected Indigenous Vegetables in Kirinyaga East Sub County, Kirinyaga County.**

Ms. Maina has defended at the Faculty level and is now expected to conduct research. Any assistance accorded will be highly appreciated.

Yours sincerely,

Prof. Moses Muraya, Ph.D
DIRECTOR
BOARD OF POSTGRADUATE STUDIES

Appendix VII: National Commission for Science, Technology and Innovation (NACOSTI) Research License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 654852

Date of Issue: 05/June/2025

RESEARCH LICENSE

This is to Certify that Ms.. JANET NJERI MAINA of Chuka University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kirinyaga on the topic: DETERMINATION OF MICRONUTRIENTS, HEAVY METALS AND PROXIMATE ANALYSIS OF SELECTED INDIGENOUS VEGETABLES IN KIRINYAGA EAST SUB-COUNTY, KIRINYAGA COUNTY for the period ending : 05/June/2026.

License No: NACOSTI/P/25/4174175

654852

Applicant Identification Number

Deputy Director

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions