ASSESSMENT OF MINERAL COMPOSITIONS IN GINGER ROOTS USING ATOMIC ABSORPTION SPECTROSCOPY (AAS)

ABSTRACT

The aim of this st1udy was to assess the composition of mineral elements in various ginger root samples. The study assessed the concentrations of the mineral elements Ca, Cu, Fe, Se, Mg, Zn, Na, P, K, and Mn in samples of ginger roots collected from Kilimanjaro, Morogoro, Iringa, Mbeya and Kagera regions. The collected ginger root samples were cleaned, oven dried, grinded to fine powder and diluted in concentrated acids. The solution samples obtained were analyzed for the mineral elements by using an Atomic Absorption Spectroscopy (AAS) method. The mean concentrations of the analyzed elements were calculated and it was found that the ginger samples had higher composition of Calcium (Ca),Magnesium (Mg), Sodium (Na), Iron (Fe), and Potassium (K) followed by Manganese (Mn) then Zinc (Zn) and Copper (Cu) and lastly no amount of Selenium (Se) was detected since its mean concentrations were below the detection limit (0.50) mg/kg for the spectrometer used in this study. The respective mean concentrations of the analyzed mineral elements were; 3.00 mg/kg (for Ca), 3.00 mg/kg (for Mg), 3.00 mg/kg (for Fe), 3.00 mg/kg (for P), 3.00 mg/kg (for K), 3.00 mg/kg (for Na), 2.40 mg/kg (for Cu), 2.80 mg/kg (for Mn) and 0.00 mg/kg (for Se).

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1.0 INTRODUCTION

The delightful flavour and pungency of spices make them indispensable in the food industry to flavour, improve and increase the appeal of their products. Spices impart aroma, colour and taste to food preparations and sometimes mask undesirable odours. In addition, they are reputed to possess several medicinal and pharmacological properties and hence find position in the preparation of a number of medicines (Parthasarathy et al. 2008). Ginger (*Zingiberofficinale Roscoe*) is an herbaceous perennial native to south-eastern Asia, which thrives in mild climates. Due to its medicinal and health-promoting properties, and high nutritional value, ginger has attracted growing interest among both dietitians and consumers. (Chamani et al. 2011, Karna et al. 2011, Shim et al. 2011). It is one of the oldest medicinal plants, which has been grown in Asia since ancient times, for nearly 3,000 years.

The spice ginger obtained from the underground stems or the rhizome of *Zingiberofficinale Roscoe*, one of the most widely used species and common condiment for various foods and beverages. Both fresh and dried ginger rhizomes are used worldwide as a spice, and ginger extracts are used extensively in the food, beverage, and confectionary industries in the production of products such as marmalade, pickles, chutney, ginger beer, ginger wine, liquors, biscuits, and other bakery products (Mishra 2009). Ginger is also widely used in both traditional and contemporary natural medicine (*Zingiberofficinale* 2010). The unique flavour properties of ginger arise from the combination of pungency and aromatic essential oil. The main pungent compounds in fresh ginger are a series of homologous phenolic ketones known as gingerols which are thermally unstable and are converted under high temperature to shogaol (Mishra 2009).

The ginger rhizome also contains resin, proteins, cellulose, pentosans, starch and mineral elements. Of these, starch is the most abundant and comprises 40–60% of the rhizome on a dry weight basis. The relative abundance of certain constituents of ginger is determined by the cultivar grown, the environmental conditions of growth and the stage of maturity at harvest (Parthasarathy et al. 2008). Humans require a suite of mineral elements in varying amounts for proper growth, health maintenance and general well-being. Minerals are essential components of our diet that serve as cofactors in the thousands of enzyme-controllactions, control the action of nerves and muscles, help maintain the body's water balance, and buffer the pH (acidity) of the cell and extracellular fluids (Minerals-Learn 2010). Plant-derived foods have the potential to

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serve as dietary sources for all human-essential minerals that make a significant contribution to daily mineral needs at all stages of the life cycle (Grusak 2002). Generally, too low or too high of a concentration of trace elements in human diet can affect the quality of human life.

Ginger (*Zingiber officinale* Roscoe) is a common condiment for various foods and beverages and widely used worldwide as a spice(Yohannes & Bhagwan 2015). Its extracts are used extensively in the food, beverage, and confectionary industries in the production of products such as marmalade, pickles, chutney, ginger beer, ginger wine, liquors, biscuits, and other bakery products. In Ethiopia, it is among the important spices used in every kitchen to flavor stew, tea, bread and local alcoholic drinks. It is also chiefly used medicinally for indigestion, stomachache, malaria, fevers, common cold, and motion sickness. The literature survey revealed that there is no study conducted on the determination of metals in ginger cultivated in Ethiopia. Hence it is worthwhile to determine the levels of essential and non-essential metals in ginger cultivated in Ethiopia.The levels of essential (Ca, Mg, Fe, Zn, Cu, Co, Cr, Mn, and Ni) and non-essential (Cd and Pb) metals in ginger (*Zingiber officinale* Roscoe) cultivated in four different regions of Ethiopia (Yohannes & Bhagwan 2015).and the soil where it was grown were determined by flame atomic absorption spectrometry. 0.5 g of oven dried ginger and soil samples were digested using 3 mL of HNO_3 and 1 mL of $HClO_4$ at 210°C for 3 h and a mixture of 6 mL aqua-regia and 1.5 mL H_2O_2 at 270°C for 3 h, respectively.The mean metal concentration (μg/g dry weight basis) ranged in the ginger and soil samples, respectively, were: Ca (2000–2540, 1770–3580), Mg (2700–4090, 1460–2440), Fe (41.8–89.0, 21700–46900), Zn (38.5–55.2, 255–412), Cu (1.1–4.8, 3.80–33.9), Co (2.0–7.6, 48.5–159), Cr (6.0–10.8, 110–163), Mn (184–401, 1760–6470), Ni (5.6–8.4, 14.1–79.3) and Cd (0.38–0.97, 0.24–1.1). The toxic metal Pb was not detected in both the ginger and soil samples.There was good correlation(Yohannes & Bhagwan 2015). between some metals in ginger and soil samples while poor correlation between other metals (Fe, Ni, Cu). This study revealed that Ethiopian gingers are good source of essential metals and free from toxic metal Pb while containing negligible amount of Cd.

Mineral uptake by plants can be affected by several factors including mineral concentrations in soils, soil pH, cation exchange capacity, organic matter content, types and varieties of plants, and age of the plant (Jung 2008). In ideal word we would take in our daily requirement of minerals by eating plants that grow in mineral rich soils (Harold and Leslie 2000; Lokeshwari and

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Chandrappa 2006). The contamination of soil by atmospheric deposition of toxic metals affects soil properties and further increases plant metal levels through root uptake (Pandey, 2009), and eventually these metals are taken up by plants parts and transfer some into the food chain. Consequently, higher soil heavy metal concentration can result in higher levels of uptake by plants (Ebong et al. 2008).

Zingiber officinale is a medicinal herb(Tanveer et al. 2014) that is used all around the world as spice. The mandate of current study was to explore the nutritional worth of ginger because of its easily availability and mostly use. The raw materials were analyzed for the proximate like moisture, fat, protein, fiber, ash & NFE and mineral profile. The composition profiling of Zingiber officinale indicated moisture, protein, fat, fiber, ash and nitrogen free extract as 75.14±13.9, 8.43±0.32, 5.35±0.17, 3.14±0.13, 2.60±0.09 and 5.37±0.18%, respectively. Moreover, Zingiber officinale contained appreciable amount of minerals especially potassium 410.91±13.97, magnesium 45.02±1.80, phosphorus 32.56±1.24, calcium 15.76±0.57, manganese 0.70±0.04, copper 0.58±0.02, iron 0.54±0.03 and zinc 0.33±0.01 mg/100g, respectively. However, potassium, magnesium, phosphorous, calcium and sodium were present in meager amounts.

Prolonged use of wastewater irrigation in peri-urban agriculture has increased levels of heavy metals (HMs) in soil, raising concerns regarding both food safety and human health. To address this issue (Singh et al. 2025), the effectiveness of agro-waste derived bioashes (ADB), specifically rice husk ash (RHA) and sugarcane bagasse ash (SBA), was investigated as soil amendment materials to immobilize HMs in soil and reduce their accumulation in crops. The aim of the present study was to evaluate the effects of RHA and SBA on HM uptake, growth, yield, nutrient quality, and seed metabolite profiles of wheat (*Triticum aestivum* L. cv. HUW 234) crop grown in HM contaminated soils, along with associated health risks. Results revealed that SBA significantly and effectively reduced Cr, Ni, Cu, Zn, and Cd accumulation in wheat seeds (13.5 %, 33.8 %, 17.6 %, 7.8 %, and 10.0 %, respectively), more compared to RHA (6.8 %, 16.9 %, 8.8 %, 3.9 %, and 5.0 %) with maximum accumulation in roots followed by shoots and least in seeds. Health risk assessments showed that the estimated daily intake (EDI) of HMs was found highest for Zn and lowest for Cd in both the children and adults consuming wheat seeds, with hazard quotient values above a unit for all the HMs.The present study concludes that SBA could be effectively used as a superior soil amendment to reduce HM toxicity in soil-wheat system, associated human health risks and to promote sustainable agriculture in peri-urban areas.

Contamination and subsequent pollution of the environment by toxic heavy metals have become an issue of global concern due to their sources, widespread distribution and multiple effects on the ecosystem. Heavy metals are generally present in agricultural soils at low levels. Due to their cumulative behaviour and toxicity, however, they have a potential hazardous effect not only on crop plants but also on human health (Uwah et al. 2009). Therefore, a comprehensive study related to the assessment of levels of essential and toxic metals of plants and soil where the plant has grown is crucial with respect to human health and the quality of its products.

According to Newerli-guz, P. (2012), ginger has long been regarded as a powerful stimulant, a heating agent and an aid to digestion. In the 1960s, it was used as a popular spice rather than a natural remedy. Recent years have brought a revived interest in the health-promoting properties of ginger. Research has revealed that ginger has strong analgesic and antiviral effects, is an effective remedy for migraine headaches, and increases peristalsis. Ginger rhizomes help lower LDL cholesterol levels, prevent nausea, ease symptoms of asthma, threat arthritis and enhance appetite (Ghosgh et al. 2011).

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The nutritional value of ginger is determined by its mineral composition. Ginger is a rich source of minerals, mostly phosphorus, potassium and calcium, which play a key role in many physiological processes in the human body. The health benefits of ginger can be attributed to its high content of mineral nutrients. Ginger is considered a valuable spice with a unique set of health-promoting properties, available around the world (Khan, A et al. 2011, Gupta et al 2014).

Therefore, this study deals with assessment of levels of mineral elements (Ca, Cu, Fe, Se, Mg, Zn, Na, P, K, and Mn) in ginger cultivated in five regions of Tanzania and it aims to fill the gap at least partially in the area and initiate others for further study on ginger and closely related plants widely used throughout the country. The outcome of this study will ultimately help to ensure the dietary safety of the society and improving the country's economy by increasing both quality and quantity of ginger cultivated in Tanzania. The assessment will facilitate the government, general public, institutions as well as farmers with information to evaluate the

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quality of the ginger to the food value and nutritional security to avoid the risk of heavy metals pollution to the communities.

2.0 MATERIALS AND METHODS

2.1 Description of the Study Areas

The ginger root samples for this study were collected from five regions in Tanzania namely; Kilimanjaro, Morogoro, Iringa, Mbeya, and Kagera. Kilimanjaro region found in northern Tanzania, has got a tropical savanna climate with bimodal rainfall patterns, providing fertile volcanic soils ideal for ginger growth (World Bank, 2019). Morogoro found in the east, experiences a tropical climate with distinct wet and dry seasons, featuring a mix of sandy loams and clay soils conducive to agriculture (Tanzania Meteorological Authority, 2021). Iringa, located in the southern highlands, has a subtropical highland climate with cooler temperatures and fertile red loam and clay soils (Iringa Region Administration, 2017). Mbeya, also in the highlands, enjoys a temperate climate due to higher elevation, with mineral-rich volcanic soils supporting optimal ginger cultivation (World Bank, 2019). Kagera region is found in the lake zone and it has a tropical rainforest climate with consistent year-round rainfall and fertile volcanic and alluvial soils, which support continuous and robust ginger growth (Kagera Region Administration, 2020). These regions have got large populations of people who are engaged in various economic activities including agriculture

2.2 Sample collection

The samples of ginger roots were brought from Kilimanjaro, Morogoro, Iringa, Mbeya and Kagera regions. The collected samples were free from visible defects or diseases to avoid any potential contamination that could affect the mineral analysis. The ginger root samples were then placed in clean, labelled polyethylene bags to prevent contamination and keep samples from different locations separate then kept in the refrigerator to maintain a temperature that minimizes metabolic activity and preserves the integrity of the samples till the preparation day.

2.3AAS Sample Preparation

Upon arrival at the laboratory, the ginger root samples were washed thoroughly with deionised water to remove soil and other surface contaminants. Stored ginger root samples will be removed from refrigeration and allowed to equilibrate to room temperature. The roots will be cut into

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small pieces and dried (Fig.1) in an oven at 60°C in a clean, dust-free environment for 24 hours to ensure complete removal of moisture prevent any microbial growth and to ensure consistency in the sample's weight (FAO, 2020).

Fig.1. Ginger fresh, slicedand allowed to dry

The dried samples were then be stored in sealed polyethylene bags at a temperature of 4°C until analysis. This preservation method was critical to prevent microbial growth and enzymatic activities that could alter the mineral composition of the samples (Tanzania Meteorological Authority, 2021). Once dried, the ginger pieces were grounded using a laboratory mill into a fine powder. The grinding process was critical to achieve a homogeneous sample that ensures uniform mineral extraction during the subsequent digestion process (World Bank, 2019).

Preparing ginger samples whose mineral compositions are to be analysed by AAS method involved main three steps followed by calibration of the AAS instrument. This process involved acid digestion, dilution as well as filtration of the digested sample as described below:

Approximately 1 gram of the ginger powder was placed in a digestion flask then 10 ml of concentrated nitric acid was added to the flask. The mixture was then heated gently on a hot plate until the initial reaction subsides. Following this, 5 ml of perchloric acid were added, and the mixture was heated until the solution became clear, indicating a complete digestion.

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The digested sample was allowed to cool and then diluted with deionised water to 50 ml. This dilution ensured that the sample concentration falls within the detectable range of the AAS (Kilimanjaro Region Administration, 2018). The diluted digested sample was filtered using Whatman filter paper to remove any particulate matter. Filtration process was done to ensure that the sample introduced into the AAS is free of any solids that could interfere with the analysis

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(Iringa Region Administration, 2017). The samples obtained from these processes were the taken to the Atomic Absorption Spectroscopic for analysis of theginger.

2.4 Sample elemental analysis and Data Collection

The data collection process using Atomic Absorption Spectroscopy (AAS) involved several critical steps to ensure accuracy and reliability in quantifying the mineral content of ginger roots from different geographic locations. Calibration standards for each mineral element (Ca, Mg, Na, K, P, Mn, Fe, Zn, Cu) was prepared using certified reference materials (CRMs) with known concentrations then an AAS instrument will be calibrated at the beginning of each analytical session. Calibration involved running the prepared standards and plotting the absorbance values against the known concentrations to create a calibration curve for each element. The linearity and accuracy of the calibration curves was verified before proceeding with sample analysis (Skoog et al., 2007).

Atomic absorption spectroscopy (AAS) is an analytical technique that measures the concentration of elements in a sample by using the principle that atoms absorb light at specific wavelengths (Fig.2):

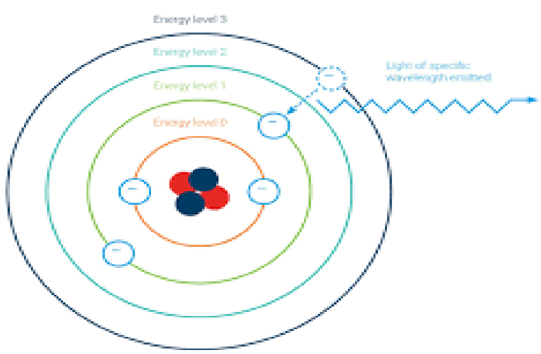

Fig.2 Sample exposed to light at the characteristic wavelength of an element, only the atoms of that element will absorb the lightandemit characteristic wavelength of an element

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Absorption

Each element has a unique electronic structure, so the radiation it absorbs is also unique. When a sample is exposed to light at the characteristic wavelength of an element, only the atoms of that element will absorb the light.

- **Measurement**

The amount of light absorbed is directly proportional to the concentration of the element in the sample. The concentration is determined by calibrating the instrument with standards of known concentration.

- **Applications**

AAS is used in many fields, including environmental monitoring, food safety, materials analysis, and bio-analysis.

AAS is a reliable, straightforward, and cost-effective technique that can detect small quantities of metallic elements. It can be used to analyze over 70 elements in solution, or directly in solid samples.

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Each prepared ginger root sample solution was introduced into the AAS instrument through a flame furnace, due to the sensitivity required for the element being analysed because the flame furnace AAS is typically used for higher-concentration elements due to its sensitivity (Welz&Sperling, 2008). Each sample solution was aspirated into a flame furnace where it was irradiated by a light source, typically a hollow cathode lamp specific to each element being analysed. The AAS was operated at the appropriate power and voltage settings for each element and a photomultiplier tube detector was used to detect and measure the absorbance of light by the sample. The absorbance is directly related to the concentration of the element in the sample according to Beer-Lambert's law (Skoog et al., 2007).

$A= \varepsilon \cdot b \cdot c$

where:

A is the absorbance (dimensionless),

ε is the molar absorptivity or molar extinction coefficient (L mol−1cm−1),

b is the path length of the sample cell (cm),

c is the concentration of the analyte (mol L−1).

This relationship shows that absorbance is directly proportional to the concentration of the element in the sample.

The AAS instrument measures the absorbance of the sample solution at specific wavelengths corresponding to the elements of interest. The absorbance values were recorded and processed by the AAS software which is equipped with advanced algorithms like Turbo Quant (TQ9232), it converted the absorbance values into concentrations of the elements.

3.0 DATA ANALYSIS AND INTERPRETATION

3.1 Introduction

This chapter comprises the analysis, presentation, and interpretation of the findings resulting from this study. The analysis and interpretation of data is carried out in a single phase which is based on the results of the experimental analysis and descriptive interpretation.

3.2 Statistical analysis

3.2.1 To Quantify levels of Calcium (Ca), Phosphorus (P), Potassium (K), Iron (Fe), Sodium (Na), and Magnesium (Mg)and to compare the mineral composition of ginger roots from different geographic locations (Table.1).

The table below shows the calcium content in ginger roots ranged from 1389.19 mg/kg in Morogoro to 1511.10 mg/kg in Kagera, indicating relatively consistent calcium levels across the different geographic locations, the phosphorus content varied from 187.67 mg/kg in Iringa to 198.33 mg/kg in Kagera, showing a moderate range of phosphorus levels, potassium content ranged from 150.56 mg/kg in Iringa to 169.99 mg/kg in Kagera, demonstrating a relatively narrow range of potassium levels. Iron content varied from 73.23 mg/kg in Mbeya to 84.12 mg/kg in Iringa, indicating a moderately wide range of iron levels. Sodium content ranged from 450.87 mg/kg in Kagera to 481.03 mg/kg in Tanga, showing a relatively consistent sodium level

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across the locations and Magnesium content varied from 1723.15 mg/kg in Mbeya to 1825.09 mg/kg in Kagera(Fig..**2.)**, demonstrating a relatively narrow range of magnesium levels.

T**a**ble**.**1Levels of Calcium (Ca), Phosphorus (P), Potassium (K), Iron (Fe), Sodium (Na), and Magnesium (Mg)**a**re compared the mineral composition of ginger roots from different geographic locations

Parameter	**Iringa**	**Mbeya**	**Kagera**	**Tanga**	**Morogoro**
Calcium (Ca)	1413.11	1399.14	1511.10	1466.07	1389.19
Phosphorus (P)	187.67	190.55	198.33	193.53	197.37
Potassium (K)	150.56	164.44	169.99	167.47	168.77
Iron (Fe)	84.12	73.23	81.01	79.33	80.00
Sodium (Na)	477.87	480.01	450.87	481.03	451.77
Magnesium (Mg)	1824.03	1723.15	1825.09	1744.19	1801.02

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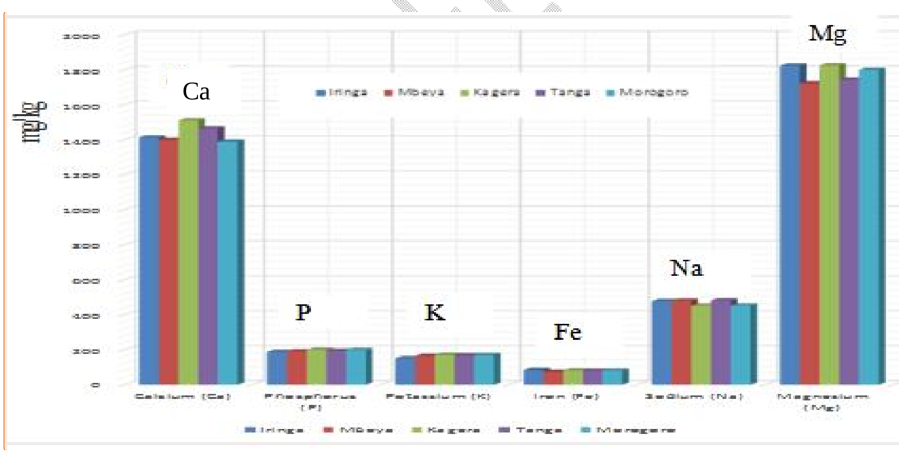

Fig.**.3.**Levels of Calcium (Ca), Phosphorus (P), Potassium (K), Iron (Fe), Sodium (Na), and Magnesium (Mg)**a**re compared the mineral composition of ginger roots from different geographic locations

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Ginger root(Zingiber officinal Rose) was analysed(Latona et al.(2012)) to identify its nutritional and anti- nutritional contents. The results showed that Ginger has 34.13% crude protein, 4.07% Ether Extract, 4.02% crude fibre content, 13.75% moisture content, 7.64% Ash content and 1.036% vitamin C. Furthermore, ginger contains major minerals like: Zn 64.0 mg/l , Mn 5.90 mg/l, Fe 279.7 mg/l, Cu 8.80 mg/l, Ca 280.0 mg/l and P 8068.0 mg/l. The result obtained confirmed the usefulness of ginger root as a potential functional food and could be explored further in new product and formulation.

Results related to mineral analysis were verified by findings of Shirin and Prakash (2010). They concluded that ginger is an amusing source of Phosphorous (174±1.2 mg/100g) followed by Calcium (88.4±0.97), Manganese (9.13±001), Iron (8.0 ± 0.2) and traces amount of Zinc, Chromium and Copper. Iron is essential for blood formation owing to a major constituent of hemoglobin while zinc is required for fertility, insulin working as well as mental and body growth. Minerals especially calcium and potassium are required in human body in large amounts. Their deficiency results in arthritis, bone and tooth related disorders. Similarly, Famurewa et al. (2011) stated that fresh ginger contain mineral contents as Ca 110 mg/100g, succeeding by Mg 60 mg/100g and K 24.91 mg/100g while iron and zinc are also present in traces. They also informed that on drying of ginger, mineral content gradually increases. Moreover results gained by Latona et al. (2012) indicated that the mineral content of ginger is 8068 mg/100g, 280, 279, 64, 8.80 and 5.90 for phosphorus, calcium, iron, zinc, copper and manganese correspondingly.

3.2.2 To Quantify levels of Selenium (Se), Copper (Cu), Manganese (Mn), and Zinc (Zn) and **to compare their mineral composition of ginger roots from different geographic locations**

Again, the table below shows the selenium content in the ginger roots from all five locations was found to be 0 mg/kg indicating no detectable levels of selenium, the copper content ranged from 5.79 mg/kg in Kagera to 6.15 mg/kg in Tanga, showing a relatively narrow range of copper levels across five locations, the Manganese content varied from 299.29 mg/kg in Kagera to 355.64 mg/kg in Iringa, demonstrating a moderately wide range of manganese levels and Zinc content ranged from 55.22 mg/kg in Kagera to 61.27 mg/kg in Iringa, indicating a relatively consistent zinc level across the locations(Table 2.).

Table 2.levels of Selenium (Se), Copper (Cu), Manganese (Mn), and Zinc (Zn) and **to compare their mineral composition of ginger roots from different geographic locations**

Parameter	Iringa	Mbeya	Kagera	Tanga	Morogoro
Selenium (Se)	0	0	0	0	0
Copper (Cu)	6.12	5.88	5.79	6.15	5.88
Manganese (Mn)	355.64	311.15	299.29	333.18	309.99
Zinc (Zn)	61.27	59.33	55.22	60.39	59.88

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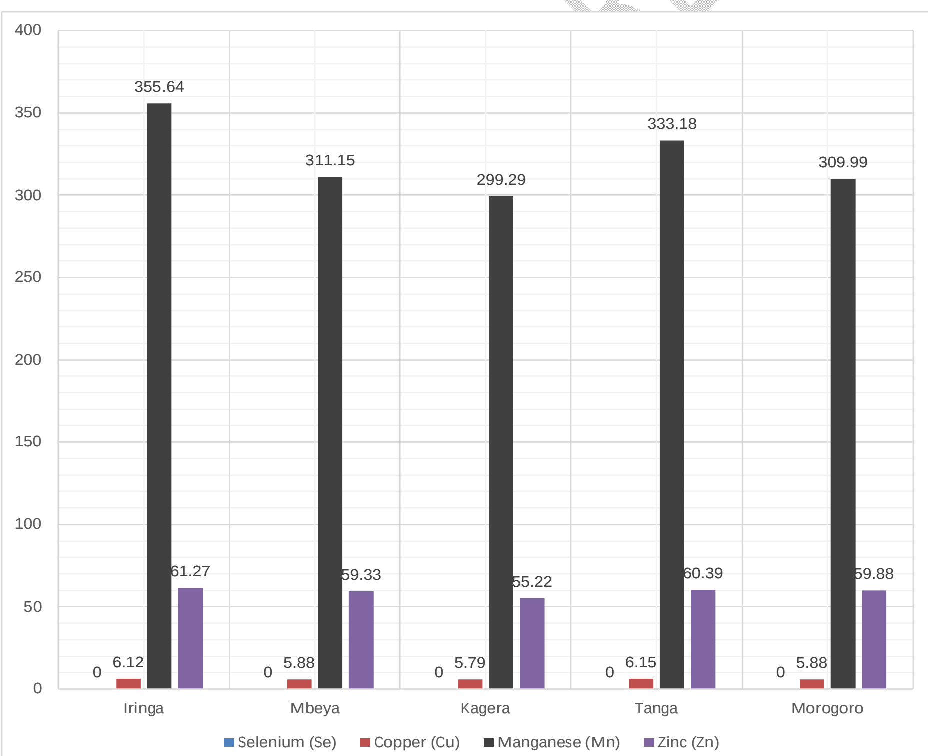
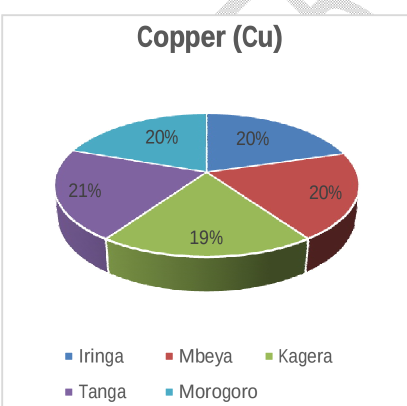
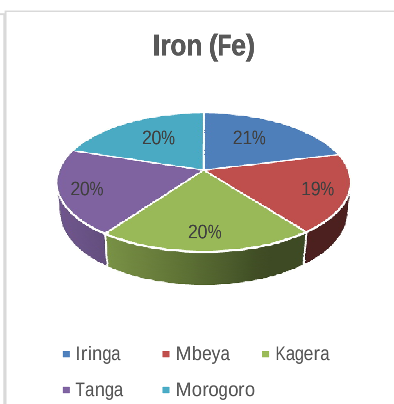


Fig. 4.levels of Selenium (Se), Copper (Cu), Manganese (Mn), and Zinc (Zn) and **to compare their mineral composition of ginger roots from different geographic locations**

The small variations in mineral content, such as the slightly higher calcium and magnesium levels in Kagera, may be attributable to factors of soil composition, climate, and agricultural practices in the respective regions while the experiment provides valuable insights into the mineral content of ginger roots from different geographic locations in Tanzania. The data suggests that the ginger roots from the five different geographic locations (Iringa, Mbeya, Kagera, Tanga, and Morogoro) have a relatively consistent mineral composition, with no statistically significant differences observed for the measured minerals (copper, manganese, and zincgiven in Fig. 3.). The absence of detectable selenium levels in the ginger roots across all locations is noteworthy, as selenium is an essential mineral with important physiological functions.

Individual representation of minerals across five locations re given in Fig. 5.





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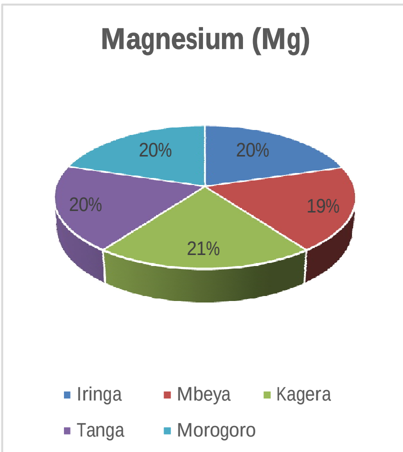
Magnesium (Mg)
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Iringa
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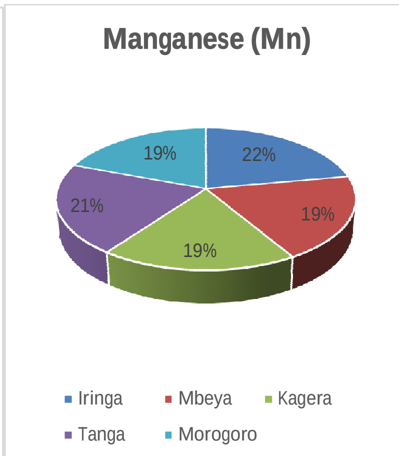
Tanga
Morogoro


Manganese (Mn)
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19%
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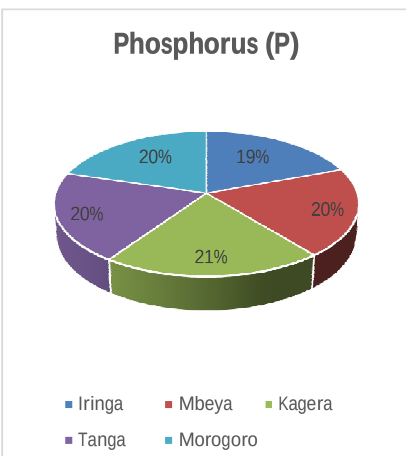
Mbeya
Kagera
Tanga
Morogoro


Phosphorus (P)
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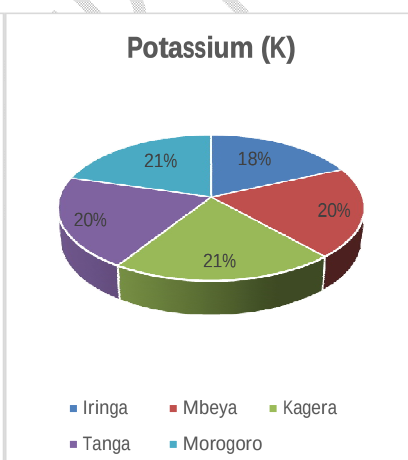
Mbeya
Kagera
Tanga
Morogoro


Potassium (K)
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21%
Iringa
Mbeya
Kagera
Tanga
Morogoro

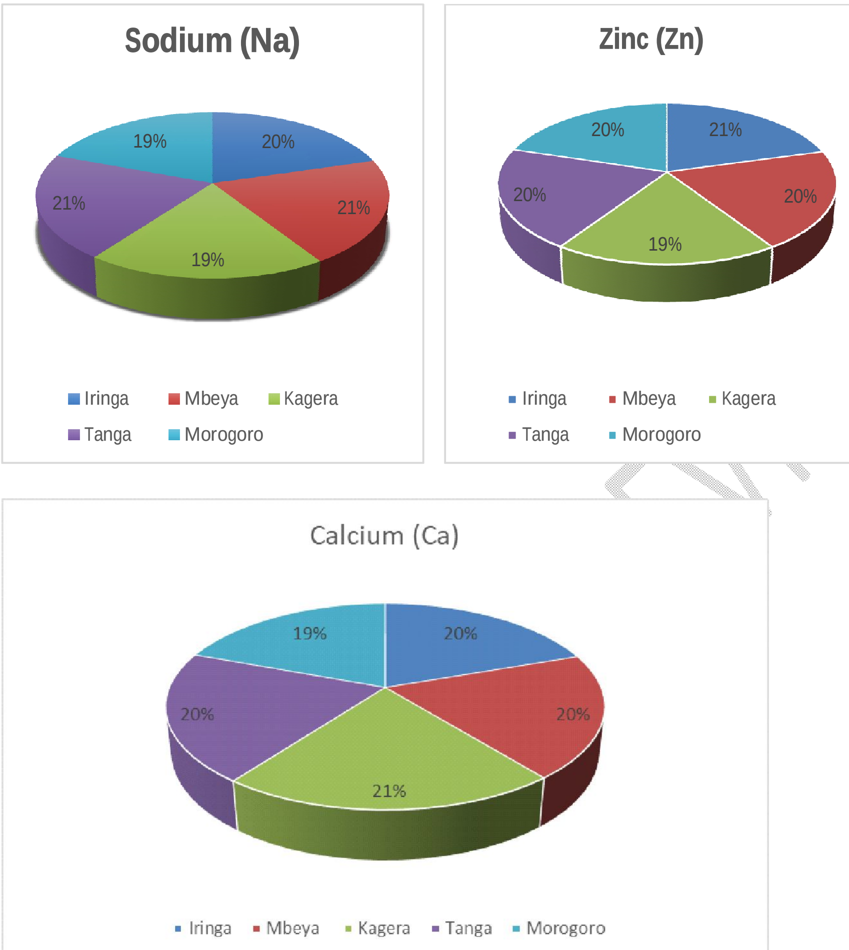

Fig. 5.Individual representation of minerals across five locations

3.2.3 Descriptive Statistics

The data set included 5 observations (N = 5) for each of the 10 mineral parameters measured. The range (difference between minimum and maximum values) provides information about the variability of mineral levels across the locations. The mineral with the largest range is 4.00, observed for calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), phosphorus (P), potassium (K), and sodium (Na), and the minerals with the smallest range of 3.00 were copper

(Cu) and zinc (Zn) while Selenium (Se) has a range of 0, indicating no variation across the locations.

The minimum and maximum values show the lowest and highest levels of each mineral observed in the ginger root samples. The minimum value for all minerals was 1.00, and the maximum value for all minerals was 5.00 except selenium (Se was 1.00, copper (Cu) and zinc (Zn) were 4.00

The sum for all minerals was 15.00 except selenium (Se) was 5.00, copper (Cu) and zinc (Zn) were 12.00, and manganese (Mn) was 14.00, indicating a consistent total quantity across the locations.

The mean values represent the average mineral levels across the 5 locations. The mean values range from 1.0000 for selenium (Se) to 3.0000 for calcium (Ca), iron (Fe), magnesium (Mg), phosphorus (P), potassium (K), and sodium (Na), the mean values for copper (Cu) and zinc (Zn) were both 2.4000, and the mean value for manganese (Mn) was 2.8000.

The standard deviation measures the dispersion or variability of the mineral levels across the locations, the standard deviation ranges from 0.0000 for selenium (Se) to 1.78885 for manganese (Mn) as shown below, the standard deviations for copper (Cu) and zinc (Zn) were both 1.14018.

The variance is the square of the standard deviation and provides another measure of the dispersion of the mineral levels, the variance ranges from 0.000 for selenium (Se) to 3.200 for manganese (Mn), the variances for copper (Cu) and zinc (Zn) were both 1.300.

The descriptive statistics indicate that the mineral levels in ginger roots across the different geographic locations have a relatively consistent profile, except selenium (Se).

Selenium is the only mineral that shows no variation across the locations, with a constant minimum, maximum, and mean value of 1.0000, and the other minerals, such as calcium, iron, magnesium, phosphorus, potassium, and sodium, exhibit consistent total quantities (sum) and average levels (mean) across the locations, but with some variability in the range and standard deviation.

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The minerals with the highest variability in levels across the locations are manganese (Mn), followed by calcium (Ca), iron (Fe), magnesium (Mg), phosphorus (P), potassium (K), and sodium (Na), Copper (Cu) and zinc (Zn) show the least variability among the measured minerals.

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4.0 CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

This study has assessed the mineral composition of the elements (Ca, P, K, Fe, Na, Mg, Cu, Zn, Mn and Se) in samples of ginger roots collected from Kilimanjaro, Morogoro, Iringa, Mbeya and Kagera regions. The respective mean concentrations of the analysed mineral elements were; 3 mg/kg (for Ca), 3.00 mg/kg (for Mg), 3.00 mg/kg (for Fe), 3.00 mg/kg (for P), 3.00 mg/kg (for K), 3.00 mg/kg (for Na), 2.4.0 mg/kg (for Cu), 2.80 mg/kg (for Mn) and 0.00 mg/kg (for Se). Selenium occurs naturally due to erosion of rocks containing salinities and serenades which are associated with sulphide minerals. Its abundance in the earth's crust is very low, estimated as 0.0005 mg/kg to 0.001 mg/kg.

The mineral content recommended ginger roots for high content in K (2442.75 gKg-1), Ca (1031 gKg-1) and Mg (663.25 gKg-1). Statistical analysis was performed using PAST software, which runs on standard Windows computers and is available free online. The stability of ginger sample increase after removing 58% of the free water. By applying cluster analysis using single linkage algorithm and Euclidean similarity measure the data are grouped in 2 main clusters. First cluster is grouping the data for 19 minutes dehydration time, while the second cluster groups for the time period (20 – 44) minutes, while the correlation coefficient is 0,7305. High content in potassium, calcium and magnesium recommended ginger roots for frequently using in cooked stuff.(Pirvulescu Luminita)

The analysis of mineral elements in ginger roots provides a valuable insight into the medicinal and nutritional properties. The presence of essential minerals such as Ca, Mg, Fe, and Zn suggests that ginger can contribute to the overall health and well-being of individuals. Although, the medicinal properties of ginger have been known for thousands of years, a significant number of studies further provide substantial evidence that ginger and its active compounds are effective against wide variety of human diseases including cancers such as gastric cancer, pancreatic cancer, liver cancer, colorectal cancer, and cholangiocarcinoma.

It can be fairly concluded that, the ginger roots are rich in mineral elements Ca, Fe, K, P, Mg, and Na while a slightly low concentrations of Cu, Zn and Mn, and no Se at all. The ginger roots therefore can contribute significantly to the food and nutritional security since its compositions

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highlight its status as a nutritious and versatile spice with a wide range of potential health benefits for the consumers provided that measures are taken to prevent them from being polluted.

4.2 RECOMMENDATIONS

Apart from the medicinal benefits of ginger roots, but its anticancer effects on other cancers diseases have yet not been established so, the efficacy of such potent agents on these cancers is warranted. Therefore, more extensive and well-controlled human studies are required to demonstrate its efficacy as an anticancer agent, as it is a safe and cost-effective alternative. Also, a further research is needed to fully understand the specific roles of these minerals in ginger and their potential health effects.Ginger is widely used in oriental cuisines. It is perhaps the most popular spice, being used in sauces, soups and main dishes, desserts and beverages. It is also an ingredient that balances and completes the food and dishes such as vegetables, seafood, white meat and fruits. Due to astringent and spices taste, it is very appropriate in cold cooked stuff, perfecting so many dishes tastes.

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