Research Article
Volume 12:1, 2025

Journal of Environmental Analytical Chemistry

ISSN: 2380-2391 Open Access

# Comparative Study on the Determination of Some Selected Essential and Heavy Metals from Avocado (*Persea americana*), Mango (*Mangifera indica*) and Banana (*Musa acuminata*) with their Supporting Soil Samples Cultivated in Yeki Worecda, Southwest Ethiopia

**Berhe Akele[1*] and Shisho Haile[2]**

[1]*Department of Chemistry, College of Natural and Computational Science, Raya University, Maichew, Ethiopia*

[2]*Department of Chemistry, College of Natural and Computational Science, Mizan-Tepi University, Tepi, Ethiopia*

## Abstract

The study was conducted in Yeki woreda Southern Nations Nationalities and Peoples Regional State, Ethiopia. Systematic random sampling Technik was followed throughout the study. Fruit and soil samples were collected from 8 kebeles of the study area. A total of 50 fruit samples per each fruit item were randomly selected from each site. Fruit samples were desiccated at 90°C for 48 hours in oven and the dried samples were ground. 0.25 kg of soil samples were collected from the soil at which the fruit plant grows. The samples were collected from all directions within 20 cm depth and were dried in oven at 90°C for 24 hours. 0.5 g of fruit sample was digested by the mixture of HCl, $HNO_3$ and $H_2O_2$ (3:1:2) at 90°C for 2 hr and 0.5 g of soil sample was digested with the mixture of $HNO_3$ and $HClO_4$ (3:1) at 90°C for 2 hr. pH and EC values of soil and fruit samples were measured by pH meter and an EC meter. OM and moisture content of samples were also determined. The moisture content ranges from 38.5–57.74 for fruit and 66-71.33 for soil samples. OM of the samples was ranges from 7.77–19.39 for fruit samples and 79.72–85.00 for soil samples. Electrical conductivities of the samples were ranges from 0.06–0.09 mS/cm for fruit samples while that of soil samples was 0.33-0.54 mS/cm. pH values obtained ranges from 7.24-7.56 for fruit samples while it was 7.35-7.66 for soil samples. The concentration of Ca>Cu>Zn>Pb in all samples. Cr was not detected in all fruit samples but detected in all soil samples. Ni and Cd were not detected in all the samples. The means of the metals were significantly different for both samples separately ($p<0.05$). Transfer factor of the metals is almost higher at mango followed by banana and avocado respectively.

**Keywords:** Fruit • Soil • Physical parameter • Chemical analysis

## Introduction

In Ethiopia 80% of the population is rural based, this 80%rural population follows the traditional agricultural ways of farming system [1,2]. In all rural parts of Ethiopia especially SNNPR consumption of wild and cultivated plants is a common phenomenon. The southern part of Ethiopia especially the Southwest is rich in biodiversity. In relation to this different wild and cultivated plants have been used as a source of food therefore, these plants contribute to improve local food security. In addition, these plants are sources of vitamins, minerals, trace elements and proteins [3].

Nutritional metals do occur naturally in fruits and vegetables as essential trace elements needed for good health, but they could be toxic when their concentrations exceed limits of safe exposure. Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in bio systems through contaminated water, soil and air. Therefore, monitoring programs for residues and contaminants contribute to improving food safety, warn of actual and potential food scares and facilitate evaluation of possible health hazards by providing continuous information on levels of environmental pollution in this world [4,5].

***Address for Correspondence:** Berhe Akele, Department of Chemistry, College of Natural and Computational Science, Raya University, Maichew, Ethiopia, Tel: 251913529563; E-mail: berheakele@gmail.com*

***Copyright:** © 2025 Akele B, et al. This is an open-access article distributed under the terms of the creative commons attribution license which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.*

**Received:** 29 November, 2023, Manuscript No. JREAC-23-121621; **Editorassigned:** 01 December, 2023, PreQC No. JREAC-23-121621 (PQ); **Reviewed:** 15 December, 2023, QC No. JREAC-23-121621; **Revised:** 13 January 2025, Manuscript No. JREAC-23-121621 (R); **Published:** 20 January, 2025, DOI: 10.37421/2380-2391.2025.12.407

## Materials and Methods

### Description of the study area

The study was conducted in Southern Nations Nationalities and Peoples (SNNP) Regional State in Sheka Zone Yeki woreda. The seat of the woreda (Tppi) is located about 610 km South of Addis Ababa at 7°12'N latitude and 35°27'E longitude with a mean elevation of 1,097 meters above sea level. The woreda's average annual rainfall ranges from 1801 to 2000 mm and an average annual temperature ranges from 21.5 to 27.14°C (Figure 1) [6,7].

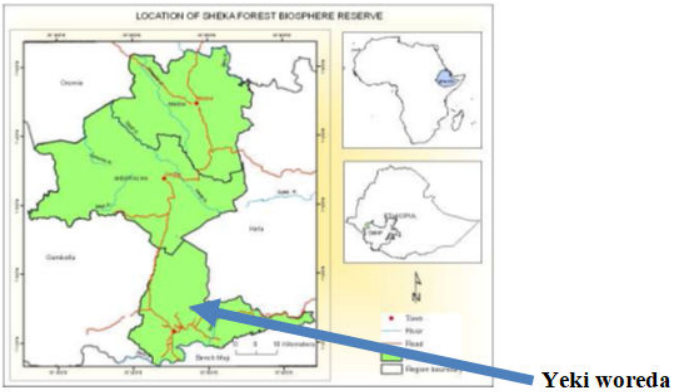


**Figure 1.** Location of the study area.

### Sample collection and preparation

Systematic random sampling technique was followed throughout the study. Accordingly, fruit and soil samples were collected from Darimu, Yeki, Kura, Fide, Zinki, Bechi, Idris and Kubito kebeles. 10 fruit plants of banana, mango and avocado were randomly selected from each site and 5 fruits were randomly taken from each fruit plant. The fruit samples were packed in to paper bags of card board container, labeled and transported to laboratory (Mizan–Tepi University) for preservation. All fruit samples were thoroughly washed with tap water and detergent solution, then after rinsed with deionized water to remove surface contaminants and any metal ion contamination. The fruit samples were peeled with a stainless-steel knife and the pulps were mixed by a mixer, the resulting fruit juices were desiccated at 90°C for 48 hours in oven (PIF 60, shettield, s 30, 2RR England) and the dried samples were ground by mortar and pestle and homogenized with blending device and stored in polyethylene bags until digestion.

Soil samples were collected from the soil at which the fruit plant grows. A sampling technique was designed for collecting soil samples; accordingly, a circle was made with radius of one meter at which the center of the circle is pointed at the base of the fruit plant. The samples were collected from all directions within 20 cm depth and then homogenized together to get about 0.25 kg of soil sample from each fruit plant. The soil samples were packaged into polyethylene plastic of card board container, labeled and transported to laboratory for analysis. Soil samples were dried in oven at 90°C for 24 hours (PIF 60, shettield, s 30, 2RR England) and were gently homogenized.

After the soil samples have been dried and sieved, representative subsamples of soil samples were taken for analysis.

### Sample digestion

Sample digestion was carried out according to Rahman S et al.; and Kalembkiewicz J et al.; with slight modifications [8,9]. All the chemicals and reagents used throughout the study were pure analytical reagents. ($HNO_3$ (69%), $H_2O_2$ (30%) and HCl (37%)). 0.5 g of fruit sample was digested by the mixture of HCl, $HNO_3$ and $H_2O_2$ (3:1:2) at 90°C for 2 hr. 0.5 g of soil sample was digested with the mixture of $HNO_3$ and $HClO_4$ (3:1) at 90°C for 2 hr. To each sample 1% w/v 'matrix modifier' lanthanum nitrate hydrate was added so that lanthanum may bind the phosphate and liberate calcium and magnesium in case large phosphate exist in the sample. The solutions were filtered with what Mann filter paper (110 mm) and were transferred to 25 mL volumetric flask and the volumes were filled with double distilled deionised water up to the mark. The digested, cooled and diluted samples were then kept in a refrigerator until analyzed by FAAS, Agilent technology with model no. 210.

### Sample analysis

pH and EC values of soil and fruit samples (solid: deionized water=1:5) were measured by pH meter and an EC meter by PH-EC Meter; Model 1615. Organic matter and moisture content were determined for both samples.

Organic matter was determined based on the mass loss principles in muffle furnace after ashing the fruit and soil samples at 500°C for 4 hr [10].

$$\%OM=Ms/Mb \times 100$$

Where,

Ms-Mass of the sample after ashing (g)

Mb-Mass of the sample before ashing (g)

OM=Organic matter, %

Moisture content was determined based on the mass loss after drying it in oven at 105°C for 24 hr.

$$\%M=Ms/Mb \times 100$$

Where,

Ms-Mass of the sample after ashing (g)

Mb-Mass of the sample before ashing (g)

M=Moisture content, %

For the determination of metal cations, the instrument (FAAS) was calibrated using five working standard solutions for each of metal interest. Working standards were prepared from the intermediate standard solutions containing 10 mg/L by diluting with double distilled deionized water. Intermediate standard solutions were prepared from the standard stock solution that contained 1000 mg/L for each metal interest. The parameters of flame atomic absorption spectrometer

such as burner and lamp alignment, slit width and wavelength adjustment were optimized for maximum signal intensity of the instrument. The acetylene and air flow rates were managed to ensure suitable flame conditions. Hollow cathode lamp for each metal interest (Ca, Cd, Cu, Cr, Ni, Pb and Zn) was operating at the manufacturer's recommended conditions used at its respective primary source line. Triplicate determinations were carried out for each sample.

### Transfer Factor (TF)

The transfer factor is the ratio of the concentration of specific metals to the total metal concentration in the respective soil sample [11].

TF=Metal concentration in fruit/metal concentration in soil

### Recovery test

To check the reliability and efficiency of the optimized procedure for the analysis of the metals from fruit and soil samples were validated using spiking method. Accordingly, 0.1 mg/L of Zn, Cu and Ca were spiked at once in to microwave digestion vessels that containing 0.5 gram fruit sample and to 0.5 gram soil samples separately and 0.05 mg/L of Ni, Pb and Cd and Cr were spiked at once in another microwave digestion vessels containing the same amount of fruit and soil samples respectively. The spiked samples were digested in the same Manner and with the same reagents as described above for fruit and soil samples digestion.

### Method detection limit

Method detection limit of the study for both fruit and soil samples were determined from the mean and standard deviation of the blanks. Ten blanks for fruit and ten blanks for soil samples were digested in the same manner as described above for fruits and soil samples, each blank was determined for each target analyte (Ca, Cd, Cu, Cr, Ni, Pb, and Zn) by flame atomic absorption spectrophotometer.

### Statistical data analysis

Statistical analysis was made to check whether there was a significant difference in physicochemical parameter results. Accordingly, t-test was used to check the whether the results difference is significant or not between fruit and soil samples and One way ANOVA was used to check whether the results difference is significant or not within the fruit samples and within soil samples respectively.

## Results and Discussion

### Physicochemical parameter analysis

**Moisture content:** The moisture content ranges from 38.5–57.74 for fruit and 66-71.33 for soil samples. The moisture content of mango>banana>avocado. This indicates that mango has highest capacity to uptake moisture than banana and avocado respectively [12].

**Organic Matter (OM):** Organic matter content indicated the high strength of the soil samples to retain more metals in to the soil particles. OM of the samples were ranges from 7.77–19.39 for fruit samples and 79.72–85.00 for soil samples. The content of OM was higher at mango soil followed by banana soil and avocado soil samples respectively with a significantly different for both samples respectively ($p<0.05$). The result confirmed that the higher metals concentration in the soil rather than in fruit samples was in agreement with the metals concentration obtained from the analysis. The result also confirmed with the electrical conductivity that obtained in this study because OM is inversely proportional with EC.

**Electrical Conductivity (EC):** Electrical conductivities of the samples were ranges from 0.06–0.09 mS/cm for fruit samples and 0.33-0.54 mS/cm for soil samples. The value of electrical conductivity was higher at mango followed by banana and avocado for fruit samples respectively and EC of avocado soil>banana soil>mango soil with a significantly different for both samples respectively ($p<0.05$). Hence, mango and banana fruits were found to be high in ionic concentration. This also confirmed higher in electrical conductivity is lower in OM which was recorded in the study. Electrical conductivities of soil samples were found to be higher than that of fruit samples.

**pH:** Soil pH is a significant factor controlling uptake of metals. Low pH may result in increased solubility and high availability of metals. Because of the pH of the soil samples were above 5.6 all soil samples allow the transfer of metals from soil to plants [13]. According to the analysis, the pH values obtained ranges from 7.24-7.56 for fruit samples and 7.35-7.66 for soil samples. The pH value of mango was the higher in both fruit and soil samples followed by banana and avocado respectively with a significantly different for both samples respectively ($p<0.05$). Hence, all most all samples were neutral and this shows that the fruit samples are suitable for consumption related to its pH values (Table 1).

| Sample code | Moisture (%) | OM (%) | EC (mS/cm) | pH |
|---|---|---|---|---|
| Avocado | 38.50 ± 0.54 | 19.39 ± 1.23 | 0.06 ± 0.005 | 7.24 ± 0.01 |
| Banana | 52.40 ± 1.21 | 13.69 ± 0.56 | 0.08 ± 0.007 | 7.52 ± 0.09 |
| Mango | 57.74 ± 0.57 | 7.77 ± 0.54 | 0.09 ± 0.007 | 7.56 ± 0.05 |
| Avocado soil | 71.33 ± 2.05 | 79.72 ± 0.05 | 0.54 ± 0.02 | 7.35 ± 0.03 |
| Banana soil | 68.00 ± 0.83 | 80.63 ± 0.12 | 0.51 ± 0.003 | 7.63 ± 0.02 |

| | | | | |
|---|---|---|---|---|
| Mango soil | 66.67 ± 0.47 | 85.00 ± 0.03 | 0.33 ± 0.03 | 7.66 ± 0.06 |

**Table 1.** Physicochemical analysis.

## Level of metals in fruit and soil samples

The result indicated that, Ca, Cu, Zn and Pb were detected in all samples. The concentration of Ca>Cu>Zn>Pb in all samples. Cr was not detected in all fruit samples but detected in all soil samples. Ni and Cd were not detected in all the samples. The means of the metals were significantly different for both samples separately ($p<0.05$).

As it is shown from Table 2, the concentrations of Ca, Cu, Zn and Pb were higher at Avocado followed by Banana and Mango at fruit and soil samples respectively, this result indicates that samples with high OM have low metal concentration.

| No. | Sample | Concentration of metal (mg/kg) mean ± SD | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Ca | Cu | Zn | Cr | Pb | Ni | Cd |
| 1 | Avocado | 91 ± 0.12 | 47 ± 0.01 | 6.9 ± 0.007 | ND | 0.059 ± 0.001 | ND | ND |
| 2 | Banana | 86 ± 0.01 | 42 ± 0.004 | 6.8 ± 0.002 | ND | 0.055 ± 0.0006 | ND | ND |
| 3 | Mango | 78 ± 0.06 | 24 ± 0.0003 | 6.7 ± 0.006 | ND | 0.053 ± 0.008 | ND | ND |
| 4 | Avocado soil | 1219 ± 0.26 | 88 ± 0.0001 | 17.2 ± 0.001 | 0.90 ± 0.001 | 0.87 ± 0.006 | ND | ND |
| 5 | Banana soil | 1169 ± 0.08 | 69 ± 0.004 | 15.6 ± 0.008 | 0.67 ± 0.01 | 0.77 ± 0.002 | ND | ND |
| 6 | Mango soil | 902 ± 0.04 | 34 ± 0.0001 | 15.3 ± 0.004 | 0.48 ± 0.001 | 0.69 ± 0.009 | ND | ND |

**Note:** Avocado soil, banana soil, mango soil=Soil sample taken from the root of the plant

**Table 2.** Determination of metals.

## Comparison of present study with different international guidelines

According to WHO (2012) the maximum level of Ca in fruits is 300 mg/kg [14]. In this study the concentration of Ca in fruit samples is 91 ± 0.12 which is at the permissible level. The permissible limit of Cu in fruits is 73.3 mg/kg and the concentration of Cu in fruit samples of the study is 47 ± 0.01 which is below this limit. The maximum level of Zn in fruits is 60 mg/kg and the concentration of Zn in fruit samples of the current study is 6.9 ± 0.007 which is below the maximum level. The maximum level of Pb in fruits is 0.1 mg/kg and the concentration of Pb in fruit samples of the current study is 0.059 ± 0.001 which is below the maximum level.

The concentration of the metals in all fruit samples was below the maximum level limit and hence, all of these fruit samples were free from the toxicity related to metal ions [15,16] (Table 3).

| Metal | Name of organization | Maximum level of metal in fruit (mg/kg) | Present study concentration of metal in fruit (mg/kg) |
|---|---|---|---|
| Ca | WHO, 2021 | 300 | 91 ± 0.12 |
| Cu | WHO, 2021 | 73.3 | 47 ± 0.01 |
| Zn | WHO,2021 | 60 | 6.9 ± 0.007 |
| Pb | WHO, 2021 | 0.1 | 0.059 ± 0.001 |

**Table 3.** Comparison results of present study with different international guidelines.

## Transfer factor of metals

The transfer factor is the ratio of the concentration of specific metal to the total metal concentration in the respective soil sample. As it is shown from Table 4, transfer factor of the metals is almost higher at mango followed by banana and avocado respectively, this due to the factor of OM [17].

| No. | Metal | Concentration of metal in sample (mg/kg) mean ± SD | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Avocado soil | Avocado | TF | Banana soil | Banana | TF | Mango soil | Mango | TF |
| 1 | Ca | 1219 ± 0.26 | 91 ± 0.12 | 0.07 | 1169 ± 0.08 | 86 ± 0.01 | 0.07 | 902 ± 0.04 | 78 ± 0.06 | 0.09 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Cu | 88 ± 0.0001 | 47 ± 0.01 | 0.5 | 69 ± 0.004 | 42 ± 0.004 | 0.63 | 34 ± 0.0001 | 24 ± 0.0003 | 0.71 |
| 3 | Zn | 17.2 ±0.001 | 6.9 ±0.007 | 0.4 | 15.6 ±0.008 | 6.8 ±0.002 | 0.43 | 15.3 ±0.004 | 6.7 ±0.006 | 0.43 |
| 4 | Cr | 0.90 ±0.001 | ND | - | 0.67 ± 0.01 | ND | - | 0.48 ± 0.001 | ND | - |
| 5 | Pb | 0.87 ±0.006 | 0.059 ±0.001 | 0.07 | 0.77 ±0.002 | 0.055 ± 0.0006 | 0.07 | 0.69 ±0.009 | 0.053 ±0.008 | 0.08 |

**Note:** Avocado soil, banana soil, mango soil=Soil sample taken from the root of the plant

**Table 4.** Transfer factor of metals.

## Conclusion

The present investigation indicated that, Cd and Ni were not detected in all samples. The concentration of the detected metals was higher in the soil samples than their respective fruit samples. The concentration of Ca>Cu>Zn>Pb in all samples. Cr was detected in all soil samples but not at all fruit samples.

The moisture content rang 38.5–57.74 in fruit and 66.67–71.33 in soils samples, the OM was 7.77–19.39 for fruit and 79.72–85 for soil samples. EC of fruit samples was range 0.06–0.09 for fruit and 0.33–0.54 for soil samples and the pH of fruit was range 7.24–7.56 and pH of soil was rage 7.35–7.66. According to this result, the concentration of Ca was range 78 mg/kg (mango)–91 mg/kg (Avocado). Cu, Zn and Pb were low in concentration at mango 24 mg/kg, 6.7 mg/kg and 0.053 mg/kg were high at avocado 47 mg/kg, 6.9 mg/kg and 0.059 mg/kg respectively.

The concentration of all metals was within the RDA in all fruit samples. All values obtained within the normal range were in a good agreement with he values reported for these fruits by different scholars. The means of the metals in both fruit and soil samples were significantly different respectively ($p<0.05$). The TF of all metals were higher at Mango followed by banana and avocado respectively, this is due to the factor of OM.

## References


1. van der Veen, Anne, and Tagel Gebrehiwot. "Effect of policy interventions on food security in Tigray, Northern Ethiopia." *Ecol Soc* 16 (2011): 1-17.
2. Kaluski, Dorit Nitzan, Einat Ophir, and Tilahun Amede. "Food security and nutrition–the Ethiopian case for action." *Public Health Nutr* 5 (2002): 373-381.
3. Kumasi, Tyhra Carolyn, and Kwadwo Asenso-Okyere. "Responding to land degradation in the highlands of Tigray, Northern Ethiopia." *International Food Policy Research Institute* 1142: 44.
4. Mahdavian, Seyed Esmael, and R. K. Somashekar. "Heavy metals and safety of fresh fruits in Bangalore city, India-A case study." *Kathmandu Univ J Sci Eng Technol* 4 (2008): 17-27.
5. Habib, Habib R., Salih M. Awadh, and Muhanad Z. Muslim. "Toxic heavy metals in soil and some plants in Baghdad, Iraq." *Al-Nahrain J Sci* 15 (2012): 1-16.
6. Hashmi, Durdana Rais, Shahnaz Ismail, and G. H. Shaikh. "Assessment of the level of trace metals in commonly edible vegetables locally available in the markets of Karachi city." *Pak J Bot* 39 (2007): 747-751.
7. Mahwash Zahra, Kirmani, Mohiuddin Sheikh, Naz Farah, and Naqvi Iftikhar Imam, et al. "Determination of some toxic and essential trace metals in some medicinal and edible plants of Karachi city." *J Basic Appl Sci* 7(2011): 89-95.
8. Rahman, Syed Hafizur, Dilara Khanam, Tanveer Mehedi Adyel, and Mohammad Shahidul Islam, et al. "Assessment of heavy metal contamination of agricultural soil around Dhaka Export Processing Zone (DEPZ), Bangladesh: implication of seasonal variation and indices." *Appl Sci* 2 (2012): 584-601.
9. Kalembkiewicz, J., and E. Soco. "Investigations of sequential extraction of chromium from soil." *Polish J Environ Stud* 11 (2002): 245-250.
10. Nouri, J., N. Khorasani, B. Lorestani, and M. Karami, et al. "Accumulation of heavy metals in soil and uptake by plant species with phytoremediation potential." *Environ Earth Sci* 59 (2009): 315-323.
11. Opaluwa, O. Da, M. Oa Aremu, L. Ob Ogbo, and K. Ab Abiola, et al. "Heavy metal concentrations in soils, plant leaves and crops grown around dump sites in Lafia Metropolis, Nasarawa State, Nigeria." *Adv Appl Sci Res* 3 (2012): 780-784.
12. Zhao, Keli, Weijun Fu, Zhengqian Ye, and Chaosheng Zhang. "Contamination and spatial variation of heavy metals in the soil-rice system in Nanxun County, Southeastern China." *Int J Environ Res Public Health* 12 (2015): 1577-1594.
13. Chopra, A. K., Chakresh Pathak, and G. Prasad. "Scenario of heavy metal contamination in agricultural soil and its management." *J Appl Nat Sci* 1(2009):99-108.
14. World Health Organization (WHO). Exposure to calcium: a major public health concern (2012).
15. Parák, Tomas, and Eva Strakova. "Zinc as a feed supplement and its impact on plasma cholesterol concentrations in breeding cocks." *Acta Veterinaria Brno* 80 (2011): 281-285.
16. IOM. Exposure to Copper: a major public health concern. (2010).
17. Kumar, Bhupander, Sanjay Kumar, Meenu Mishra, and S. K. Singh, et al. "Geochemical fractionation of some heavy metals in soils in the vicinity of sukinda mining Area, Orissa." *Adv Appl Sci Res* 2 (2011): 263-272.


**How to cite this article:** Akele, Berhe and Shisho Haile. "Comparative Study on the Determination of Some Selected Essential and Heavy Metals from Avocado (*Persea americana*), Mango (*Mangifera indica*) and Banana (*Musa acuminata*) with their Supporting Soil Samples Cultivated in Yeki Worecda, Southwest Ethiopia." *J Environ Anal Chem* 12 (2025): 407.