# Levels of Essential Elements in Selected Persea Americana Varieties as Potential Minerals

Kithure J.G.N., Nyandieka I. J.

*Department of Chemistry, University of Nairobi, P.O. BOX 30197, 00100, Nairobi, Kenya*

***Abstract*: Persea americana is a Scientific Name for Avocados. They are a good source of micronutrients like iron, zinc, magnesium, manganese, and copper because of their high concentration of these vital trace elements. These are essential to the human body because they boost the immune system and carry out processes including respiration, cell synthesis, and transcription. This study aimed at assessing the levels of essential trace elements, which include; zinc, iron, magnesium, manganese, and copper in the selected two avocado varieties, (Hass and Fuerte). The metal elements were examined using the Atomic Absorption Spectrophotometer (AAS). In Hass avocados, magnesium concentrations were found to be 0.1197 ±0.0107 mg/g, manganese 0.0077±0.0017 mg/g, iron 0.0368±0.0044 mg/g, zinc 0.0209±0.0029 mg/g), and copper 0.0019±0.0001 mg/g. The magnesium level was 0.1434±0.0069 mg/g, manganese 0.0058±0.0006 mg/g, iron 0.0252±0.0041 mg/g, zinc 0.02102±0.0013 mg/g, and copper level was 0.0017 0.0005 mg/g in the Fuerte avocado variety. According to these findings, the avocado varieties did not have significantly different quantities of critical elements. The avocado fruit varieties studied were able to meet the Recommended Dietary Allowance (RDA) requirements for manganese and copper minerals and half the RDA for zinc and iron. From the study, it was shown that a fresh piece of avocado of mass 200 g can provide more than half the RDA for manganese, zinc, iron, and copper essential elements. We recommend avocado inclusion in the diet as it provides essential trace elements for the human body hence reducing the rise of non-communicable diseases.**

***Keywords*: Avocado Fruit, Essential, Trace Elements, Recommended Dietary Allowance, and Immune System.**

## I. INTRODUCTION

The scientific name of avocado is Persea americana. This plant was first cultivated in Mexico and Central America before it spread into other parts of the globe[1]. It belongs to the flowering plant family Lauraceae[2]. Its fruit is a pear-shaped fruit that is produced by tropical evergreen trees and has a nutty and creamy taste when it is ripe. It has a rough outer skin, oily flesh, and a large seed at the center. The fruit has been used for centuries as food and for therapeutic importance. This is because they contain Fiber, sugars, proteins, antioxidants, folate, healthy fats, potassium, vitamin K, vitamin C, vitamin E, vitamin B[2], and essential elements[3]. They also contain in small amounts essential elements like zinc, manganese, phosphorus, iron, copper, and magnesium. Avocados are also rich in fiber and antioxidants that are good for the human body[4].

The term essential element refers to a chemical element that is present in a natural material that is required by living organisms for proper growth, development, and physiology of the organism[5]. Examples of the essential elements are Iron, manganese, magnesium, zinc, and copper. These elements play important roles in the human body, where some are important for enzyme reactions as they take part in the conversion of substrate molecules to specific end products. Some take part in the generation and utilization of metabolic energy in the body. For instance, the human body uses manganese to synthesize connective tissues, blood clotting factors, bones, and sex hormones. Magnesium regulates blood glucose and pressure and also takes part in DNA and RNA synthesis[5]. Zinc is a cofactor in metabolic and cell growth enzymes. It is also a constituent of the antioxidant superoxide dismutase that provides a defense against oxidative stress in the body[6]. Other essential elements like iron take part in the biological processes for example iron binds with oxygen and transports it to the body cells where it releases the oxygen. However, essential trace elements are toxic to the human body at excessive levels and can lead to many fatal diseases such as cancer[5]

Currently, it is predicted that about a third of the cancer cases and half of the cardiovascular cases are thought to have been caused by human poor diet patterns[7]. These cases can, however, be reduced by creating awareness among human being about the importance of taking fruits like ripe avocado since it has been proven that they have nutrients that help in combatting non-communicable diseases. In fact, studies have shown the inverse association between fruits like avocado consumption and non-communicable diseases[7]. Government and private organizations are helping raise human awareness regarding the importance of making better dietary choices and avoiding consuming fast foods that are rich in energy, fats, and free sugars. These kinds of foods lack essential elements that are required in the body to boost the immune system so that it can be able to fight diseases.

Assessment of the essential elements in selected avocado varieties (Hass and Fuerte varieties) will aid to promote avocado consumption in Kenya which will help in boosting the immunity system of people, maintain cardiovascular health and muscle function[3], and reduce food insecurity in the country since avocado production countrywide is on the increase. The study aims at acquiring knowledge that helps human beings re-orient, adapt, and invest in better dietary plans.

## II. MATERIALS AND METHODS

To achieve the objective of the study, the samples were collected, treated, transported to the laboratory, digested, and analyzed using Atomic Absorption Spectrophotometer (AAS).

*2.1: Study Area.*

The avocado varieties were sampled from Mathioya, Kigumo, and Muruka in Murang’a County in Kenya which lies between latitudes 0° 34’ and 107’ South and longitudes of 36 and 37° 27’[8]. This county is estimated to produce about 120,645 tons yearly within 4319 hectares making it the leading cultivator of avocado in Kenya[9]. This study was carried out in the month of March which is in the long season of avocado (March to August)[10].

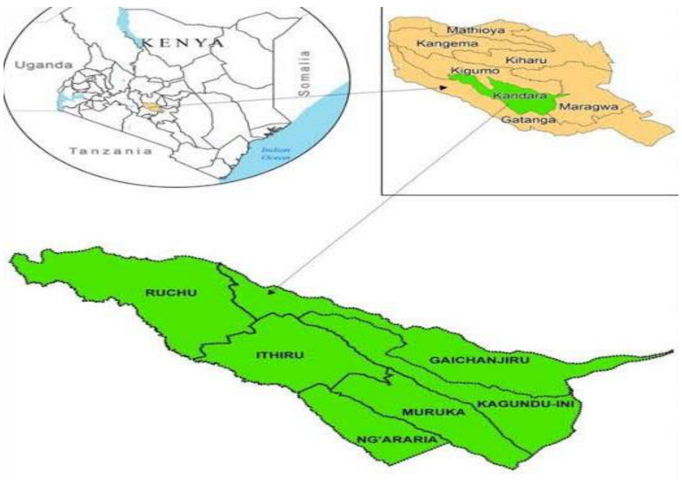


Figure 2.1: Map of the sample collection sites.

*2.2: Sampling, Packaging, and Transportation to the Laboratory.*

The two varieties of avocado fruit were harvested in duplicates. The fruits were put into perforated polythene bags which were labeled to indicate the date at the time of collection, the place from which they were sampled, and the variety of the fruit. The bags were stored in portable refrigerators which were transported on the same day to the chemistry department laboratory at the University of Nairobi. The bags were preserved in a deep freezer until the time of analysis.

*2.3: Sample treatment and digestion*

The varieties of avocado that were analyzed were Hass and Fuerte, they are shown in Figure 2.1 and Figure 2.2 respectively. All the avocado samples were thoroughly washed with distilled water in order to remove all the unwanted substances. They were then cut using a pre-cleaned stainless steel kitchen knife exposing the buttery part which was then cut into small pieces. Those pieces were then transferred in an aluminum foil which was in an oven. The oven was closed after which the temperature was set to 100 ºC. The samples were then left for 24 hours to completely dry.

The dried sample was crushed into a fine powder using a pestle and mortar from which 2 g was weighed using Fischer scale A-160 analytical weighing balance and transferred into a beaker. 15 ml of hydrochloric acid, 1 ml of perchloric acid, and 5 ml of nitric acid were added to the beaker containing the powder and heated on a hot plate with a heat control knob and stir knob to a temperature of 108 ºC for 2 hours as shown in Figure 2.3 after which the solution was allowed to cool. The temperature was monitored using a mercury-in-glass thermometer. A filter funnel, a filter paper, and a 50 ml volumetric flask were used to filter the solution. The filtrate in the 50 ml volumetric flask was topped with distilled water to the mark. Each avocado variety from every sampling site was prepared in duplicates.

Figure 2.1: Hass avocado.

Figure 2.2: Fuerte avocado.

Figure 2.3: Digestion step of the avocado varieties.

*2.4: Reagents used and cleaning of sampling containers and glassware*

The sampling containers and the glassware were cleaned using tap water and liquid detergents. They were then soaked in 10 % analytical grade nitric acid for 24 hours after which they were rinsed with distilled water. The glassware was dried at 80 ºC in a Gallen Kapoven model OV-160 Oven while the sampling containers were dried on an open clean laboratory bench. The cleaned glass wares and sampling containers were kept in a safe place until the samples were collected, digested, and analyzed.

During the analysis, ANALAR grade (purity of 99.99%) hydrochloric acid, nitric acid, perchloric acid, magnesium salt, copper salt, zinc salt, iron salt, and manganese salt were used. These salts were used to prepare respective stock solutions. This was achieved by weighing the required amount of the salt and dissolving it in deionized water to give 1000 mg/L of standard solution.

*2.5: Sample Analysis*

Glasswares such as 250 ml beaker, 50 ml volumetric flask, measuring cylinders, watch glass, and sampling bottles were used during the analysis. The sampling bottles were used to store the digested samples (Figure 2.4) Each sampling bottle was labeled to identify the sample solution that it contains. The levels of manganese, magnesium, copper, zinc, and iron were determined using AAS Shimadzu 6300. This was achieved by introducing each sample solution into the instrument and recording the steady reading. After each sample analysis, distilled water was introduced into the instrument to adjust it to its initial settings.

Figure 2.4: A photo of digested avocado sample solutions stored in sampling containers awaiting AAS analysis.

*2.6: Preparation of stock solution and developing the calibration curves.*

By weighing 3.798 g of copper nitrate, 1.000 g of zinc metal, 4.840 g of iron (II) chloride, and 3.6077 g of manganese chloride, respectively, the stock solutions of magnesium, copper, zinc, iron, and manganese were created. The weighed salts were dissolved in 1000 ml of deionized water to create a 10 ppm standard solution. Each stock solution was serially diluted to create standard solutions at concentrations of 0.5 ppm, 1.0 ppm, 1.5 ppm, 2 ppm, 2.5 ppm, 3.0 ppm, and 4 ppm.

As illustrated in Figure 2.5, the instrument's reading was zeroed by adding distilled water. The device was used to assess the absorbance of the 0.5 ppm, 1.0 ppm, 1.5 ppm, 2 ppm, 2.5 ppm, 3.0 ppm, and 4 ppm solutions of each metal under investigation. For iron, zinc, copper, manganese, and magnesium, the AAS machine wavelength was set at 248.3 nm, 213.9 nm, 324.7 nm, 279.5 nm, and 285.2 nm, respectively. The outcomes were put to use in creating a calibration curve for every metal.


Figure 2.5: A photo showing the process of water injection into the machine to zero the reading.

## III. RESULTS AND DISCUSSION

*3.1: Introduction*

The levels of essential elements were determined in two avocado varieties (Hass and Fuerte) in this study. Table 3.1 show the ideal conditions for the essential metals that were determined in this research project by the AAS at various wavelengths. The samples were analyzed for the metal ions in triplicates and the results are presented in Table 3.2 and Table 3.3 as mean and standard deviations. The calibration curves developed in the study were interpolated in excel to determine the concentration of the metal ions.

Table 3.1: Optimum conditions for metals determined using AAS.

| Element | Wavelength (nm) | Type of flame | Sensitivity (ppm) | Working range (ppm) | Detection limit (ppm) |
|---|---|---|---|---|---|
| Zinc | 213.9 | Air acetylene | 0.01 | 0.4 – 1.6 | 0.001 |
| Iron | 248.3 | Air acetylene | 0.04 | 2.5 - 10 | 0.006 |
| Magnesium | 285.2 | Air acetylene | 0.003 | 0.1 – 0.4 | 0.0002 |
| Manganese | 279.5 | Air acetylene | 0.021 | 1 – 4 | 0.002 |
| Copper | 324.7 | Air acetylene | 0.04 | 2 – 8 | 0.002 |

*3.1.1: Levels of essential elements in the avocado varieties*

A fresh piece of Hass avocado variety that weighs about 200 g can provide 7.3656 ± 0.8836 mg of iron, 4.1770 ± 0.5824 mg of zinc, 23.9432 ± 2.1472 mg of magnesium, 1.5332 ± 0.3456 mg of manganese, and 0.3839 ± 0.0219 mg of copper. On the other hand, Fuerte avocado of the same weight contains 5.0376 ± 0.8285 mg of iron, 2.0477 ± 0.2670 mg of zinc, 28.676.2 ± 1.3763 mg of magnesium, 1.1687 ± 0.1256 mg of manganese, and 0.3340 ± 0.00105 mg of copper. The levels of the essential elements in Hass and Fuerte avocado varieties from Muruka, Kigumo, and Mathioya are summarized in Table 3.2 and Table 3.3 respectively.

Table 3.2: Levels of essential elements in Fuerte avocado varieties (mean ±std) mg/L

| **Sample site** | **Mg** | **Mn** | **Zn** | **Cu** | **Fe** |
|---|---|---|---|---|---|
| **Mathioya** | 0.1385 ± 0.0545 | 0.0057 ± 0.0006 | 0.0111 ± 0.0028 | 0.0017 ± 0.0002 | 0.0297 ± 0.0115 |
| **Kigumo** | 0.1512 ± 0.0116 | 0.0065 ± 0.0012 | 0.0109 ± 0.0005 | 0.0016 ± 0.0002 | 0.0244 ± 0.0010 |
| **Muruka** | 0.1405 ± 0.0172 | 0.0053 ± 0.0006 | 0.0087 ± 0.0018 | 0.0017 ± 0.0005 | 0.0215 ± 0.0025 |

Table 3.3: Levels of heavy metals in Hass avocado varieties (mean ±std) mg/L

| Sample site | Mg | Mn | Zn | Cu | Fe |
|---|---|---|---|---|---|
| Mathioya | 0.1090 ± 0.0153 | 0.0092 ± 0.0023 | 0.0232 ± 0.0061 | 0.0020 ± 0.0002 | 0.0366 ± 0.0114 |
| Kigumo | 0.1304 ± 0.0136 | 0.0080 ± 0.0020 | 0.0219 ± 0.0047 | 0.0018 ± 0.0002 | 0.0414 ± 0.0036 |
| Muruka | 0.1198 ± 0.0241 | 0.0058 ± 0.0010 | 0.0176 ± 0.0128 | 0.0020 ± 0.0005 | 0.0326 ± 0.0104 |

*3.2: Discussion*

The study showed that in all the three sites where the avocado samples were collected, magnesium mineral was highest in both Hass and Fuerte avocado varieties, which ranged from 0.1090 ± 0.0153 to 0.1304 ± 0.0136 mg/g and 0.1385 ± 0.0545 to 0.1512 ± 0.0116 mg/g respectively. On average a fresh piece of Hass avocado that weighs about 200 g can provide 23.9432 ± 2.1472 mg and that of Fuerte avocado can provide 28.6762 ± 1.3763 mg of magnesium essential element. Even though the levels of magnesium were highest in all the samples, they were not high enough to meet the daily requirement of magnesium intake in the human body. Since RDA of magnesium is 420 mg/day for men above 31 years of age, 400 mg/day for men below 30 years of age, 310 mg/day for women between 19 to 30 years of age, and 320 mg/day for women above 31 years of age according to the World Health Organization (WHO), Kenya Bureau of Standards (KEBS), and Food and Agriculture Organization (FAO) regulating authorities[11].

200 g of Hass avocado can provide between 1.5332 ± 0.3456 mg while Fuerte avocado can provide between 1.1687 ± 0.1256 mg of manganese essential element, which meets more than half the RDA of manganese. This is because the WHO, KEBS, and FAO, the governing bodies, state that the RDA for manganese is 2.3 mg/day for men and 1.8 mg/day for women[11].

About 4.1770 ± 0.5824 mg of zinc is present in a 200 g fresh Hass avocado, while 2.0477 ± 0.2670 mg of zinc is present in a Fuerte avocado. As per the WHO, KEBS, and FAO regulatory agencies, Hass supplies over 44% of the RDA for zinc for a man daily, whereas Fuerte gives roughly 22% of that amount. The RDA for zinc is 11 mg for males and 8 mg for women[11].

The RDA of copper is 0.9 mg/day for an adult according to the WHO, KEBS, and FAO regulating authorities[11]. A fresh piece of Hass avocado that weighs about 200 g can provide 0.3839 ± 0.0219 mg and that of Fuerte avocado can provide 0.3340 ± 0.0105 mg of the copper essential element which is half the RDA for copper. This means that a person can take an avocado a day and meet half the daily requirement of copper essential element.

According to the WHO, KEBS, and FAO regulatory bodies, the recommended dietary allowance (RDA) for iron is 8 mg/day for males and women over 51 and 18 mg/day for women between the ages of 19 and 50[11]. Fresh Hass avocados have an iron content of between 7.3656 ± 0.8836 mg per 200 g, whereas Fuerte avocados have an iron content of between 5.0376 ± 0.8285 mg per 200 g, which is less than the RDA. Accordingly, when consumed, Hass avocados may satisfy 90% of the RDA for males and older women over the age of 51, whereas Fuerte avocados can satisfy 63% of it.

Apart from the magnesium element, all the other elements were higher in the Hass avocado variety than in the Fuerte avocado variety. This shows that the Hass avocado variety is higher in essential elements and can be a better source of minerals than the Fuerte avocado variety. Mathioya location avocado samples had the highest levels of iron and zinc essential elements. Magnesium essential element was highest in avocado samples from Kigumo location.

## IV. CONCLUSION AND RECOMMENDATION

*4.1: Conclusion*

It was found that avocado fruit is rich in essential elements required by the body in the current study. The avocado fruit can provide more than enough of the RDA of manganese and copper required by the human body. Also, avocado can supplement other foods rich in essential elements in providing minerals like iron and zinc. Magnesium mineral levels in avocado were below the RDA in this study and hence the fruit cannot be depended on entirely as a potential source of the magnesium element.

*4.2: Recommendation*

The following recommendations were made from the current study:

1. The public should include more avocado fruits in their diets, this will supplement other sources of the essential elements as avocadoes do contribute significantly to the RDA levels.
2. Farmers should do Hass avocado farming as this variety is higher in minerals compared to the Fuerte avocado variety.
3. A study should be done to determine how the locality of avocado farming affects the levels of minerals that the fruits will have at their maturity.
4. Further research should be done by analyzing more other varieties of avocados rather than the ones that were done in this study.

## REFERENCES

[1] Bergh, B.; Ellstrand, N. Taxonomy of the avocado. Calif. Avocado Soc. Yearb. 1986, 70, 135–145.

[2] Dreher, M. L., & Davenport, A. J. (2013). Hass avocado composition and potential health effects. Critical Reviews in Food Science and Nutrition, 53(7), 738-750. doi:10.1080/10408398.2011.556759.

[3] Bhuyan, D.J., Alsherbiny, M. A., Perera, S., Low, M., Basu, A., Devi, O. A., …& Papoutsis, K. 2019). The odyssey of bioactive compounds in avocado (persea americana) and their health benefits Antioxidants, 8(10), 426.

[4] Vincente, A. R., Manganaris, G. A., Ortiz, C. M., Sozzi, G. O., & Crisosto, C. H. (2014). Nutritional quality of fruits and vegetables. In Postharvest han dling (pp. 69-122). Academic press.Younus H. Therapeutic potentials of superoxide dismutase. Int J Health Sci (Qassim). 2018;12(3):88-93.

[5] Al-Fartusie, F., & Mohssan, S. (2017). Essential Trace Elements and Their Vital Roles in Human Body.

[6] Younus H. Therapeutic potentials of superoxide dismutase. Int J Health Sci (Qassim). 2018;12(3):88-93.

[7] Yahia, E. M., Maldonado Celis, M. E., & Svendsen, M. (2017). The contribution of fruit and vegetable consumption to human health. Fruit and vegetable Phytochemicals. Yahia, EM, ed. Hoboken: John Wiley & Sons, 3-52.

[8] Karing'u, K.N., Isaboke, H.N. and Ndirangu, S.N. (2021), "Transaction costs and participation in avocado export marketing in Murang'a County, Kenya", Journal of Agribusiness in Developing and Emerging Economies, Vol. 11 No. 3, pp. 221-240.

[9] United State Agence for International Development (2017), Horticultural Validated Report 2016-2017, Government Printer, Nairobi.

[10] Amare, M., Mariara, J., Oostendorp, R. and Pradhan, M. (2019), "The impact of smallholder farmers' participation in avocado export markets on the labour market, farm yields, sales prices, and incomes in Kenya", Land Use Policy, Vol. 88, p. 104168.

[11] Food and Nutrition Board. (2011). Institute of Medicine, National Academies.