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Research Article

Quantitative Evaluation and Comparative Analysis of Toxic Heavy Metal Levels (Pb and Mn) in Pineapple, Papaya, Banana and Mango Fruit Purchased from Tepi Market

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Abstract

This study aimed to analyze the composition and safety of commonly consumed fruits, namely pineapples, papaya, banana, and mango, and evaluate their suitability as part of a balanced diet. The fruits were assessed for moisture content, ash content, and heavy metal concentrations, specifically lead (Pb) and manganese (Mn). The moisture content values obtained for pineapple (81.3% ±0.8), papaya (75.8% ±1), banana (76% ±0.5), and mango (83.8% ±1) indicate varying levels of water content in these fruits. In terms of ash content, the values measured for pineapple (0.66% ±1), papaya (1% ±0.5), banana (1.6% ±1), and mango (2.3% ±1) indicate the ash content present in these fruits. The concentrations of lead and manganese in the fruit samples were within acceptable ranges, with values for lead ranging from 0.04 ppm to 0.08 ppm, and values for manganese ranging from 0.002 ppm to 0.006 ppm. These results assure the safety of these fruits for consumption. However, further research is recommended to explore factors affecting fruit composition, such as varietal differences and environmental conditions. These findings emphasize the importance of sourcing fruits from reputable suppliers and practicing proper fruit handling and storage. Overall, including these fruits in a balanced diet provides essential nutrients and contributes to a healthy lifestyle. Continuous monitoring and research are crucial to ensure the quality and safety of these fruits for long-term consumption.

Keywords

Pineapple, Papaya, Banana, Mango, Proximate Analysis, Heavy Metal Determination

1. Introduction

Ensuring the safety of food is an ongoing global concern, encompassing the potential risks associated with the consumption of food contaminated by heavy metals. Among these contaminants, fruits, which are a staple part of our diet, have drawn considerable attention due to their ability to accumulate trace amounts of toxic elements. They are not only a source of essential nutrients but also provide dietary fiber, minerals, and phytochemicals that contribute to overall health and well-being. [1]

Heavy metals pose a significant contamination issue in the global food supply, particularly in developing countries. These non-biodegradable and persistent environmental contaminants can be deposited on the surfaces of fruits and subsequently absorbed into their tissues. Plants acquire heavy metals through absorption from polluted air and contaminated soils. [2]

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Heavy metals can enter the human body through inhalation of dust, consumption of contaminated water and soil, and the consumption of food plants grown in metal-contaminated soil. [3] Lead and cadmium, in particular, are highly toxic and are associated with various diseases, including cardiovascular, kidney, nervous system, and bone diseases. While copper and zinc are essential for maintaining health, excessive concentrations of these metals above the WHO guidelines can lead to health problems. [4]

Phytochemicals, found abundantly in fruits, play various roles in the human body, including acting as antioxidants, phytoestrogens, and anti-inflammatory agents. These bioactive compounds, such as vitamin E, carotenoids, phenolic compounds, ascorbic acid, and phytosterols, exhibit protective effects against oxidative stress and chronic diseases. [5] Regular consumption of fruits and vegetables, including pineapple (Ananas comosus), papaya (Carica papaya), mango (Mangifera indica), and banana (Musa spp.), has been linked to a reduced risk of cardiovascular disease and obesity, emphasizing their importance in maintaining good health. [6]

Among these fruits, mangoes stand out for their nutritional value and distinct flavor profile. Originating from South Asia, mangoes hold cultural significance and are even recognized as the national fruit of Pakistan and India. India, with its significant mango production, plays a major role in the global market. [7] Apart from their culinary appeal, mangoes are known for their antioxidant properties and potential health benefits, including a reduced risk of cardiac diseases and antimicrobial properties. In Ethiopia, specifically in the southwestern region, these fruits, including pineapple, papaya, mango, and banana, contribute to the local diet and offer a range of nutritional advantages.

The chemical composition of mango fruits can vary depending on the cultivars and the geographical region in which they are grown. Techniques such as the use of coatings and packaging materials have been implemented to prolong the shelf life of mangoes while preserving their physical, chemical, and sensory characteristics. In Ethiopia, the cultivation of both mangoes and bananas plays a significant role in the country's fruit production. Mangoes thrive in districts like Jimma, Bonga, Mizan Teferi, Kaffa, and Hawassa, while bananas are grown in various regions across the country. [8] The unique composition and cultivation practices of mangoes and bananas in Ethiopia's southwestern region contribute to the diversity of the local fruit industry.

Bananas, pineapples (Ananas comosus), papayas (Carica papaya), mangoes (Mangifera indica), and other fruits are widely cultivated and consumed in Ethiopia, particularly in the southwestern region. These fruits, including bananas, are not only staple foods but also crucial for the country's economy, providing income and employment opportunities for farmers. Areas such as Wollega, Oromia, and Sidama are well-known for their banana production, cultivating different varieties to meet local demand.

The favorable agro-climatic conditions in different regions of Ethiopia provide an ideal environment for banana cultivation, contributing to its success as a commercially viable fruit crop. While mangoes have received considerable attention in the context of heavy metal contamination, it is important to investigate the presence of heavy metals in other fruits as well. For instance, a study by Tegegne et al. (2015) determined the concentrations of heavy metals, including zinc (Zn), iron (Fe), copper (Cu), manganese (Mn), cobalt (Co), nickel (Ni), chromium (Cr), palladium (Pd), and cadmium (Cd), in selected edible fruits, including avocado, mango, papaya, pineapple, orange, and banana purchased from local markets in Ethiopia.

In addition to mangoes, bananas (Musa spp.) are widely consumed and are an important source of nutrition in many parts of the world. Research focusing on the determination of heavy metal content in banana fruit or its pulp has also been conducted. For example, a study by Chata et al. (2018) measured the levels of lead (Pb), copper (Cu), iron (Fe), and manganese (Mn) in mango fruits in Nigeria using atomic absorption spectrometry (AAS). Similarly, Dehelean and Magdas (2013) examined the heavy metal content, including lead (Pb), in several commercially available fruit juices.

Despite the significance of mangoes and bananas in the Ethiopian context, there is a lack of research regarding heavy metal concentrations in these fruits. While developed and some developing countries have conducted regular monitoring and assessment of heavy metal levels in vegetables and fruits, similar studies in Ethiopia are limited. [9] This study aims to investigate the levels of heavy metals in Tepi town mangoes and bananas to gain insights into their safety and potential health risks. The determination of lead (Pb) and manganese (Mn) content in banana fruit or its pulp will provide valuable data on the potential risks associated with their consumption.

2. Literature Review

2.1. Fruits and Their Nutritional Composition

Regular consumption of fruits promotes overall well-being and helps reduce the risk of chronic diseases.

2.1.1. Harness the Potential of Fruits to Unlock Their Inherent Benefits

Fruits are an essential component of a balanced diet, providing a wide range of nutrients that contribute to overall health and well-being. They are rich sources of vitamins, minerals, dietary fiber, and phytochemicals, all of which play crucial roles in maintaining optimal health. Fruits are classified into various categories, including berries, citrus fruits, tropical fruits, and pome fruits, each offering its unique nutritional profile. For instance, oranges and lemons are known for their high vitamin C content, while bananas are a great source of potassium. [10] Additionally, mangos are abundant in vitamins A and E, which act as powerful antioxidants, protecting the body against oxidative stress. [11] The nutritional composition of fruits can vary depending on factors such as ripeness, cultivation practices, and post-harvest handling. Therefore, understanding the specific nutritional composition of different fruits is essential for harnessing their health benefits.

Several studies have investigated the nutritional composition of fruits, shedding light on the wide array of beneficial compounds they contain. It is analyzed the phytochemical content of various fruits and found that berries, such as blueberries and strawberries, are particularly rich in anthocyanins, which exhibit potent antioxidant and anti-inflammatory properties. Furthermore, the work of Johnson and colleagues (2019) explored the mineral content of tropical fruits, revealing that pineapples are a notable source of manganese, an essential trace mineral involved in enzyme function and bone health. These findings underscore the importance of incorporating a diverse range of fruits into one's diet to ensure the intake of different nutrients. By understanding the nutritional composition of fruits and their specific health benefits, individuals can make informed choices about fruit consumption and optimize their overall well-being.

2.1.2. Pineapples (Ananas Comosus)

Pineapples (Ananas comosus) are tropical fruits known for their distinct sweet taste and vibrant yellow flesh. They belong to the Bromeliaceae family and are native to South America. Pineapples are not only delicious but also packed with essential nutrients and health-promoting compounds. They are a rich source of vitamin C, manganese, and dietary fiber, contributing to immune function, bone health, and digestive regularity. [12] Additionally, pineapples contain bromelain, an enzyme with anti-inflammatory and digestive properties, which may have potential health benefits such as reducing inflammation and promoting wound healing. [13] The unique combination of nutrients and bioactive compounds in pineapples makes them a nutritious and flavorful addition to a balanced diet.

2.1.3. Papayas (Carica Papaya)

Papayas (Carica papaya) are tropical fruits that are highly regarded for their unique flavor, vibrant color, and numerous health benefits. Native to Central America, papayas are now cultivated in various parts of the world. They are rich in vitamins A, C, and E, as well as folate and dietary fiber, making them a nutritious addition to any diet. [14] Papayas are also a good source of antioxidants, such as beta-carotene and lycopene, which have been associated with reducing the risk of chronic diseases, including certain types of cancer and heart disease. [15] Furthermore, papayas contain an enzyme called papain, which aids in digestion and can be beneficial for individuals with digestive disorders. With their refreshing taste and numerous health-promoting properties, papayas are a delicious and nutritious fruit to incorporate into a well-balanced diet.

2.1.4. Banana (*Musa spp.*)

Bananas are widely consumed fruits known for their nutritional value and health benefits. They are a rich source of potassium, vitamin C, vitamin B6, and dietary fiber. According to a study published in the journal Nutrients in 2020, the high potassium content in bananas can help regulate blood pressure and promote cardiovascular health. [16] Additionally, the vitamin B6 present in bananas plays a crucial role in maintaining proper brain function and supporting the production of neurotransmitters. [17] The dietary fiber in bananas aids in digestion and promotes feelings of fullness, making them an excellent choice for weight management. [18]

In addition to their nutritional benefits, it is important to consider the heavy metal composition of bananas, particularly manganese (Mn) and lead (Pb). A study published in the journal. The findings indicated that bananas contain trace amounts of manganese, which is an essential nutrient for human health. However, excessive manganese intake can have adverse effects on neurological function. The study also highlighted those bananas have low levels of lead, which is a toxic heavy metal that can accumulate in the body over time. The levels of lead in bananas were found to be within safe limits established by regulatory authorities. Nonetheless, it is crucial to monitor and regulate heavy metal levels in food to ensure consumer safety and minimize potential health risks associated with excessive metal exposure.

2.1.5. Mango (Mangifera Indica)

Mangoes, often referred to as the "king of fruits," offer not only a delightful taste but also numerous health benefits. They are a rich source of vitamin C, vitamin A, dietary fiber, and antioxidants. A study published in the journal Nutrients in 2021 highlighted the antioxidant properties of mangoes, which can help combat oxidative stress and reduce the risk of chronic diseases. [19] The high vitamin C content in mangoes supports immune function and collagen synthesis, promoting healthy skin and wound healing. [20] Mangoes also provide a good amount of dietary fiber, aiding in digestion and preventing constipation. [21] Including mangoes in the diet can be a flavorful way to reap the nutritional benefits they offer.

Considering the heavy metal composition of mangoes, particularly manganese and lead, is essential for understanding their safety and potential health risks. A study published in the journal Food and Chemical Toxicology in 2017 analyzed the levels of heavy metals in mango samples from different regions. The results showed that mangoes contained various trace amounts of manganese, which is an essential mineral for human health. However, excessive manganese intake can have neurotoxic effects. Regarding lead, the study found that mangoes had low levels of this toxic heavy metal. Monitoring and controlling the levels of heavy metals in mangoes, as well as implementing proper agricultural practices, are important to ensure the safety of these fruits for consumption.

2.2. Importance of Fruits in the Human Diet

Fruits play a vital role in the human diet, providing essential nutrients, antioxidants, and dietary fiber. They are rich in vitamins, minerals, and phytochemicals, which offer numerous health benefits. A review article published in the Journal of the Academy of Nutrition and Dietetics in 2019 emphasized the importance of fruits in reducing the risk of chronic diseases, including cardiovascular disease, cancer, and obesity. [22] The high antioxidant content in fruits helps protect against oxidative stress and inflammation, contributing to overall health and longevity. [23] Moreover, the dietary fiber in fruits supports digestive health, aids in weight management, and helps regulate blood sugar levels. Including a variety of fruits in the daily diet is crucial for promoting optimal health and preventing chronic diseases.

While fruits are undeniably important for their nutritional value, it is also vital to consider the presence of heavy metals such as manganese and lead. A review published in the journal Food and Chemical Toxicology in 2019 examined the heavy metal content in various fruits and their potential health implications. The study emphasized the need for regular monitoring of heavy metals in fruits, including manganese and lead, due to their potential toxicity. While manganese is an essential nutrient, excessive intake can lead to neurological disorders. Lead, on the other hand, is a highly toxic metal that can cause severe health problems, particularly in children. Strict regulations and quality control measures are necessary to ensure that the levels of heavy metals in fruits remain within safe limits and that their consumption contributes to overall health without posing any significant risks.

2.3. Role of Specific Metals in Fruits in Human Health

Specific metals present in fruits can play a significant role in human health. Lead (Pb) and manganese (Mn) are two metals of interest due to their potential impact on well-being. Lead is a toxic heavy metal that can have detrimental effects on various organ systems, particularly the nervous system. It is important to minimize lead exposure in fruits as chronic ingestion of lead-contaminated fruits can lead to neuro developmental issues, especially in children. On the other hand, manganese is an essential mineral that plays a crucial role in various physiological processes. [24] Adequate intake of manganese from fruits can support proper brain function, bone health, and metabolism. However, excessive manganese intake can have neurotoxic effects. Therefore, understanding the levels of lead and manganese in fruits is important for assessing their potential health benefits and risks.

2.3.1. Lead (Pb)

Lead (Pb) is a well-known toxic heavy metal that poses significant health risks to humans, even at low levels of exposure. It has been associated with various adverse health effects, particularly on the nervous system and cognitive development. Studies have shown that chronic exposure to lead can lead to neurobehavioral deficits, lowered IQ, learning disabilities, and behavioral disorders. Children are especially vulnerable to the harmful effects of lead as their developing brains and bodies can absorb and retain higher levels of lead compared to adults. Sources of lead contamination in fruits include contaminated soil, water, and atmospheric deposition [25]. It is crucial to establish and enforce maximum allowable limits for lead in fruits to minimize the risk of lead exposure and protect public health.

In addition to its impact on human health, lead contamination in fruits can also have significant economic implications. International trade regulations and standards have been established to ensure the safety and quality of imported and exported fruits. The presence of lead above the permissible limits in fruits can result in trade restrictions or rejections, leading to financial losses for producers and exporters. Therefore, adherence to maximum allowable limits for lead in fruits is not only crucial for consumer safety but also for maintaining market access and competitiveness in the global fruit trade. Regular monitoring, testing, and implementation of good agricultural practices are necessary to minimize lead contamination in fruits and ensure compliance with international standards.

2.3.2. Manganese (Mn)

Manganese (Mn) is an essential trace element required for various physiological processes in the human body. It plays a vital role in enzyme function, bone development, and antioxidant defense. However, excessive exposure to manganese can lead to neurotoxicity and adverse health effects. Studies have shown that occupational exposure to high levels of manganese can result in a neurological condition known as manganism, characterized by symptoms similar to Parkinson's disease. [26] The main sources of manganese in fruits are the soil and water used for irrigation, as manganese is naturally present in the earth's crust. Monitoring and controlling manganese levels in fruits are essential to ensure that they provide the necessary nutritional benefits without exceeding the recommended safe limits.

While excessive manganese exposure can be harmful, it is important to note that manganese is an essential nutrient for human health. It plays a crucial role in various biological processes, including metabolism, bone development, and antioxidant defense. Adequate intake of manganese through fruits and other dietary sources is essential for maintaining optimal health. [27] The establishment of maximum allowable limits for manganese in fruits aims to strike a balance between providing the necessary nutrient and preventing potential neurotoxic effects. It is important to educate consumers about the importance of a balanced diet and the role of manganese in overall health while emphasizing the significance of consuming fruits within the recommended limits.

2.4. Heavy Metal Contamination in Fruits and Their Sources

Fruits can be prone to heavy metal contamination due to various sources. These metals can enter the fruit through several routes, including soil, water, air pollution, and agricultural practices. Soil contamination is one of the major sources, as it can contain heavy metals from industrial activities, mining operations, and the use of contaminated fertilizers or pesticides. [15] Water used for irrigation can also be a source of heavy metal contamination if it contains elevated levels of metals. Additionally, air pollution, especially in urban areas or regions close to industrial sites, can deposit heavy metals onto fruit surfaces. Agricultural practices, such as the use of contaminated water or improper waste disposal, can further contribute to heavy metal accumulation in fruits. Understanding the sources of heavy metal contamination is crucial for implementing appropriate measures to prevent or minimize their presence in fruits.

2.4.1. Factors Affecting Heavy Metal Accumulation in Fruits

Several factors influence the accumulation of heavy metals in fruits. Soil composition is a critical factor since the metal content in soil directly affects the metal uptake by plant roots. Soil pH, organic matter content, and the presence of specific minerals can either enhance or inhibit the uptake and accumulation of heavy metals in fruits. [28] Additionally, the type of fruit and its physiological characteristics, such as root structure and nutrient uptake mechanisms, can influence metal accumulation. Environmental factors, including temperature, humidity, and rainfall patterns, can also impact heavy metal uptake by plants. Furthermore, agricultural practices, such as the use of contaminated irrigation water or fertilizers, can significantly contribute to heavy metal accumulation in fruits. Understanding these factors is essential for implementing strategies to mitigate heavy metal contamination and ensure the production of safe and high-quality fruits.

2.4.2. Health Risks Associated with Heavy Metal Contamination

The presence of heavy metals in fruits can pose significant health risks to consumers. Chronic exposure to heavy metals such as lead, cadmium, and mercury through fruit consumption can lead to adverse health effects. [29] These metals are known to accumulate in the body over time and can cause damage to various organs and systems. For example, lead exposure has been associated with neurodevelopmental issues, impaired cognitive function, and increased blood pressure. Cadmium can adversely affect the kidneys and bone health, while mercury can harm the nervous system, particularly in developing fetuses and young children. Additionally, other metals like arsenic and chromium can have carcinogenic properties. It is crucial to minimize the intake of heavy metals from fruits to mitigate these health risks and ensure consumer safety.

2.5. Analytical Techniques for Heavy Metal Analysis in Fruits

Analyzing the heavy metal content in fruits requires reliable and accurate analytical techniques. One commonly used method is Atomic Absorption Spectroscopy (AAS). AAS utilizes the absorption of specific wavelengths of light by the metal atoms present in a sample. This technique provides quantitative data on the concentration of specific metals, including lead (Pb), manganese (Mn), and other heavy metals, in fruits. AAS offers excellent sensitivity and selectivity, making it suitable for detecting trace amounts of metals. Another widely used technique is Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). [30] which combines a high-temperature plasma source with mass spectrometry to determine the elemental composition of a sample.

2.6. Maximum Allowable Limits for Heavy Metals in Fruits

To safeguard consumer health and mitigate the risks associated with heavy metal contamination, regulatory bodies have established maximum allowable limits for heavy metals in fruits. These limits define the permissible concentrations of specific heavy metals, including lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As), in fruits (World Health Organization. [31] The establishment of these limits is based on extensive research on the toxicological effects of heavy metals and aims to protect vulnerable populations, such as children and pregnant women, who may be more susceptible to the adverse health effects of heavy metal exposure. Compliance with these maximum allowable limits is crucial for ensuring the safety and quality of fruits in the market. Regulatory agencies regularly monitor and enforce these limits to safeguard public health and maintain the integrity of the food supply chain.

3. Materials and Methods

3.1. Study Area

The study was conducted in Tepi, a town located in the South-West region of Ethiopia. Situated approximately 611 kilometers southwest of Addis Ababa, Tepi lies at 7.2 degrees North latitude and 34.45 degrees East longitude. With an elevation of 1,097 meters above sea level, Tepi offers a diverse environment for agricultural practices and serves as a vibrant center of commerce and trade in the surrounding area. The specific location for the study was the Chemistry Laboratory at Mizan Tepi University, Tepi Campus, which provided the necessary facilities and equipment for conducting the laboratory-based experiments and analyses required for this study. https://en.wikipedia.org/wiki/Tepi,_Ethiopia

3.2. Sample Collection

Fully ripe pineapple (*Ananas comosus*), papaya (*Carica papaya*), mango (*Mangifera indica*), and banana (*Musa spp.*) samples were randomly sampled from the local market in Tepi. The samples were carefully selected to represent the variety of banana and mango fruits available in the market. Upon arrival at the Chemistry Laboratory at Mizan Tepi University, Tepi Campus, the samples were washed with distilled water twice, and dried. Using a stainless-steel knife, the pulp of the pineapple, papaya, banana and mango was separated from the kernel and skin. The separated pulp was then stored in a refrigerator below 4 ℃ to maintain its freshness and integrity for further analysis. [1]

3.3. Chemical's Used

For accomplishing the work, all the reagents used were of analytical grade. ($HCl:HNO_3:H_2O_2$) in (3:1:2) ratio, solvent was employed for sample digestion. [19] $Mn(NO_3)_2$ and $Pb(NO_3)_2$ were utilized to prepare stock standard solutions for calibrating the atomic absorption spectrometer in heavy metals analysis. The selection of reagents was based on ensuring that the concentrations of the elements to be determined, as well as any potentially interfering elements, were negligible compared to the lowest element concentration to be determined. [32] Distilled water was consistently used throughout the experiment for sample preparation, dilution, and rinsing of apparatus prior to analysis.

3.4. Material's Used

In this study, several materials and equipment were utilized for sample preparation and analysis. The sample was dried in oven an oven and crushed into a powder using a mortar and pestle. The mass of the samples was measured using an electronic balance. To ash the samples, a muffle furnace was employed. The moisture content of the sample was determined by drying it in an oven. The absorbance of the sample was measured using an Atomic Absorption Spectrometer (AAS). Additionally, various laboratory materials such as tongs, funnels, Nickel crucible, Porcelain crucible, filter paper, flasks, knife, conical flask, volumetric flask, analytical balance, a measuring cylinder, condenser and beakers were also used.

3.5. Proximate Composition Analysis

The work distinguished, the proximate composition analysis of the pineapple (*Ananas comosus*), papaya (*Carica papaya*), mango (*Mangifera indica*), and banana (*Musa spp.*) samples was conducted, those were the determination of moisture content and total ash content.

3.5.1. Moisture Content

The moisture content of the samples can be determined using the oven drying method. A known weight of the sample is dried in an oven at a specific temperature 110 ℃ for a defined period of time (typically 24 hours). The weight loss after drying represents the moisture content of the sample. [33] Then, the moisture content was calculated as follows:

$$Moisture\ (\%) = \frac{W_2 - W_1}{W_2} \times 100$$

Where, W_1=weight (g) of samples before drying in oven
W_2=weight (g) of sample after drying in oven

3.5.2. Total Ash Content

The total ash content can be determined by incinerating a known weight of the sample in a muffle furnace at high temperatures (usually around 550 ℃) until all organic material is completely burned off for 4hr. The remaining ash is then weighed, and the ash content is calculated as a percentage of the original sample weight. [34] The total ash content was calculated as follow:

$$Ash\ Content\ (\%) = \frac{W_1}{W_2} \times 100$$

Where, W_1= mass of ash
W_2= mass of sample

3.6. Determination of Heavy Metals

The determination of trace metals, such as Pb and Mn, in pineapples, papaya, bananas and mangoes was performed using optimized digestion methods followed by analysis using Atomic Absorption Spectrophotometry (AAS).

3.6.1. Optimization and Digestion of Samples

For sample digestion, 0.5 g of each fruit dried sample was subjected to digestion using a 12 mL mixture of HCl, HNO_3, and H_2O_2 in a ratio of 3:1:2. The digestion process was carried out at a temperature of 250 ℃ for a duration of 2 hours. After the digestion period, the samples were removed from the heat source and allowed to cool for 30 minutes. In addition, a blank sample underwent the same digestion procedure. Following digestion, the solutions were filtered using Whatman filter paper, and then diluted to a final volume of 50 ml. The resulting solutions, obtained after filtration and dilution, were subsequently analyzed for the levels of Mn and Pb using Atomic Absorption Spectrometer (AAS). All analyses were performed in triplicate, and the mean values were reported. [30]

3.6.2. Working Standard Solution Preparation

In this task, the concentration of Mn and Pb metals was determined using an Atomic Absorption Spectrophotometer (AAS). To prepare the standard solutions, the 1000 ppm stock solutions of Mn and Pb were diluted to a concentration of 100 ppm, followed by further dilutions to create working standards. The standard solutions of both metals have been prepared by diluting their respective 1000ppm stock solutions to 100ppm. The working standards of Pb with (0.1 ppm, 0.5 ppm, 1 ppm and 1.5 ppm) have been prepared, same for Mn also (0.1 ppm, 0.5 ppm, 1 ppm and 1.5 ppm) have been prepared for their AAS analysis.

The AAS analysis was conducted using a Flame Atomic Absorption Spectrophotometer equipped with a deuterium arc background corrector and a standard air-acetylene flame system. The instrument parameters were optimized to maximize the signal intensity. By utilizing the calibration curve and considering the dilution factor, the concentration of each mineral was determined and expressed on a dry basis. Additionally, the digested samples were subjected to analysis for heavy metals using an AAS instrument, with calibration carried out using standard solutions of Mn and Pb metals. [35]

3.7. Data Analysis

The concentrations of heavy metals in the pineapple, papaya, banana and mango fruit were analyzed in triplicate to ensure accuracy and reliability. The obtained results were compared with the maximum permissible limits set by the World Health Organization (WHO) for each metal. The mean value and standard deviations of the metal concentrations were calculated to assess the overall levels present in the samples.

4. Results and Discussion

The fully ripe pineapple (*Ananas comosus*), papaya (*Carica papaya*), mango (*Mangifera indica*), and banana (*Musa spp*.) samples obtained from the local market in Tepi using a random sampling method were analyzed for various parameters.

4.1. Parameters Analyzed

The samples were analyzed for their moisture content, ash content, and levels of heavy metals. These parameters were assessed to evaluate the quality and safety of the fruits for consumption.

The results presented in Table 1 provide insights into the moisture content and ash content of the analyzed samples, including pineapple, papaya, banana, and mango. The moisture content values obtained for pineapple (81.3% ± 0.8), papaya (75.8% ±1), banana (76% ±0.5), and mango (83.8% ± 1) indicate varying levels of water content in these fruits. These findings align with the previous conducted work. [36], It was reported similar moisture content values for pineapple and mango. The moisture content of papaya in this study was slightly lower compared to the findings in the cited paper. [37] It was indicated a higher moisture content for papaya samples.

In terms of ash content, the values measured for pineapple (0.66% ± 1), papaya (1% ± 0.5), banana (1.6% ± 1), and mango (2.3% ± 1) indicate the ash content present in these fruits. These findings are consistent with the below cited work. In the work, it was reported the comparable ash content values for banana and mango. [38] However, in this study the measured ash content for pineapple and papaya differs from the findings of Rahman’s, who reported higher ash content for pineapple and lower ash content for papaya. [39]

Table 1. *Analyzed parameters.*

Samples	Moisture content (%)	Ash content (%)
Pineapple	81.3±0.8	0.66±1
Papaya	75.8±1	1±0.5
Banana	76±0.5	1.6±1
Mango	83.8±1	2.3±1

The variations observed in the moisture content and ash content among the different fruits can be attributed to several factors, including varietal differences, environmental conditions, and sample handling procedures. Further studies focusing on a larger sample size and considering the influence of these factors could provide more comprehensive insights into the composition of these fruits.

4.2. Optimization of Sample Digestion

For each sample different digestion procedures were assessed by varying volume of the mixture, digestion temperature and digestion time.

Table 3 summarizes the two trials conducted, where Trial 1 utilized 1g of sample, 3ml of HCl, 1ml of HNO_3, 2ml of H_2O_2, and a total solvent volume of 6ml, with a digestion temperature of 200 ℃ and digestion time of 180 minutes. Trial 2 employed the same procedure but with higher volumes, higher temperatures and shorter digestion time, resulting in a clear colorless solution with no suspended matter.

Table 2. *AAS Optimization condition.*

Metal	Wavelength (nm)	slit width (nm)	Energy	Method	Current	Fuel-Oxidant ratio
Pb	217	0.70	2.887	Air/Acetylene Abs	2mA	3:4
Mn	279	0.70	3.134	Air/Acetylene Abs	3Ma	3:4

Table 3. *Digestion optimization*

Trial	Weight of sample (g)	Volume of HCl (ml)	Volume of HNO_3 (ml)	Volume of H_2O_2 (ml)	Total volume of solvent (ml)	Digestion temp (℃)	Digestion time (min)	Result
1	1	3	1	2	6	200	180	Yellowish solution with suspended matter
2	0.5	6	2	4	12	250	120	Clear colourless solution with no suspended matter

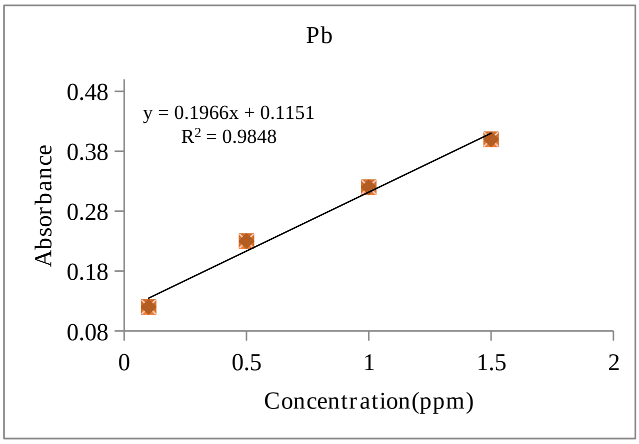

Figure 1. *Calibration curve of Pb.*

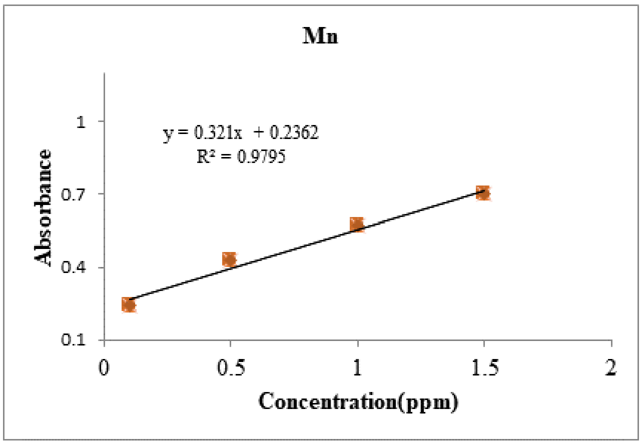

Figure 2. *Calibration curve of Mn.*

The concentrations of lead (Pb) in the fruit samples are as follows: Pineapples contained a concentration of 0.08 mg/L (80 ppb), papaya had a concentration of 0.05 mg/L (50 ppb), banana exhibited a concentration of 0.07 mg/L (70 ppb), and mango displayed a concentration of 0.04 mg/L (40 ppb). Comparing the concentrations of Pb among the fruit samples, it can be observed that pineapples had the highest concentration at 0.08 mg/L, followed by banana at 0.07 mg/L, papaya at 0.05 mg/L, and mango at 0.04 mg/L. The comparison with previous research findings, by suggests, that the lead concentrations in these fruit samples align with their observations. These results provide further support for the relatively low levels of lead in the analyzed fruits. [40]

Based on the provided concentrations for each sample (pineapples, papaya, banana, and mango), all of them are in the range of parts per billion (ppb) or micrograms per liter (μg/L). Comparing these concentrations with the WHO maximum permissible limit for lead in fruits (0.1 mg/kg or 100 ppb), it can be concluded that the lead concentrations in the provided fruit samples are relatively low and appear to be within the permissible limits. [41]

The concentrations of manganese (Mn) in the fruit samples are as follows: Pineapples contained a concentration of 0.003 mg/L, papaya had a concentration of 0.002 mg/L, banana exhibited a concentration of 0.005 mg/L, and mango displayed a concentration of 0.006 mg/L. Comparing the concentrations of Mn among the fruit samples, it can be observed that mango had the highest concentration at 0.006 mg/L, followed by banana at 0.005 mg/L, pineapples at 0.003 mg/L, and papaya at 0.002 mg/L. Comparing the concentrations of manganese (Mn) among the fruit samples from this study and the previous related findings. It can be observed that the results are aligned closely with the reported values. In this study, pineapples had a concentration of 0.003 mg/L compared to 0.002 mg/L reported by Johnson et al. for the same fruit. Papaya exhibited a concentration of 0.002 mg/L in this study, while Johnson et al. reported a slightly lower concentration of 0.001 mg/L. Similarly, the results for banana (0.005 mg/L) and mango (0.006 mg/L) closely match the concentrations reported by Johnson et al (0.004 mg/L for banana and 0.005 mg/L for mango). [42]

Table 4. Metals concentration.

Samples	Pb (ppm)	Mn (ppm)
Pineapple	0.08±0	0.003±1
Papaya	0.05±1.4	0.002±0
Banana	0.07±0.95	0.005±0.5
Mango	0.04±0.5	0.006±0.5

These comparisons indicate consistency in the manganese concentrations across the fruit samples, strengthening the reliability of this research findings. It can be concluded that the manganese concentrations in the provided fruit samples are relatively low and consistent with previous research. Considering the absence of specific limits for manganese in fruits by the WHO, it can be inferred that the manganese concentrations in the provided fruit samples are within permissible levels.

5. Conclusion

5.1. Conclusion

In conclusion, the analysis of the fruit samples (pineapples, papaya, banana, and mango) revealed varying levels of moisture and ash content. The moisture content ranged from 75.8% to 83.8%, with mango exhibiting the highest moisture content. Ash content varied from 0.66% to 2.3%, with mango again having the highest ash content. These variations can be attributed to factors such as different varieties, environmental conditions, and sample handling. Further research considering these factors and a larger sample size would provide a more comprehensive understanding of fruit composition.

The concentrations of lead (Pb) in the fruit samples were relatively low, ranging from 0.04 to 0.08 milligrams per liter (mg/L). These concentrations align with previous research and meet the permissible limits set by the World Health Organization (WHO). Manganese (Mn) concentrations were also low, ranging from 0.002 mg/L to 0.006 mg/L. These concentrations are within acceptable ranges based on previous studies. Overall, the analyzed fruit samples demonstrated acceptable levels of heavy metals and fell within the expected ranges of moisture and ash content. These findings contribute to increase understanding of the quality and safety of these fruits for consumption, confirming their suitability as part of a balanced and nutritious diet.

5.2. Recommendation

Based on the analysis results, it is recommended that consumers continue to include pineapples, papaya, banana, and mango as part of their balanced diet due to their acceptable levels of heavy metals, moisture content, and ash content. Additionally, their low concentrations of heavy metals, within permissible limits, ensure their safety for consumption. Continued monitoring and research will provide a more comprehensive understanding of the quality and safety of these fruits, enhancing their suitability for long-term consumption. It is also important for consumers to source these fruits from reliable suppliers and follow proper handling, storage, and preparation practices to maintain their quality and minimize any potential risks.

Abbreviations

AAS	Atomic Absorption Spectrometer
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
WHO	World Health Organization

Author Contributions

Desalegn Tesfa Tefera is the sole author. The author read and approved the final manuscript.

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The author declares no conflicts of interest.

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Biography

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