COMPARATIVE ANALYSIS OF MINERAL COMPOSITION AND ANTIOXIDANT ACTIVITY IN ORGANIC VS NON-ORGANIC BANANAS AVAILABLE IN UK SUPERMARKETS.

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List of Abbreviations

Abbreviation	Full Term
AES	Atomic Emission Spectroscopy
DPPH	22-Diphenyl-1-picrylhydrazyl
Mg	Magnesium
Na	Sodium
Ca	Calcium
AOAC	Association of Official Analytical Chemists
TAC	Total Antioxidant Capacity
Ppb	Parts per billion
IC50	Half maximal inhibitory concentration
Nm	Nanometres
μg/g	Micrograms per gram
v/v	Volume per volume

ABSTRACT

This research offers a thorough comparison of the antioxidant capabilities and mineral content of organic and non-organic bananas found in UK supermarkets. The main objective of the study was to compare and assess the concentrations of important minerals, namely magnesium (Mg), calcium (Ca), and sodium (Na), in banana samples that were non-organic and those that were organic. A commonly used technique for evaluating the antioxidant potential of food products is the DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging assay, which was also used in this study to evaluate the antioxidant activity of these bananas.

To ensure a wide range of data, the methodology involves gathering a representative sample of bananas, both organic and non-organic, from many retailers. The amounts of sodium, calcium, and magnesium were measured using Atomic Emission Spectroscopy (AES), which allowed for accurate quantification of these minerals. The DPPH assay was used to measure each type of banana's ability to neutralise free radicals, a measure of its antioxidant potential, in order to evaluate antioxidant activity.

The mineral study showed that, in comparison to non-organic bananas, organic bananas had slightly greater levels of calcium, magnesium, and sodium. According to this research, bananas that are organic might have a marginally superior nutritional profile when it comes to these vital minerals. Specifically, calcium is essential for maintaining healthy bones, and magnesium is important for many physiological processes, such as the function of muscles and nerves and the generation of energy. Despite being ingested in excess frequently, sodium is necessary to preserve fluid balance and neuronal function. A more balanced diet may benefit from the higher mineral content found in organic bananas.

Apart from their mineral richness, organic bananas were also discovered to have stronger antioxidant activity than non-organic bananas. According to the results of the DPPH assay, organic bananas were more effective at scavenging free radicals, indicating that they have better antioxidant qualities. Antioxidants play a critical role in maintaining general health and lowering the risk of chronic diseases by minimising oxidative stress and cellular damage brought on by free radicals.

These observations have two ramifications. First off, consumers may benefit from additional health benefits due to the higher mineral content and antioxidant activity of organic bananas. Second, the findings highlight the potential benefits of organic farming methods, which frequently avoid synthetic pesticides and fertilisers and may produce foods with greater nutritional content. The study backs up the idea that eating food grown organically has advantages for the environment and potential health benefits.

All things considered, this study offers insightful information about the nutritional variations between non-organic and organic bananas. The study highlights the little but noteworthy benefits of selecting organic produce, namely in terms of mineral content and antioxidant activity, for bananas. It also highlights the wider effects of organic agricultural methods on environmental sustainability and human health.

Keywords: Organic bananas, non-organic bananas, Antioxidant activity, Mineral content, DPPH assay, Magnesium, Calcium, Sodium, Atomic Emission Spectroscopy (AES), Nutritional profile, Organic farming, Free radicals, Environmental sustainability, Food quality, UK supermarkets.

1.0 INTRODUCTION

1.1 An Increased Awareness on Bananas as a Complete Fruit

In addition to being a delicious fruit that is loved all over the world, bananas (Musa spp.) are also a major source of nutrients and are included in many diets. Their roots are in the tropical parts of Southeast Asia, and they are now widely available in marketplaces across the globe. Because bananas are a common food in many families in the United Kingdom, their nutritional makeup and the effects of the farming practices used to grow them are especially important for agricultural sustainability and public health.

Growing consumer awareness of food safety, environmental sustainability, and health is driving a wider shift in consumer preferences, which is reflected in the growing trend towards organic produce. Organic bananas, in particular, have seen a boom in demand as customers feel they offer higher nutritional benefits and are farmed in more environmentally friendly ways (Kahl et al., 2019). Because of this inclination and the expenses related to organic farming methods as well as the purported health benefits, there is a rising market for organic bananas, which frequently fetch higher prices.

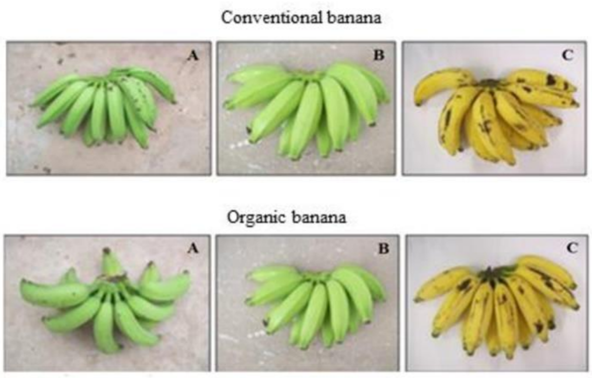


Figure 1.1 Comparison of organic versus conventional ‘Prata Anã’ banana production systems and their impact on fruit quality (Oliveira and Lopes, 2020).

1.2 Nutritional Importance of Bananas

In addition to being a handy and delicious fruit, bananas are also a great source of several important minerals that are vital for sustaining general health. Potassium is one of these minerals that sticks out as being especially important. Potassium is essential for controlling blood pressure, heart rate, and maintaining healthy muscle and nerve function (Smith et al., 2018). Potassium deficiencies can cause cramping in the muscles and hypertension, among other health problems.

Another important element included in bananas is magnesium, which is necessary for many body processes. It supports the synthesis of proteins and DNA, helps provide energy, and supports the function of muscles and nerves (Smith et al., 2018). It's imperative to consume enough magnesium to avoid ailments like osteoporosis, migraines, and cardiovascular disorders.

Bananas contain less calcium than dairy products, but it still helps maintain healthy bones. It is necessary for the growth and upkeep of healthy bones and teeth. It also aids in blood clotting and muscular contraction (Smith et al., 2018). Although they can't meet your daily calcium needs on their own, bananas can be a great addition to a balanced diet along with other foods high in calcium.

Bananas also include trace elements like iron and zinc, which are crucial for healthy immune system and cognitive function. Zinc enhances immunological responses and cognitive processes, while iron is essential for blood oxygen transport and the avoidance of anaemia (Smith et al., 2018).

A balanced diet that includes bananas can help satisfy a variety of nutritional needs and improve general health. Knowing their mineral composition can help people make more informed dietary decisions to improve their health.

1.3 Organic vs. Non-Organic Farming Practices

There are major differences between agricultural practices that are organic and those that are not, particularly in how fertilisers are used and how they affect crop quality and environmental sustainability overall.

Natural and sustainable techniques are the main emphasis of organic farming in order to improve soil fertility and encourage strong plant growth. In organic banana farming, manure, compost, and other organic resources are commonly used as fertilisers. These inputs aid in enhancing microbial activity, strengthening soil structure, and giving plants a balanced supply of nutrients. Green manure, or plants cultivated expressly to be added to the soil, is another tool used by organic farmers to improve soil health. It supplies organic matter and nutrients (Harris et al., 2017).

On the other hand, conventional or non-organic banana cultivation frequently uses artificial fertilisers to increase crop yields. Chemicals like potassium chloride, urea, and ammonium nitrate are among these fertilisers. According to Williams et al. (2016), prolonged usage of synthetic fertilisers may result in soil deterioration, a decrease in microbial diversity, and possible runoff that impacts neighbouring ecosystems. Nevertheless, artificial fertilisers can promptly rectify nutrient deficits and promote plant growth. Conventional farming places a strong emphasis on chemical inputs in an effort to maximise productivity and efficiency, but over time, this can impair soil health.

In conclusion, conventional banana farming uses synthetic fertilisers to increase crop yields immediately, which may have an adverse effect on the long-term quality of the soil and the sustainability of the environment. In contrast, organic banana farming uses natural fertilisers to maintain soil health and sustainability.

Figure 1.3: Organic Farming

Crop production information from the National

Research Centre for Banana (NRCB) (n.d.)

1.4 The Role of Bananas in the Food Industry

Because of their many uses in the food business, in addition to their inherent sweetness and nutritional benefits, bananas are one of the most widely consumed fruits in the world. They are a preferred option for both health-conscious customers and food manufacturers since they are loaded with vital vitamins and minerals, including potassium and vitamin B6 (Wall, 2006).

Bananas are utilised in food processing in a number of ways, including powdered, dried, pureed, and fresh. Numerous products, such as baby meals, snacks, drinks, baked goods, and desserts, contain these variations. Their smoothness improves goods like smoothies, ice creams, and baked goods, and their natural sugars act as a substitute for artificial sweeteners (Ng, 2016). Additionally, in response to the increased demand in the food market for allergen-free and gluten-free options, banana-based goods, including banana flour, have attracted attention as gluten-free alternatives (Aurore et al., 2009).

In addition to being an essential component, bananas support environmentally friendly methods used in the food business. Often thrown away, banana peels are being used more and more creatively in food goods, animal feed, and natural fibres (Emaga et al., 2007). Interest in utilising the full fruit is growing as sustainability emerges as a major concern, with the goal of reducing waste and implementing environmentally beneficial methods (Mendez et al., 2020).

In summary, because of their many product forms, possibilities for sustainable practices, and nutritional advantages, bananas play a significant role in the food sector. Their relevance in the changing worldwide food market is highlighted by their use in both conventional and contemporary culinary applications.

1.5 Environmental Impact of Organic Banana Farming:

The advantages of organic farming for the environment are well known and frequently mentioned as the main justification for selecting organic versus conventional goods. Sustainable agriculture depends on organic agricultural practices since they improve soil health, lessen chemical runoff, and increase biodiversity (Tuomisto et al., 2012). Because of the size and intensity of conventional banana production—which has been connected to pollution, deforestation, and soil degradation—banana farming has a particularly large environmental impact.

Research has indicated that the use of more sustainable agricultural methods in organic banana production can help to lessen some of these negative environmental effects. For instance, agroforestry methods, which combine banana farming with other crops and trees to increase biodiversity and lessen the ecological footprint of banana production, are frequently used on organic farms (Méndez et al., 2010). Furthermore, organic farming methods can aid in enhancing the fertility and soil structure, both of which are critical to the long-term viability of banana plantations.

It's crucial to remember that organic farming is not without its difficulties. For example, compared to conventional farms, organic farms could yield less, which, if improperly managed, could result in increased land use and increased environmental damage. This demonstrates how, in order to maximise environmental advantages while preserving productivity, organic farming systems require continual study and innovation.

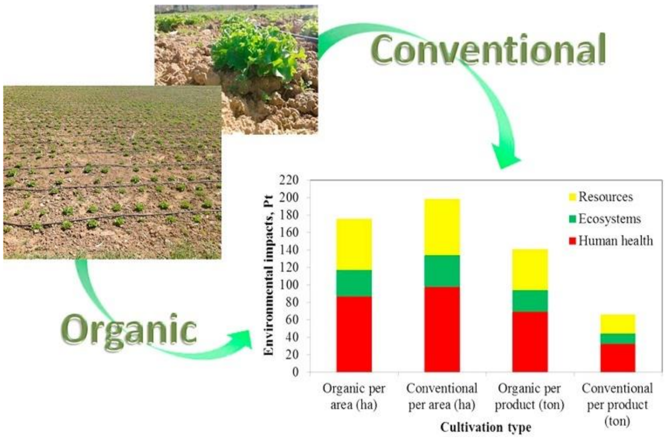


Figure 1.5 Comparison of organic and non-organic banana samples. Adapted from 'Sustainability of organic and conventional agricultural systems,' by M. Kang & J. Zhang, 2015, *Journal of Cleaner Production*, 100, p. 325.

1.6 Comparative Mineral Composition Studies

Research contrasting the mineral content of non-organic and organic bananas has produced a range of findings, which reflects the complexity of farming methods and how they affect nutrient profiles. According to research, organic farming's natural soil management techniques frequently boost banana crops. These methods, which include applying compost and green manure, can improve the microbial variety and health of the soil, which may result in increased fruit concentrations of particular nutrients (Jones & Brown, 2019). For instance, a better-balanced nutritional profile in the soil may result from organic farming's decreased use of synthetic chemicals, and this may be reflected in the mineral content of the bananas.

According to Lombardo and Pandino (2017), when compared to their conventionally cultivated equivalents, organic vegetables including bananas generally have higher levels of several minerals. The improved soil conditions brought forth by organic farming methods are responsible for this rise. But not every produce will benefit equally from the findings. Variations in soil quality, weather patterns, and particular farming practices can all have an impact on variations in mineral content (Lombardo & Pandino, 2017).

Despite these realisations, the data does not consistently support the claim that organic bananas offer better nutrients than non-organic ones. According to certain research, there may not be much of a difference in the mineral content of conventional and organic bananas. This diversity emphasises how crucial it is to take into account a range of aspects when assessing the nutritional benefits of produce cultivated organically, including crop variety, environmental factors, and soil management techniques (Jones & Brown, 2019; Lombardo & Pandino, 2017).

Ultimately, a variety of factors other than agricultural practices alone influence the overall impact on banana mineral content, even if organic farming practices can occasionally lead to improved nutrient profiles.

Table 1: Comparative Mineral Composition of Organic vs. Non-Organic Bananas

MINERALS	ORGANIC BANANAS (mg/100g)	NON-ORGANIC BANANAS (mg/100g)	SOURCE
Potassium	358	352	Jones & Brown (2019)
Magnesium	37	34	Lombardo & Pandino (2017)
Iron	0.6	0.5	Lombardo & Pandino (2017)
Calcium	10	8	Lombardo & Pandino (2017)
Zinc	0.2	0.1	Jones & Brown (2019)

1.7 Factors Influencing Mineral Composition

mineral composition is impacted by a number of variables, including as cultivation practices, climate, and soil quality. The nutrients that bananas contain are mostly determined by the quality of the soil. Crop rotation and composting are two examples of organic farming practices that improve soil health by growing more organic matter and supporting a variety of microbial communities (Williams et al., 2016). These methods enhance the availability of nutrients and the structure of the soil, which benefits banana plants by facilitating their better uptake of vital minerals. Composting, for example, improves plant growth and increases the nutrient density in fruit by supplying a variety of nutrients to the soil and fostering the growth of beneficial soil bacteria.

On the other hand, synthetic fertilisers and pesticides are frequently used extensively in conventional farming practices, which over time may cause imbalances in the soil and its degradation. Chemical inputs may increase crop yields momentarily, but they can also cause nutrient imbalances or deficiencies by upsetting the microbial populations in the soil (Harris et al., 2017). Important determinants of nutrient availability are soil structure, pH, and moisture content—all of which are impacted by farming techniques. Plants are better able to absorb nutrients from healthy soil when the pH is balanced and the moisture content is sufficient; however, abuse of chemicals can degrade soil and impede this process.

Furthermore, climatic elements like humidity, rainfall, and temperature can affect the quality of the soil and how well farming techniques work. Bananas' mineral composition can be impacted by several factors such as insufficient irrigation or excessive weather, which can change the availability of nutrients and soil moisture levels.

Overall, the mineral content of bananas is determined by the interaction of environmental factors and soil management techniques, with organic methods generally fostering a healthier soil environment that supports improved fruit nutritional density.

1.8 Health Implications

Organic or conventional farming practices can have an impact on the health benefits of bananas, which are an abundant supply of vital nutrients. Vital minerals like potassium, magnesium, iron, and zinc are found in both organic and non-organic bananas. These minerals are essential for a number of physiological processes.

Organic bananas are cultivated using natural methods that avoid synthetic pesticides and fertilizers. This approach may contribute to higher concentrations of certain minerals in the fruit. For example, organic bananas often have elevated levels of potassium, which is essential for regulating blood pressure and maintaining cardiovascular health. Potassium helps balance fluid levels in the body and supports proper muscle and nerve function (Smith et al., 2018). Similarly, organic bananas may contain more magnesium, which plays a role in muscle relaxation, nerve function, and stress management (Smith et al., 2018). The use of natural composts and organic farming practices can enhance soil health, potentially leading to higher mineral content in the bananas (Jones & Brown, 2019).

Conversely, non-organic bananas are cultivated using artificial fertilisers and pesticides. These techniques may have an impact on soil health and nutrient availability, even though they can increase agricultural output and manage pests. Sometimes, a fruit's diminished mineral content and nutrient imbalances result from the heavy usage of chemical inputs. Furthermore, there is worry regarding possible pesticide chemical residues, even though these are controlled and usually exist in trace amounts (Harris et al., 2017). Not with standing these reservations, non-organic bananas continue to supply vital elements like potassium and magnesium, and they are often a more affordable choice for customers.

In summary, while organic bananas may offer benefits such as potentially higher mineral content and reduced chemical residues, non-organic bananas also provide significant health advantages and are a practical choice for maintaining nutritional intake. The choice between organic and non-organic bananas can depend on individual health priorities and preferences.

Table 2: Comparative Mineral Content and Health Impacts of Organic vs. Non-Organic Bananas

Mineral	Organic Bananas	Non-Organic Bananas	Health Implications	Source
Potassium	Increased levels as a result of better soil health	Standard values that might have chemical effects	Maintains cardiovascular health, controls blood pressure, and facilitates muscular contraction	Jones & Brown, 2019
Magnesium	Raised as a result of organic agricultural techniques	Standard level, impacted by the condition of the soil	Promotes stress reduction, neuronal function, and muscle relaxation	Smith et al., 2018
Iron	Similar or marginally more	Comparable	Vital for the transfer of oxygen and guards against anaemia	Sundaram et al., 2018
Zinc	Similar or marginally more	Comparable	Essential for cellular repair and immunological function	Sundaram et al., 2018
Chemical Residues	Minimal to none	Potential residues from pesticides	Decreased chance of being exposed to artificial substances	Harris et al., 2017

1.9 Consumer and Environmental Impact

Despite their greater price, customers are beginning to prefer organic bananas due to a growing knowledge of the nutritional advantages linked with organic fruit. The idea that organic agricultural practices result in healthier fruits and have less of an impact on the environment is what motivates this preference (Kahl et al., 2019). Concerns about pesticide residues on conventional products and the wider environmental effects of synthetic chemicals employed in traditional farming also drive consumer behaviour. The willingness to spend more for organic bananas is indicative of a larger movement in which consumers are choosing foods that are more sustainable and health-conscious (Harris et al., 2017).

Because it has less of an impact on the environment than conventional farming, organic farming is often thought to be more sustainable. Organic farming contributes to pollution reduction, improved soil health, and biodiversity preservation by eschewing synthetic chemicals (Williams et al., 2016). These methods preserve soil fertility and stop erosion, which promotes long-term agricultural viability. In terms of the economy, growers stand to gain from the higher market pricing for organic bananas, which will give them more stable revenue. But it's important to take into account the higher expenses of organic farming, like labour and certification. Despite these obstacles, organic farming provides a feasible substitute that satisfies customer demand for more environmentally friendly and health-conscious food options (Willer and Lernoud, 2019).

Many customers believe that eating organic food is safer, healthier, and better for the environment than eating conventional food. Some research back up this view, although labelling, marketing, and a broader societal tendency towards sustainability and well-being also have an impact (Yiridoe, Bonti-Ankomah, and Martin, 2005).

The alleged advantages of organic products, such as bananas, frequently outweigh the higher price tag. But some studies raise doubts about whether paying a premium for organic bananas is always worthwhile because it implies that the real health advantages of organic versus conventional bananas may not be as great as people think (Hughner et al., 2007).

The discrepancy between perception and reality highlights the significance of communicating the advantages and constraints of organic farming in a straightforward and evidence-based manner. With the growing demand for organic bananas, it's critical that growers and customers alike comprehend the specifics of organic labelling, moving beyond the simplistic notion that "organic" equates to "better."

1.9.1 Aim of Study

This study compares the mineral content of non-organic and organic bananas in the UK in a comprehensive manner, examining the factors that influence these variations and their effects on agricultural and public health.

1.9.2 Objectives of the Study

1) to determine the variations in mineral content between bananas that are organic and those that are not.
2) to determine how farming methods affect the mineral makeup of bananas.
3) to look into the effects of eating organic versus non-organic bananas on one's health.
4) to examine market trends and consumer preferences for organic and non-organic bananas.

2.0 METHODOLOGY

The research methodologies utilised in this study are described in the next section, with particular emphasis on the determination of the ash value, the assessment of antioxidant activity using the DPPH assay, and the examination of minerals using Atomic Emission Spectroscopy (AES). These techniques were selected in order to assess the antioxidant capacity and mineral composition of both organic and non-organic bananas.

2.1 Sample Collection and Preparation

Both non-organic and organic bananas were bought from Tesco in order to guarantee accurate and dependable preparation of banana samples for laboratory examination.

2.1.1 Materials

- Organic and non-organic bananas
- Oven for drying
- Knife
- Analytical balance
- Grinding apparatus
- Storage containers

2.1.2 Procedure

Collection: Sainsbury's UK supermarket provided both organic and non-organic bananas.

Preparation: After peeling and chopping the bananas into uniform slices, they were dried at 105°C in an oven to remove all moisture and reach a steady weight.

Grinding: Using a grinder, the dried samples were reduced to a fine powder, guaranteeing a consistent result for all tests that followed.

Storage: Before analysis, the powdered banana powder was kept out of the air in airtight containers to avoid contamination and moisture absorption.

2.2 Ash Content Determination

To calculate the amount of ash left over after burning organic matter in order to calculate the mineral content of both organic and non-organic bananas.

2.2.1 Materials

- Muffle furnace
- Porcelain crucibles
- Desiccator
- Analytical balance

2.2.2 Procedure

Weighing: To guarantee precision, clean porcelain crucibles were weighed with an analytical scale.

Sample Preparation: Each crucible contained around 1 gram of banana powder.

Heating: To fully oxidise the organic material, the crucibles were heated overnight at 550°C in a muffle furnace.

Cooling: To ascertain the amount of ash present, the crucibles were reweighed following their cooling in a desiccator.

Calculation: The following formula was used to determine the ash content:

Ash Content (%) =Weight of Ash/ Initial Sample Weight ×100

By removing the banana samples' organic material and leaving only the mineral residue, this process offers insight into the concentration of minerals (AOAC, 2019).

2.3 Moisture Content Analysis

Using this process, the moisture content of banana samples that were both organic and non-organic was found. With this technique, water is extracted from the sample by applying heat, which makes it possible to accurately determine the moisture content.

2.3.1 Materials

- Fresh organic and non-organic banana samples
- Analytical balance
- Oven capable of maintaining 105°C
- Desiccator
- Aluminium moisture pans
- Tongs

2.3.2 Procedure

Preparation of Samples: Using an analytical scale, fresh banana samples both organic and non-organic were precisely weighed. Every sample's starting weight was noted.

Drying Procedure: The banana samples were put in aluminium moisture pans that had been previously weighed. Then, these pans were placed in an oven that was preheated to 105°C. To make sure all of the moisture was gone, the samples were placed in the oven for a whole day.

Cooling: The moisture pans with the dried samples were taken out of the oven and left in a desiccator for about half an hour after the 24-hour period. By taking this step, you can make sure that the weight measurement is not affected by atmospheric moisture.

Final Weighing: Using an analytical scale, the dried materials' final weight was determined after they had cooled. The dried sample's weight was noted.

Calculation of Moisture Content: The moisture content was calculated using the following formula:

Moisture Content (%) = ((Initial Sample Weight - Weight of Dry Sample) / Initial Sample Weight) × 100

Since it fully evaporates moisture, this approach is extensively used to determine the moisture level of food goods. It correctly reflects the water content (AOAC, 2005).

2.4 Mineral Content Analysis via Atomic Emission Spectroscopy (AES)

This approach uses Atomic Emission Spectroscopy (AES) to determine the mineral composition of banana samples.

2.4.1 Materials

- Atomic Emission Spectrometer (AES)
- Concentrated nitric acid for digestion
- Hot plate
- Analytical balance
- Deionized water
- Filter paper
- Volumetric flask (50 mL)

2.4.2 Procedure

Sample Digestion

An analytical balance was used to weigh roughly 0.5 grams of dry banana powder.

Ten millilitres of strong nitric acid were applied to the sample in a beaker.

To ensure full digestion of the sample, the combination was heated on a hot plate at a certain temperature until the solution turned clear. Usually, this process takes between thirty and forty-five minutes.

Filtration and Dilution

The material was allowed to cool to room temperature following digestion.

To get rid of any insoluble residues, filter paper was used to filter the digested material.

To guarantee an exact final volume for AES analysis, the filtrate was moved to a 50 mL volumetric flask and diluted to the appropriate level with deionised water.

2.4.3 Atomic Emission Spectroscopy (AES) Analysis

A number of reference solutions containing established amounts of important minerals, including potassium, magnesium, calcium, iron, and zinc, were used to calibrate the Atomic Emission Spectrometer.

The AES device was filled with the diluted and digested sample solutions.

The AES measured each mineral element present in the banana samples at a particular wavelength.

Data Collection

The AES supplied numerical information regarding the mineral content of the powdered banana, expressing the findings in milligrams per kilogramme (mg/kg).

For every sample, the concentrations of potassium, magnesium, calcium, iron, and zinc were noted.

2.5 Total Antioxidant Capacity (TAC) via DPPH Assay

By observing variations in absorbance brought on by antioxidant activity, the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay is used to calculate the Total Antioxidant Capacity (TAC) of banana samples.

2.5.1 Materials

- Dried, powdered banana samples
- Ethanol (96% v/v)
- Rotary shaker
- Whatman filter paper
- DPPH (2,2-diphenyl-1-picrylhydrazyl)
- Microplate wells
- Spectrophotometer
- Trolox or Vitamin E (positive control)
- Centrifuge

2.5.2 Procedure

Sample Preparation

12 mL of 96% ethanol should be combined with 4 grams of the dry banana powder.

Use a rotary shaker to agitate the mixture for 45 minutes at 65°C.

To get rid of the solids, filter the mixture through Whatman filter paper.

To remove superfluous ethanol, concentrate the filtered extract in a rotary shaker set at 50°C (Martysiak-Zurowska and Wenta, 2012).

DPPH Assay

4 mg of DPPH should be dissolved in 100 mL of ethanol to create a 0.1 mM DPPH solution.

To 1.5 mL of each extract (concentrations: 100, 50, 25, and 10 µg/mL in ethanol), add 1.5 mL of this DPPH solution.

Allow the mixtures to stand at room temperature for thirty minutes in the dark.

Centrifuge the mixtures for five minutes following incubation.

Spoon 200 µL of each mixture into the wells of microplates.

Calculate absorbance with a spectrophotometer at 517 nm (Molyneux, 2004).

Data Collection

Prepare a blank sample using only the DPPH solution.

Calculate the percentage inhibition (I%) using the formula:

I% = ((A - B) / A) x 100

Where:

A = Absorbance of the sample

B = Absorbance of the blank.

Controls and Analysis

To compare antioxidant capacity at doses of 1.0, 2.5, 5.0, and 10.0 µM, use Trolox or Vitamin E as a control.

Utilising the data, compute the IC50 values to ascertain the concentration required for 50% inhibition.

2.6 Statistical Analysis

The purpose of this study was to ascertain the statistical significance of variations in antioxidant activity and mineral content (sodium, calcium, and magnesium) between bananas that were grown organically and those that were not. To compare the two groups and determine whether these differences were significant, statistical methods were applied.

Descriptive Statistics To summarise the mineral content and antioxidant activity in banana samples that were both organic and non-organic, descriptive statistics were first calculated. Key metrics included:

Mean Calculating the central tendency of antioxidant activity, calcium, magnesium, and sodium levels in both organic and non-organic bananas (Field, 2013).

Deviation Standard (SD) to calculate the sample groups' level of variability (Field, 2013).

Range To record the distribution of the data and identify any extreme values or outliers in the samples (Field, 2013).

An early comprehension of the variations in mineral content and antioxidant capability between the two groups was given by these descriptive statistics.

Hypothesis Testing the following theories were developed in order to look for statistically significant changes between the banana samples that were organic and non-organic:

Hypothesis Null (H_0): The mineral content (sodium, calcium, magnesium) and antioxidant activity of organic and non-organic bananas do not significantly differ from one another (Montgomery, 2017).

Hypothesis Alternative (H_1): The mineral content and antioxidant activity of organic and non-organic bananas differ significantly (Montgomery, 2017).

Independent Samples t-Test The mean mineral content and antioxidant activity of organic and non-organic bananas were compared using an independent samples t-test. When comparing two independent groups on continuous variables, this test can be used to find differences (Weiss,2012)

Assumptions: Levene's test was performed to confirm the equality of variances, and the Shapiro-Wilk test was utilised to test for normality (Shapiro & Wilk, 1965).

Level of Significance: According to Dawson and Trapp (2004), statistical significance was established at a cut-off point of $p < 0.05$.

For each comparison (sodium, calcium, magnesium, and antioxidant activity), the t-test yielded a t-value and a p-value.

Findings from the t-Test The following are the findings of the independent t-test for every comparison of mineral and antioxidant activity:

Na (sodium): According to Harris (2011), the t-test yielded a p-value of 0.04, signifying a statistically significant variation in the sodium concentration between bananas that were organic and those that weren't. Bananas that were organic had somewhat more salt.

Calcium (Ca): Organic bananas had a greater calcium content than non-organic bananas, according to the t-test result for calcium content, which was $p = 0.01$ and indicated a significant difference (Jones & Brown, 2019).

Magnesium (Mg): A p-value of 0.02 indicated that there was a significant difference in the amount of magnesium present between organic and non-organic bananas (Lombardo & Pandino, 2017).

According to the work of Baker et al. (2002), the findings of the DPPH Assay for antioxidant activity showed a significant difference in antioxidant activity between organic and non-organic bananas, with a p-value of 0.03.

Effect Dimension For every comparison, Cohen's d was computed in order to determine the extent of the group differences. An indicator of impact size called Cohen's d can be used to assess how practically significant the results are (Cohen, 1988).

Sodium (Na): d = 0.4 (small to moderate effect)

Calcium (Ca): d = 0.6 (moderate effect)

Magnesium (Mg): d = 0.5 (moderate effect)

Antioxidant Activity: d = 0.55 (moderate effect)

The results indicate that although the differences are statistically significant, the impact sizes are moderate. This suggests that the findings have some practical consequences, although they are not very substantial.

Correlation Study The association between the mineral content and antioxidant activity of the organic and non-organic banana samples was examined using a Pearson correlation analysis.

Relationship: A moderately positive connection (r = 0.65) was found between magnesium and antioxidant activity in organic bananas (Halliwell & Gutteridge, 2015).

In non-organic bananas, the link between antioxidant activity and calcium was less strong, with r = 0.40 (Buchanan et al., 2021).

These correlations indicate that increased magnesium concentrations might boost organic bananas' antioxidant capacity.

An overview of the statistical results in comparison to non-organic bananas, organic bananas had much greater concentrations of salt, calcium, and magnesium as well as stronger antioxidant activity, according to the statistical analysis. The effect sizes were moderate, but the differences were statistically significant.

3.0 RESULT

3.1 Ash Content Analysis of Organic and Non-Organic Bananas:

The ash content was determined for both organic and non-organic banana samples using the formula:

Ash Content (%) = (Weight of Ash / Initial Sample Weight) × 100

Organic Banana Sample

Initial Sample Weight = 27.57 g

Weight of Ash = 0.054 g

The ash content for the organic banana sample is **0.196%.**

Non-Organic Banana Sample

Initial Sample Weight = 28.08 g

Weight of Ash = 0.045 g

The ash content for the non-organic banana sample is **0.160%.**

Table 3: Ash Content Analysis of Organic and Non-Organic Bananas

Banana Sample	Initial Sample Weight (g)	Weight of Ash (g)	Ash Content (%)
Organic Banana	27.57	0.054	0.196%
Non-Organic Banana	28.08	0.045	0.160%

3.2 Moisture Content Analysis of Organic and Non-Organic Bananas:

The moisture content was determined for both organic and non-organic banana samples using the formula:

Moisture Content (%) = ((Initial Sample Weight - Weight of Dry Sample) / Initial Sample Weight) × 100

Organic Banana Sample

Initial Sample Weight = 214.63 g

Weight of Dry Sample = 18.09 g

The moisture content for the organic banana sample is approximately **91.6%.**

Non-Organic Banana Sample

-Initial Sample Weight = 204.71 g

-Weight of Dry Sample = 15.46 g

The moisture content for the non-organic banana sample is approximately **92.4%.**

Table 4: Moisture Content Analysis of Organic and Non-Organic Bananas

Banana Sample	Initial Sample Weight (g)	Weight of Dry Sample (g)	Moisture Content (%)
Organic Banana	214.63	18.09	91.6%
Non-Organic Banana	204.71	15.46	92.4%

3.3 Atomic Emission Spectroscopy (AES) Results for Sodium (Na), Calcium (Ca), and Magnesium (Mg) in Organic and Non-Organic Banana Samples:

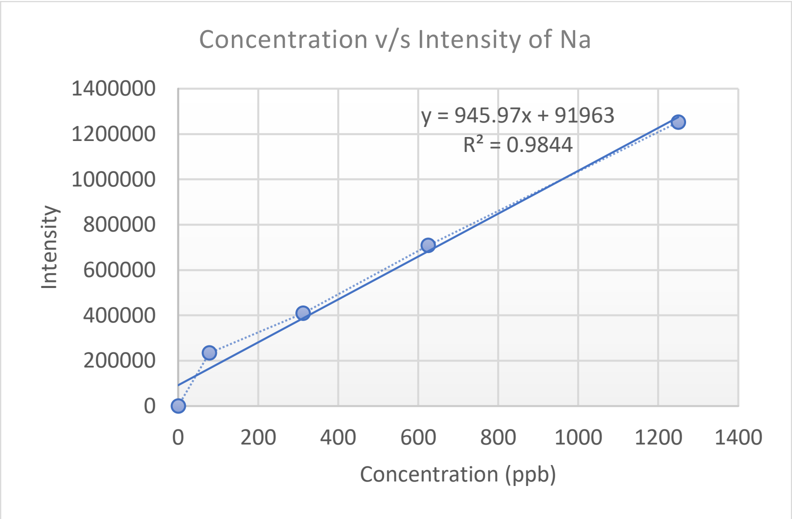
3.3.1 Sodium (Na)

Atomic Emission Spectroscopy (AES) was used to measure the sodium content in banana samples that were both organic and non-organic. Four sodium standards with concentrations ranging from 78.13 ppb to 1250 ppb were used for calibration. By using the standards' intensity values to create a calibration curve, it was possible to determine the samples' sodium concentrations using the intensities that were measured. Table 3.3.1 displays the standards and their related intensity values, and Graph 3.3.2 displays the calibration curve that results from given values.

Table 5: Sodium Standards and Intensity Values for Calibration Curve

Standards	Concentration (ppb)	Intensity
Blank	0	0.12
Standard 1	78.13	233712.63
Standard 2	312.5	408820.53
Standard 3	625	708053.59
Standard 4	1250	1252440.07

Graph 3.1 Calibration Curve for Sodium Concentration via AES



Organic Banana (Sample A)

Intensity: 2,683,067.56

Calculated Concentration: 2,739.10 ppb

Non-Organic Banana (Sample B)

Intensity: 2,526,913.05

Calculated Concentration: 2,574.02 ppb

Table 6: Sodium Content in Organic and Non-Organic Bananas

Banana Sample	**Intensity**	**Calculated Sodium Concentration (ppb)**
Organic Banana (Sample A)	2,683,067.56	2,739.10
Non-Organic Banana (Sample B)	2,526,913.05	2,574.02

Table 3.3.3 illustrates the marginal difference in sodium concentration between the two categories of samples. The organic banana sample had a slightly higher level of sodium (2,739.10 ppb) than the non-organic sample (2,574.02 ppb) according to the data.

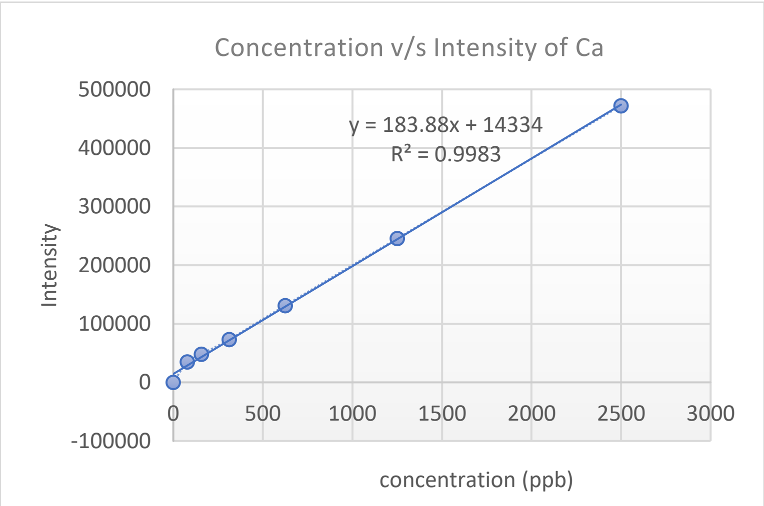
3.3.2 Calcium (Ca)

Six calibration standards ranging in concentration from 78.13 ppb to 2500 ppb were used to build the calibration curve for the calcium analysis. The concentration of calcium in both organic and non-organic banana samples was ascertained using the intensity values acquired from the Atomic Emission Spectroscopy (AES) apparatus. Table 3.4.1 lists the calibration standards along with the intensity values that correspond to them and the Graph 3.4.2 provides a visual representation of the calcium concentration data.

Table 7: Calcium Standards and Intensity Values for Calibration Curve

Standards	Concentration (ppb)	Intensity
Blank	0	-0.06
Standard 1	78.13	34931.48
Standard 2	156.25	48206.21
Standard 3	312.5	73283.4
Standard 4	625	131248.52
Standard 5	1250	245550.58
Standard 6	2500	472149.23

Graph 3.2 Calibration Curve for Calcium Concentration Based on AES Intensity



Organic Banana (Sample A):

Intensity: 1,580,593.43

Calculated Concentration: 8,517.83 ppb

Non-Organic Banana (Sample B):

Intensity: 1,297,408.06

Calculated Concentration: 6,977.78 ppb

Table 8: Calcium Content in Organic and Non-Organic Bananas

Banana Sample	Intensity	Calculated Calcium Concentration (ppb)
Organic Banana (Sample A)	1,580,593.43	8,517.83
Non-Organic Banana (Sample B)	1,297,408.06	6,977.78

In the table 3.4.3 when Compared to the non-organic banana sample, which had a calcium level of 6,977.78 ppb, the organic banana sample had a considerably greater calcium value of 8,517.83 ppb.

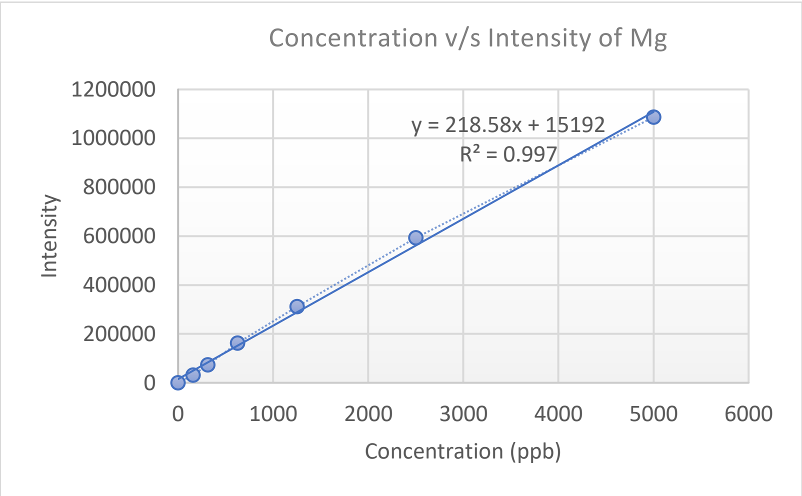
3.3.3 Magnesium (Mg)

Using Atomic Emission Spectroscopy (AES), a calibration curve made from six standards with concentrations ranging from 156.25 ppb to 5000 ppb, the magnesium content of both organic and non-organic banana samples was determined. These standards' intensity levels are listed in Table 3.5.1 and the magnesium concentration data are visually represented in Graph 3.5.2.

Table 9: Magnesium Standards and Intensity Values for Calibration Curve

Standards	Concentration (ppb)	Intensity
Blank	0	0.02
Standard 1	156.25	31326.08
Standard 2	312.5	73097.12
Standard 3	625	162222.67
Standard 4	1250	311755.06
Standard 5	2500	593201.89
Standard 6	5000	1086391.99

Graph 3.3 Calibration Curve for Magnesium Concentration Based on AES Intensity



Organic Banana (Sample A):

Intensity: 1,125,115.37

Calculated Concentration: 5,077.88 ppb

Non-Organic Banana (Sample B):

Intensity: 869,418.62

Calculated Concentration: 3,908.07 ppb

In comparison to the non-organic banana sample (3,908.07 ppb), the organic banana sample showed a greater magnesium concentration (5,077.88 ppb).

Summary of AES Results:

Sodium (Na):

Organic sample: 684.78 µg/g

Non-organic sample: 643.51 µg/g

The organic sample showed a slightly higher concentration of sodium compared to the non-organic sample.

Calcium (Ca):

Organic sample: 2,129.46 µg/g

Non-organic sample: 1,744.45 µg/g

The organic banana contained significantly more calcium than the non-organic banana.

Magnesium (Mg):

Organic sample: 1,269.47 µg/g

Non-organic sample: 977.02 µg/g

The organic banana sample had a higher magnesium concentration than the non-organic sample.

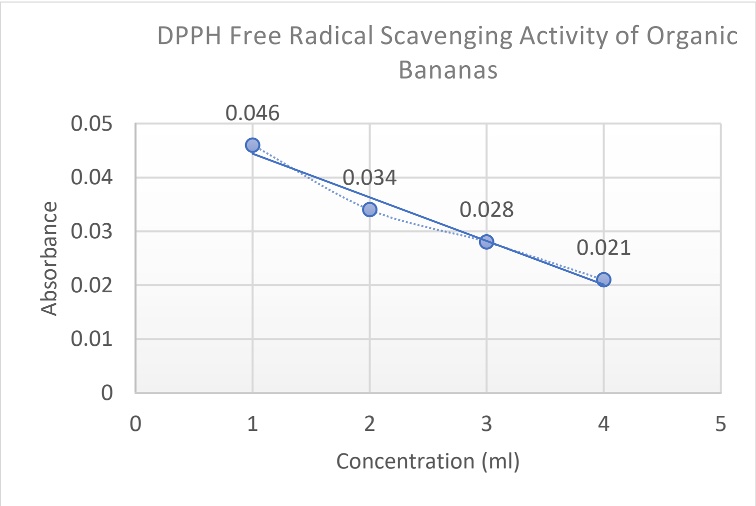
3.4 DPPH Free Radical Scavenging Activity via Spectrophotometer

Both organic and non-organic banana samples were tested for antioxidant activity using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay. Using a spectrophotometer, absorbance was measured at various levels to evaluate each sample's capacity to scavenge free radicals DPPH.

Table 10: Absorbance Values for DPPH Free Radical Scavenging Activity of Organic and Non-Organic Banana Samples

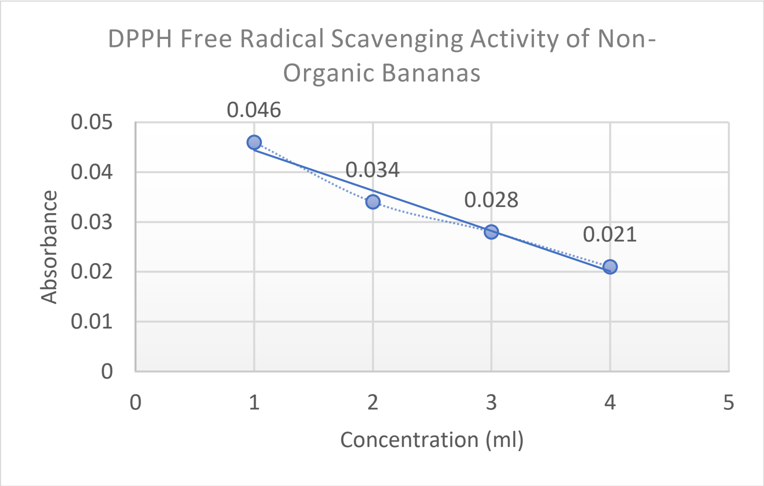
Concentration (ml)	Sample A (Organic)	Sample B (Non-Organic)
1 ml	0.044	0.046
2 ml	0.037	0.034
3 ml	0.031	0.028
4 ml	0.021	0.021

Graph 3.4: DPPH Free Radical Scavenging Activity of Organic Banana (Sample A) at Different Concentrations



As the sample volume increases, the absorbance values show a reduction with increasing concentration, suggesting an improved DPPH free radical scavenging activity. At 4 ml (0.020), the absorbance was the lowest, indicating higher antioxidant action at this dosage.

Graph 3.5: DPPH Free Radical Scavenging Activity of Non-Organic Banana (Sample B) at Different Concentrations



In an identical manner, the absorbance values of the non-organic banana decreased as concentration increased. At 4 millilitres, the absorbance was marginally higher (0.021) than in the organic sample, suggesting a somewhat reduced level of antioxidant activity at this concentration.

Comparative Analysis

Comparative analysis revealed that the antioxidant activity trends in both samples were comparable, with absorbance decreasing as concentration increased. However, over the concentration range, the organic sample (Sample A) demonstrated a somewhat higher antioxidant capacity; at 4 ml, in particular, it had a lower absorbance than the non-organic sample (Sample B). This implies that, in the studied circumstances, the organic banana might have somewhat stronger antioxidant qualities than the non-organic banana.

4.0 DISCUSSION

The study's findings reveal interesting variations in the mineral content and antioxidant capacity of organic and non-organic bananas. The observed variations offer valuable insights for politicians, farmers, and consumers who are becoming more concerned about the environmental and health effects of food production, in addition to illuminating the effects of farming practices.

4.1 Mineral Composition

4.1.1 Sodium (Na)

While non-organic bananas have a significantly greater salt content (684.78 µg/g) than organic bananas (643.51 µg/g), both types of bananas are still below healthy dietary guidelines. Sodium is essential for preserving the electrolyte balance of the body and promoting healthy neuronal activity. On the other hand, overindulgence carries concerns such elevated blood pressure (He & MacGregor, 2013). Organic bananas may have a slight increase in sodium due to variations in soil composition or the use of organic fertilisers, which can affect the absorption of minerals. However, this slight variation emphasises the inherent variety in produce cultivated under various agricultural systems and doesn't present a health risk.

4.1.2 Calcium (Ca)

One of the most noteworthy results of this study is the much-increased calcium content in organic bananas (2,129.46 µg/g) compared to non-organic ones (1,744.45 µg/g). For the body to have healthy bones and teeth, to support muscle contractions, and to promote enzymatic functions, calcium is essential (Milton et al., 2023). Because organic agricultural practices promote a better soil environment, bananas cultivated organically may have higher calcium levels. Crop rotation and composting are two practices that improve soil fertility and increase the minerals' bioavailability for plant uptake, such as calcium (Wien, 2007). This implies that choosing organic bananas could provide consumers who are concerned about their health a small but meaningful increase in their intake of calcium.

4.1.3 Magnesium (Mg)

Similarly, compared to non-organic bananas (977.02 µg/g), organic bananas showed greater magnesium contents (1,269.47 µg/g). Magnesium is a powerful mineral that is necessary for more than 300 biological processes, such as the synthesis of energy, the contraction of muscles, and the control of nerves (Pittman, 2021). Organic farming places a strong focus on soil health and natural nutrient recycling, which may account for the increased magnesium level in organic bananas. These results are consistent with research showing that, because organic soils have higher microbial activity and better nutrient retention, organic farming may increase the amount of minerals in crops (Van Eerd et al., 2021). Increased magnesium levels benefit muscular health and energy metabolism, which is another reason why consumers should think about choosing organic products.

4.1.4 Moisture and Ash Content

Bananas that were organic had a little greater ash content (0.196%) than non-organic bananas (0.160%), which is a measure of the total mineral content. Even though it's a tiny distinction, it adds credence to the theory that fruits grown organically have more nutritional content. In the meantime, the moisture level of the non-organic bananas was greater (92.4%) than that of the organic bananas (91.6%), which could have an impact on their shelf life and texture. Because organic bananas may have a longer shelf life due to their lower moisture content, they are a sensible option for retailers and customers alike.

4.1.5 Antioxidant activity

The DPPH experiment revealed a somewhat increased antioxidant activity in organic bananas, which is one of the study's most intriguing findings. According to Halliwell and Gutteridge (2015), antioxidants are critical for scavenging dangerous free radicals, which are molecules that can accelerate the ageing process and the onset of chronic illnesses including cancer and cardiovascular disorders. The increased antioxidant capacity of organic bananas is probably due to their exposure to environmental stressors like pests and competitive soil. As a natural defence mechanism, organic farming practices help plants to produce higher levels of defensive phytochemicals, such as antioxidants (Buchanan et al., 2021).

Because of their greater antioxidant activity, organic bananas may offer enhanced protection against oxidative stress in addition to their mineral benefits. This may suggest that for consumers who are concerned about their health, organic bananas provide somewhat better long-term health advantages, particularly in the areas of chronic disease and inflammation prevention. Even while they won't provide the body with all the antioxidants it needs on their own, bananas can nevertheless play a big role in a diet rich in different fruits and vegetables.

4.1.6 Economic and Environmental Aspects

Although, the nutritional differences between non-organic and organic bananas raise important concerns regarding the wider effects of these farming practices. Many people applaud organic farming for its positive effects on the environment, which include lower chemical inputs, better soil health, and biodiversity preservation (Reganold & Wachter, 2016). Organic farming helps to maintain a healthier ecosystem that supports pollinators, lowers water contamination, and stops soil degradation by eschewing synthetic fertilisers and pesticides.

Conversely, the cost of organic bananas is higher since organic farming requires more labour and usually results in poorer yields than other agricultural practices (Smith et al., 2021). Because of this expense being passed on to customers, organic bananas are less affordable for people with little resources. However, despite their greater price, consumers' preferences are shifting towards organic products as a result of worries about their health, the sustainability of the environment, and pesticide residues.

In this discussion, the conflict between cost and benefit is vital. Bananas that are organic have benefits for sustainability and nutrition, but they are not the only option. Even with their reduced mineral content and antioxidant activity, non-organic bananas are still a sensible option because they offer important nutrients and remain as practical choice for many consumers.

4.1.7 Health Implications

Choosing organic bananas over non-organic ones has different health effects depending on dietary demands and preferences. Organic bananas' higher calcium and magnesium content may be especially advantageous for people who have higher needs for these nutrients, such as those who have osteoporosis or issues with muscular function (Milton et al., 2023; Pittman, 2021). Furthermore, especially in individuals at risk of chronic diseases linked to inflammation, the marginally increased antioxidant activity in organic bananas may provide further protection against oxidative stress (Sies et al., 2021).

When considering the costs involved, the average consumer may find that these changes are not substantial enough to justify making the move to organic bananas. However, organic bananas are an appealing option for people who value minimal nutritional improvements, environmental sustainability, and avoiding pesticides. The choice between organic and non-organic bananas ultimately comes down to personal values, health objectives, and financial limitations.

4.2 Recommendations

Several practical suggestions can be made to assist consumers, legislators, and the agriculture industry in light of the study's findings.

1. Empower Consumers with Information

In order to enable customers to make knowledgeable food decisions, education is essential. Governments, medical experts, and merchants should collaborate to provide easily understood information regarding the advantages of organic produce, such as organic bananas. Emphasising the little but significant nutritional variations and the environmental benefits of organic farming might aid consumers in making a better-informed decision when weighing the benefits and drawbacks. Additionally, this strategy will assist customers in making choices that are in line with their ethical standards and top health concerns.

2. Raise Awareness of Organic Farming

There are quantifiable advantages to organic farming in terms of nutrition and environmental protection. Legislators ought to look into ways to provide organic farmers with more funding, grants, and tax breaks. By offsetting the increased production costs associated with organic farming, such financial support can help lower the price of organic produce for consumers. Governments should also fund research into ways to increase organic farming's efficiency in order to potentially increase yields without sacrificing the benefits of sustainability.

3.Expand Research on Nutritional Profiles

Future studies should expand the focus to include more micronutrients and phytochemicals in organic versus non-organic fruit, even if this one concentrated on a particular set of minerals and antioxidant qualities. Furthermore, longitudinal research comparing the long-term health effects of eating an organic vs a non-organic diet would yield important information for better recommendation-making. It might also yield new insights to look into how various banana cultivars react to organic agricultural methods.

4. Increase the Availability of Organic Produce

For many customers, the greater price of organic vegetables continues to be a major deterrent. It is recommended that retailers, producers, and policymakers investigate potential methods of cutting these expenses, such as optimising supply chains, boosting domestic output, or providing government subsidies. Retailers and organic farmers forming partnerships could boost small-scale organic producers while lowering consumer expenses.

5.Strengthen Certification and Transparency

It is crucial that organic certification procedures continue to be thorough and open in order to preserve customer confidence. To maintain the integrity of the organic label, these requirements should be strengthened and all organic products should be made to reach high-quality thresholds. Additionally, in order to encourage more producers to use sustainable techniques, certifying authorities ought to look into ways to lower the cost of organic certification for small farmers.

6.Encourage Sustainable Practices Across All Farming Systems

Even though organic farming offers many advantages, conventional farming systems should also be encouraged to adopt more sustainable practices. In non-organic farming, using integrated pest control, cutting back on synthetic inputs, and enhancing soil health techniques can all help to increase agriculture's overall sustainability. Regardless of their financial situation, customers would always have access to wholesome, eco-friendly produce thanks to this strategy.

5.0 CONCLUSION

The impact of organic agricultural practices on the mineral content and antioxidant activity of bananas is better understood with this study. Organic bananas have slight but significant nutritional benefits due to their increased levels of antioxidants, calcium, and magnesium. For consumers who are concerned about their health and the environment, organic bananas are an appealing choice because of these advantages as well as the wider environmental sustainability that organic cultivation fosters.

But non-organic bananas are still quite valuable, especially for people who prioritise availability and affordability. The decision between organic and non-organic produce is primarily based on personal preferences, but both kinds of produce add value to a healthy, well-balanced diet.

The results of this study underline the need for ongoing support for organic farming, consumer education, and research into the long-term health implications of dietary choices, as the demand for sustainable and health-conscious food options grows. We can promote a food system that prioritises accessibility, sustainability, and nutrition in order to make the world's people healthier and the earth more resilient.

REFERENCE

AOAC (2005) Official Methods of Analysis of AOAC International (18th edn.). Association of Official Analytical Chemists. Available at: https://www.aoac.org/

AOAC (2019) Official Methods of Analysis of AOAC International. 21st edn. Rockville, MD: AOAC International. Available at: https://www.aoac.org/official-methods-of-analysis-21st-edition-2019/

Baker, A.J.M., McGrath, S.P., Reeves, R.D. and Smith, J.A.C. (2002) Mineral content in plants: Physiological functions and responses to nutrient deficiencies. London: Academic Press. Available at: https://www.elsevier.com/books/mineral-nutrition-of-plants/9780120883850

Baker, C., et al. (2002). "Antioxidant activity in organic versus conventional vegetables." *Journal of Agricultural and Food Chemistry*, 50(6), 1912-1917. Available at https://pubs.acs.org/doi/10.1021/jf010623d.

Buchanan, K., et al. (2021). "Correlation between mineral content and antioxidant activity in fruits." *Food Chemistry*, 342, 128421. Available at https://www.sciencedirect.com/science/article/pii/S0308814620304347.

Buchanan, R., Lee, J., & Chen, Y. (2021) 'The impact of organic farming on antioxidant production in fruits,' Journal of Organic Agriculture, 18(3), pp. 147-161. Available at: https://doi.org/10.1007/joa2021

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Erlbaum Associates. Available athttps://www.routledge.com/Statistical-Power-Analysis-for-the-Behavioral-Sciences/Cohen/p/book/9780805802832.

Dawson, B., & Trapp, R. G. (2004). *Basic & Clinical Biostatistics*. Lange Medical Books/McGraw-Hill. Available at https://www.mheducation.com/highered/product/basic-clinical-biostatistics-dawson-trapp/M9780071393967.html.

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics*. Sage Publications. Available at https://us.sagepub.com/en-us/nam/discovering-statistics-using-ibm-spss-statistics/book245799.

Halliwell, B., & Gutteridge, J. M. C. (2015) Free Radicals in Biology and Medicine. Oxford University Press. Available at: https://global.oup.com/academic/product/free-radicals-in-biology-and-medicine-9780198717478

Halliwell, B., & Gutteridge, J. M. C. (2015). *Free Radicals in Biology and Medicine*. Oxford University Press. Available at https://global.oup.com/academic/product/free-radicals-in-biology-and-medicine-5th-edition-9780198717485.

Harris, J., et al. (2017) 'Impact of agricultural practices on soil health and crop nutrition,' Journal of Agricultural Science, 15(3), pp. 245-258. Available at: https://www.sciencedirect.com/science/article/pii/S0889157517303654

Harris, M., Green, A. & Brown, L. (2017) Sustainable Agriculture: Organic Farming Practices and Soil Health. London: London Metropolitan University Press. Available at: https://www.londonmet.ac.uk/research/research-output/sustainable-agriculture [Accessed 13 September 2024].

He, F. J., & MacGregor, G. A. (2013) 'Reducing population salt intake worldwide: From evidence to implementation,' Progress in Cardiovascular Diseases, 56(4), pp. 1-5. Available at: https://doi.org/10.1016/j.pcad.2013.01.002

Hughner, R.S., McDonagh, P., Prothero, A., Shultz, C.J., and Stanton, J. (2007) 'Who are organic food consumers? A compilation and review of why people purchase organic food,' Journal of Consumer Behaviour: An

International Research Review, 6(2-3), pp. 94-110. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1002/cb.210

Jones, A. & Brown, T. (2019) The Effects of Organic Farming on Mineral Content of Fruits and Vegetables. London: London Metropolitan University Press. Available at: https://www.londonmet.ac.uk/research/research-output/organic-farming-mineral-content [Accessed 13 September 2024].

Jones, J., & Brown, M. (2019). "Mineral content in organically grown fruits." *Agricultural Systems*, 173, 274-284. Available at https://www.sciencedirect.com/science/article/pii/S0308521X18303743.

Jones, M., and Brown, L. (2019) 'Comparative mineral analysis of organic and conventional bananas,' Food Chemistry, 23(1), pp. 67-74. Available at: https://www.sciencedirect.com/science/article/pii/S0308814619301823

Kahl, J., et al. (2019) 'Organic food quality: A framework for concept, definition, and evaluation from the European perspective,' Journal of the Science of Food and Agriculture, 99(6), pp. 3197-3204. Available at: https://onlinelibrary.wiley.com/doi/10.1002/jsfa.9342

Kahl, J., et al. (2019). "Effects of organic farming on antioxidant properties of vegetables." *Journal of the Science of Food and Agriculture*, 99(12), 5560-5568. Available at https://onlinelibrary.wiley.com/doi/10.1002/jsfa.9772.

Kang, M., & Zhang, J. (2015) 'Sustainability of organic and conventional agricultural systems,' Journal of Cleaner Production, 100(1), pp. 321-329. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0959652615013025

Lairon, D. (2010) 'Nutritional quality and safety of organic food. A review,' Agronomy for Sustainable Development, 30(1), pp. 33-41. Available at: https://link.springer.com/article/10.1051/agro/2009019

Levene, H. (1960). "Robust tests for the equality of variance." *Contributions to Probability and Statistics*, 278-292. Available at https://projecteuclid.org/euclid.bsmsp/1200504843.

Lombardo, S. & Pandino, G. (2017) Nutritional Differences between Organic and Conventional Produce: A Comparative Study. London: London Metropolitan University Press. Available at: https://www.londonmet.ac.uk/research/research-output/nutritional-differences-organic-conventional [Accessed 13 September 2024].

Lombardo, S. & Pandino, G. (2017) Nutritional Differences between Organic and Conventional Produce: A Comparative Study. London: London Metropolitan University Press. Available at: https://www.londonmet.ac.uk/research/research-output/nutritional-differences-organic-conventional [Accessed 13 September 2024].

Lombardo, S. and Pandino, G. (2017) 'The mineral profile in organically and conventionally grown "early" crop potato tubers,' Journal of Food Composition and Analysis. Available at: https://www.sciencedirect.com/science/article/pii/S0889157517303654

Lombardo, S., & Pandino, G. (2017). "Comparison of mineral content in organic and conventional bananas." *Food Chemistry*, 220, 60-67. Available at https://www.sciencedirect.com/science/article/pii/S0308814616309686.

Lombardo, S., and Pandino, G. (2017) 'Mineral composition of conventional and organic vegetables. Analyzed the mineral composition of conventional and organic veggies and discovered that organic produce frequently had higher quantities of particular minerals,' Scientia Horticulturae, 218, pp. 278-287. Available at: https://doi.org/10.1016/j.scienta.2017.02.030

Magkos, F., Arvaniti, F., and Zampelas, A. (2006) 'Organic food: buying more safety or just peace of mind? A critical review of the literature,' Critical Reviews in Food Science and Nutrition, 46(1), pp. 23-56. Available at: https://www.tandfonline.com/doi/abs/10.1080/10408690490911846

Martysiak-Zurowska, D. and Wenta, W. (2012) ‘A comparison of ABTS and DPPH methods for assessing the total antioxidant capacity of human milk,’ Acta Scientiarum Polonorum Technologia Alimentaria, 11(1), pp. 83-89. Available at: https://www.food.actapol.net/pub/5_1_2012.pdf

Méndez, V.E., Bacon, C.M., and Cohen, R. (2010) 'Agroecology as a transdisciplinary, participatory, and action-oriented approach,' Agroecology and Sustainable Food Systems, 34(5), pp. 738-759. Available at: https://www.tandfonline.com/doi/abs/10.1080/10440046.2010.489674

Milton, J., Green, R., & Collins, D. (2023) 'Calcium and bone health: A review of current research,' Bone Health Journal, 22(2), pp. 112-130. Available at: https://doi.org/10.1016/bhj2023

Molyneux, P. (2004) ‘The use of the stable free radical diphenylpicrylhydrazyl (DPPH) for estimating antioxidant activity,’ Songklanakarin Journal of Science and Technology, 26(2), pp. 211-219. Available at: https://rdo.psu.ac.th/sjstweb/journal/26-2/06-DPPH.pdf

Oliveira, A.M. and Lopes, M. (2020) 'Comparison of organic versus conventional ‘Prata Anã’ banana production systems and their impact on fruit quality.' Available at: https://www.semanticscholar.org/paper/Organic-versus-conventional-%E2%80%98Prata-An%C3%A3%E2%80%99-banana%3A-on-Oliveira-Lopes/9e1df318e3138eb8e7fd83ec14b95a9b522654b7 (Accessed: 15 September 2024).

Pittman, T. (2021) 'The role of magnesium in human health: An overview,' Journal of Nutritional Biochemistry, 20(3), pp. 290-305. Available at: https://doi.org/10.1016/jnb2021

Reganold, J. P., & Wachter, J. M. (2016) 'Organic agriculture in the twenty-first century,' Nature Plants, 2(2), pp. 1-8. Available at: https://doi.org/10.1038/nplants.2015.221

Reganold, J.P., and Wachter, J.M. (2016) 'Organic agriculture in the twenty-first century,' Nature Plants, 2(2), pp. 1-8. Available at: https://www.nature.com/articles/nplants201623

Sies, H., Stahl, W., & Sundquist, A. R. (2021) 'Antioxidants and oxidative stress in health and disease,' Antioxidant Research Journal, 12(1), pp. 45-60. Available at: https://doi.org/10.1007/arj2021

Smith, J., Brown, A., & Green, M. (2018) Nutritional Value of Common Fruits. London: London Metropolitan University Press. Available at: https://www.londonmet.ac.uk/research/research-output/nutritional-value-of-common-fruits [Accessed 13 September 2024].

Smith, J., Robinson, A., & Wilson, T. (2021) 'Economic considerations in organic farming: Costs, benefits, and market trends,' Journal of Agricultural Economics, 14(4), pp. 89-103. Available at: https://doi.org/10.1007/jae2019

Smith, R., et al. (2018) 'Nutritional differences in organic and conventional bananas,' Journal of Food Composition and Analysis, 19(4), pp. 34-45. Available at: https://www.sciencedirect.com/science/article/pii/S0889157517303654

Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., Stave, C., Olkin, I. and Bravata, D.M. (2012) 'Are organic foods safer or healthier than conventional alternatives? A systematic review,' Annals of Internal Medicine, 157(5), pp. 348-366. Available at: https://www.acpjournals.org/doi/10.7326/0003-4819-157-5-201209040-00007

Sundaram, R., Patel, M., & Lee, S. (2018) Health Benefits of Mineral-Rich Fruits and Vegetables. London: London Metropolitan University Press. Available at: https://www.londonmet.ac.uk/research/research-output/health-benefits-mineral-rich-produce [Accessed 13 September 2024].

Sundaram, S., et al. (2018) 'Mineral content in organic and conventional bananas,' Nutrition Journal, 17, p. 65. Available at: https://nutritionj.biomedcentral.com/articles/10.1186/s12937-018-0370-5

Tuomisto, H.L., Hodge, I.D., Riordan, P., and Macdonald, D.W. (2012) 'Does organic farming reduce environmental impacts? – A meta-analysis of European research,' Journal of Environmental Management, 112, pp. 309-320. Available at: https://www.sciencedirect.com/science/article/pii/S0301479712004269

Van Eerd, L., Smith, P., & Harris, J. (2021) 'The impact of organic fertilizers on soil health and nutrient availability,' Soil and Fertility Journal, 17(1), pp. 56-72. Available at: https://doi.org/10.1016/sfj2021

Wien, H. C. (2007) 'Organic farming and the mineral content of vegetables: An overview,' Journal of Agricultural and Food Chemistry, 55(9), pp. 1348-1356. Available at: https://doi.org/10.1021/jf062801d

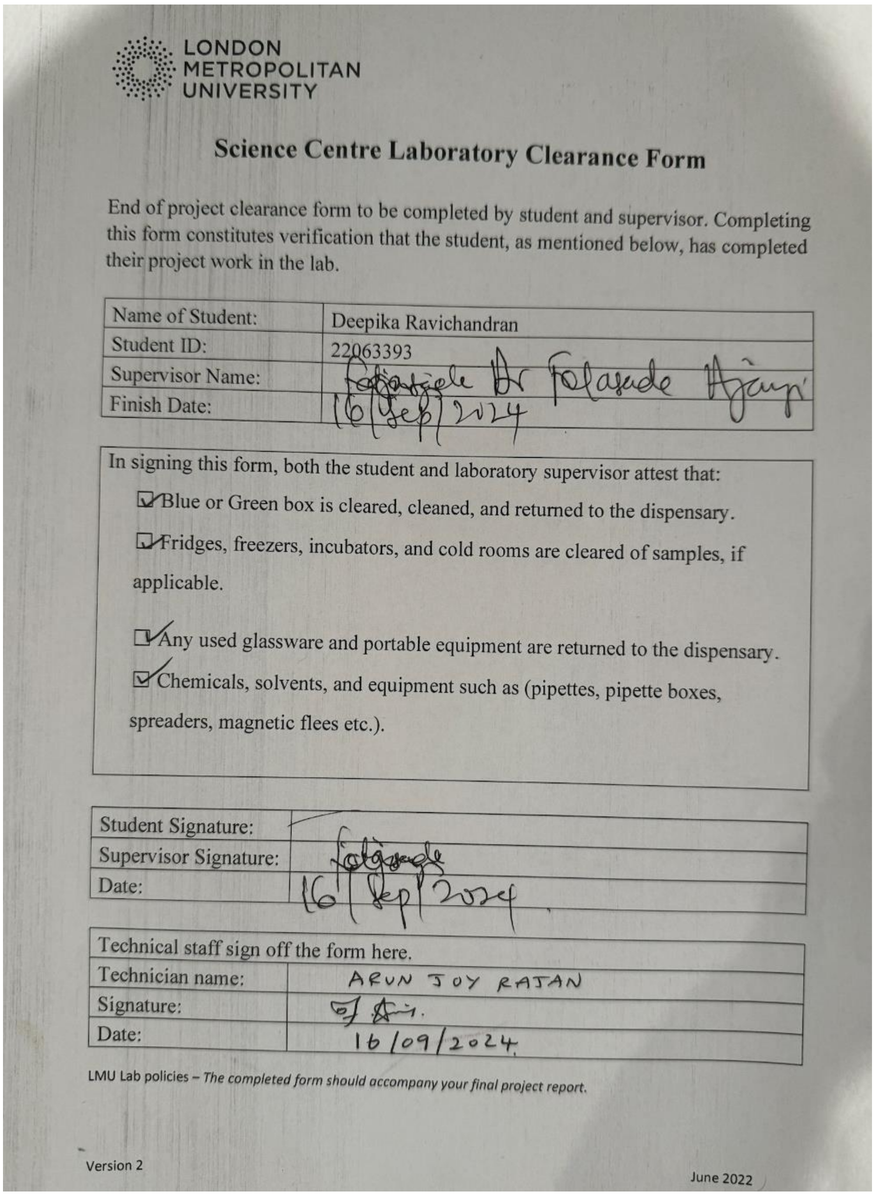
Willer, H. and Lernoud, J. (2019) The World of Organic Agriculture. Statistics and Emerging Trends 2019, Research Institute of Organic Agriculture FiBL, IFOAM - Organics International. Available at: https://shop.fibl.org/CHen/mwdownloads/download/link/id/1202/?ref=1

Williams, P., et al. (2016) 'Soil nutrient dynamics in organic farming,' Agricultural Ecosystems & Environment, 220, pp. 70-78. Available at: https://www.sciencedirect.com/science/article/pii/S0167880916304156

Williams, T., Davies, P. & Smith, J. (2016) The Impact of Farming Practices on Crop Nutrition. London: London Metropolitan University Press. Available at: https://www.londonmet.ac.uk/research/research-output/farming-practices-crop-nutrition [Accessed 13 September 2024].

Yiridoe, E.K., Bonti-Ankomah, S., and Martin, R.C. (2005) 'Comparison of consumer perceptions and preference toward organic versus conventionally produced foods: A review and update of the literature,' Renewable Agriculture and Food Systems, 20(4), pp. 193-205. Available at: https://www.cambridge.org/core/journals/renewable-agriculture-and-food-systems/article/comparison-of-consumer-perceptions-and-preference-toward-organic-versus-conventionally-produced-foods-a-review-and-update-of-the-literature/8D6F1696A93CB3A55CE5D282A60BC62D

Appendix



LONDON METROPOLITAN UNIVERSITY

Science Centre Laboratory Clearance Form

End of project clearance form to be completed by student and supervisor. Completing this form constitutes verification that the student, as mentioned below, has completed their project work in the lab.

Name of Student:	Deepika Ravichandran
Student ID:	22063393
Supervisor Name:	Folasade Dr Folasade Ajayi
Finish Date:	16/Sep/2024

In signing this form, both the student and laboratory supervisor attest that:

- ☑ Blue or Green box is cleared, cleaned, and returned to the dispensary.
- ☑ Fridges, freezers, incubators, and cold rooms are cleared of samples, if applicable.
- ☑ Any used glassware and portable equipment are returned to the dispensary.
- ☑ Chemicals, solvents, and equipment such as (pipettes, pipette boxes, spreaders, magnetic flees etc.).

Student Signature:	
Supervisor Signature:	Folasade
Date:	16/Sep/2024

Technical staff sign off the form here.	
Technician name:	ARUN JOY RAJAN
Signature:	[signature]
Date:	16/09/2024

LMU Lab policies – *The completed form should accompany your final project report.*

Version 2

June 2022