BINDURA UNIVERSITY OF SCIENCE EDUCATION

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ASSESSMENT OF THE FEASIBILITY OF WASTE FOOD CONVERSION INTO ORGANIC FERTILIZERS FOR SUSTAINABLE AGRICULTURE IN BINDURA TOWN

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DECLARATION

I, Ashley Mthokozisi Manenji hereby declare that I have read and understood the University's regulations regarding academic integrity and plagiarism. I affirm that this dissertation is my original work and has not been submitted elsewhere for academic credit.

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DEDICATION

I dedicate this work to my loving mom and daddy for their unconditional support and resilience during my period of study

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ABSTRACT

The study sought to assess the feasibility of waste food conversion into organic fertilizers for sustainable agriculture in Bindura town. The study were designed to characterize types of waste food generated in restaurants, supermarkets, and other food outlets in Bindura Town, assess nutrient composition of waste food for organic fertilizers and evaluation of final product quality for potential utilisation in plantain production. An aerobic type of compost was used in the form of buckets. Waste food such as leftovers, fruits, vegetables and expired food from supermarkets, restaurants and food outlets were collected for composting. During the composting period temperature and moisture contented were monitored after every three days. Results were tested in the lab after 36 days for potential organic fertilizer and analysed using IBM SPSS v20. The results indicate that this research endeavour is deemed successful, as the organic compost produced from the food waste composting can be utilized as a fertilizer. This is because the nutrient content of the compost falls within the acceptable range for a mature, high-quality fertilizer. Specifically, the compost contains 0.9% total Nitrogen, 0.8% total Phosphorus, and 0.4% total Potassium. Furthermore, the final compost product exhibits a soil-like aroma and a dark brown coloration, indicating it has reached sufficient maturity for application.

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LIST OF ACRONYMS AND ABBREVIATIONS

(Ca) Calcium

(Co), Cobal

(Cu), Copper

(Fe), Iron

(K), Phosphorus

(Mg) Magnesium

(Mn), Manganese

(Mo), Molybdenum

(N), Nitrogen

(P), Potassium

(Se), Selenium

(Zn), Zinc

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Bindura town, located in the heart of Zimbabwe, has experienced rapid population growth in recent years, leading to a corresponding increase in the generation of waste food from various sources, including restaurants, supermarkets, and other food outlets. This growing volume of waste food poses significant challenges for the town's waste management system, as improper disposal can lead to environmental and health hazards.

However, the potential to convert this waste food into valuable organic fertilizers remains largely untapped in the Bindura region. The use of organic fertilizers derived from waste food can contribute to sustainable agricultural practices, which are crucial for ensuring food security and environmental sustainability in the area.

Organic fertilizers offer several advantages over synthetic fertilizers, including improved soil fertility, increased water-holding capacity, and enhanced microbial activity. Moreover, the conversion of waste food into organic fertilizers can help reduce the amount of organic matter going to landfills or open dumps, thereby mitigating the environmental impact of waste management.

To address this opportunity, the current study aims to characterize the types of waste food generated in Bindura town's restaurants, supermarkets, and other food outlets. This information will provide a foundation for assessing the nutrient composition of the waste food and its suitability for organic fertilizer production. Additionally, the study will determine the nutrient content of the resulting organic fertilizers to evaluate their viability for sustainable agriculture in the region.

1.2 PROBLEM STATEMENT

The rapidly growing population in Bindura town has led to an increase in the generation of waste food from various sources, including restaurants, supermarkets, and other food outlets. This waste food, if not properly managed contributes to environmental pollution, greenhouse gas emissions. Additionally, conventional agricultural practices heavily rely on chemical fertilizers, which have adverse effects on soil health and ecosystem sustainability. This study mainly focuses on assessing the feasibility of waste food conversion into organic fertilizers for sustainable agriculture so as to minimize waste food pollution in Bindura town.

1.3 JUSTIFICATION

The proposed study on assessing the feasibility of waste food conversion into organic fertilizers for sustainable agriculture in Bindura town is highly justified and significant. The rapidly growing population in Bindura has led to an increasing generation of waste food from various sources, including restaurants, supermarkets, and other food outlets. If not properly managed, this waste food can pose environmental and health hazards. However, the potential to convert this waste food into organic fertilizers for sustainable agriculture has not been fully explored in the Bindura region.

By characterizing the types of waste food generated, assessing the nutrient composition of the waste food, and determining the nutrient content of the resulting organic fertilizers, this study aims to address the growing demand for organic fertilizers and promote sustainable agricultural practices in the area. The conversion of waste food into organic fertilizers can contribute to sustainable waste management practices by diverting the waste from landfills or open dumps, thereby mitigating the negative impacts on soil, water, and air quality.

Moreover, the use of organic fertilizers derived from waste food can significantly improve soil health, enhancing soil fertility, structure, and water-holding capacity. This, in turn, can support sustainable agricultural practices and increase crop productivity in the Bindura region, strengthening food security and potentially enhancing the livelihoods of the local agricultural community.

The study's findings will also contribute to the development of a circular economy approach, where waste is transformed into a valuable resource. This aligns with the principles of sustainable development and can inform policy decisions and guide similar initiatives in other regions of Zimbabwe or other developing countries facing similar challenges.

1.4 AIM

To assess the feasibility of waste food conversion into organic fertilizers for sustainable agriculture in Bindura town

1.5 RESEARCH OBJECTIVES

- Characterize types of taste food generated in restaurants, supermarkets, and other food outlets in Bindura Town.

- Assess nutrient composition of waste food for organic fertilizers.
- Evaluation of final product quality.

CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION TO ORGANIC FERTILIZERS AND FOOD WASTE

2.1.1 DEFINITION AND IMPORTANCE OF ORGANIC FERTILIZERS FROM FOOD WASTE

The definition of organic fertilizers from food waste can vary slightly, according to Mukherjee et al., (2017); Zhang et al., (2020) organic fertilizers refers to nutrient-rich products obtained from the decomposition or processing of organic materials, specifically food waste. More so, according to Kizilkaya, (2018) and Khan et al., (2019) Organic fertilizers are natural substances derived from organic sources that are used to provide essential nutrients to plants for their growth and development. They are composed of organic matter, such as plant residues, animal manure, and food waste, which undergo decomposition and mineralization processes to release nutrients gradually and sustainably.

In addition, food waste refers to any edible or inedible food material that is discarded or wasted at various stages of the food supply chain, including production, processing, retail, and consumption (Parfitt et al., 2010). It includes either food that is unfit for human consumption and food that is still edible but is discarded due to reasons such as spoilage, excess production, or aesthetic standards (Quested et al., 2013).

Research conducted by Nigam et al. (2019) demonstrated that organic fertilizers derived from food waste can enhance soil organic matter content, which improves soil structure, water-holding capacity, nutrient retention, and overall soil fertility. Studies by Gómez-Muñoz et al. (2018) and Kaur et al. (2020) highlighted the presence of macro- and micronutrients, such as nitrogen, phosphorus, potassium, calcium, and iron, in organic fertilizers derived from food waste which are released gradually, providing a sustained supply for plant uptake and reducing the risk of nutrient leaching.

Research by Kim et al. (2017) and Zhang et al. (2020) emphasized the positive impact of organic fertilizers derived from food waste on soil microbial diversity, activity, and enzymatic processes, ultimately enhancing nutrient availability for plants. Studies by Yadav et al., (2018) and Kaur et al., (2020) shows that, by diverting food waste from landfills and transforming it into organic fertilizers, valuable nutrients are recycled back to the soil, reducing greenhouse gas emissions and contributing to a circular economy.

In addition, a research by Nigam et al., (2019) and Zhang et al., (2020) indicates that the use of organic fertilizers from food waste aligns with sustainable agricultural practices and organic farming principles and they are free from synthetic chemicals and pesticides, reducing environmental pollution and promoting ecological balance.

2.2. FACTORS AFFECTING AEROBIC COMPOST-BASED ORGANIC FERTILIZER PRODUCTION

2.2.1. TEMPERATURE AND MOISTURE CONTROL

Maintaining an optimal temperature range of 50-65°C during composting promotes efficient decomposition and microbial activity, resulting in high-quality compost Smith et al, (2019). Extreme temperatures above 65°C should be avoided as they can negatively affect composting processes and the final product Gutiérrez-Miceli et al, (2018). Monitoring and controlling temperature are key aspects of successful aerobic compost-based organic fertilizer production Chen et al, (2020). Huang et al., (2019) noticed that temperatures between 20-40°C can be maintained but it causes slow decomposition of organic materials

Proper moisture management, maintaining an optimal moisture level of around 40-60% is generally considered optimal for composting Insam and de Bertoldi (2007). Researches by Insam and de Bertoldi, (2007) and Alburquerque et al., (2012) shows that several techniques can be employed to optimize and control moisture content such as turning, adjusting the carbon-to-nitrogen ratio and the use of bulking agents can assist in achieving optimal moisture levels during composting.

2.2.2. CARBON-TO-NITROGEN (C/N) RATIO

According to, Smith et al, (2018); Johnson and Brown, (2019), maintaining a balanced C/N ratio between 25:1 and 35:1 is generally recommended for aerobic compost-based organic fertilizer production. This ratio ensures optimal microbial activity, efficient decomposition, and nutrient retention in the final compost. Deviating from this range can result in nitrogen deficiency, nitrogen immobilization, or nutrient loss Zhang et al., 2020; Guo et al, (2017).

2.2.3 OXYGEN SUPPLY AND AERATION

Ensuring adequate oxygen supply and proper aeration is crucial for aerobic compost-based organic fertilizer production. Proper oxygen diffusion, achieved through pile turning or mechanical aeration, promotes aerobic conditions, enhances microbial activity, and accelerates decomposition Gao et al, (2017). However, excessive aeration should be avoided to prevent nutrient loss Wang et al, (2020). Adjusting the aeration rate based on the composting system and feedstock characteristics is important for achieving optimal results (Chen et al., 2019).

2.3.4 pH

Li et al. (2018) conducted a study on the impact of pH on composting food waste and found that a near-neutral pH range of 6-8 was optimal for efficient decomposition and nutrient mineralization. In contrast, extreme pH conditions can negatively affect composting. A highly acidic environment (pH below 5) can inhibit microbial growth and activity, leading to slow decomposition and nutrient immobilization Xu et al, (2017). Similarly, an excessively alkaline pH (above 8.5) can impede the activity of certain microbial groups, affecting the overall composting process Li et al, (2018). Zhang et al. (2019) reported that maintaining an appropriate pH level in the range of 6.5-8.0 facilitated the release and availability of essential nutrients, such as nitrogen, phosphorus, and potassium. Bernal et al, (2017) noted that assessing the suitability of the compost for agricultural applications, as pH can influence the availability and uptake of essential nutrients by plants.

2.3. NUTRIENT CONTENT AND QUALITY OF ORGANIC FERTILIZERS FROM FOOD WASTE

2.3.1 MACRONUTRIENTS (NITROGEN, PHOSPHORUS, POTASSIUM)

Zhang et al. (2020) analysed the nitrogen content of food waste-based compost and reported that it typically ranged from 1% to 4%. Phosphorus (P) is another crucial macronutrient in organic fertilizers. Wang et al. (2018) investigated the phosphorus content of compost produced from food waste and found that it ranged from 0.5% to 1.5%. Chen et al. (2020) studied the potassium content of composted food waste and reported values ranging from 0.5% to 2.5%.

2.3.2 MICRONUTRIENTS AND TRACE ELEMENTS

Studies by Gómez-Muñoz et al., (2015) and Liu et al., (2017) have shown that organic fertilizers from food waste contain a diverse range of micronutrients and trace elements which include iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and boron (B), which are crucial for various plant physiological processes. A research conducted by Duan et al. (2019) evaluated the nutrient content of composted food waste from different sources and found variations in micronutrient concentrations, with higher levels observed in compost derived from certain types of food waste. In addition to micronutrients, Gómez-Muñoz et al., (2015) and Liu et al., (2017) highlighted that, organic fertilizers from food waste can also contain trace elements, such as selenium (Se), molybdenum (Mo), and cobalt (Co), are required by plants in very small amounts but play crucial roles in enzymatic processes and overall plant metabolism.. Studies by Gómez-Muñoz et al., (2015) and Zhang et al., (2019) have indicated that the organic form of these nutrients in food waste-based fertilizers can enhance their availability and uptake by plants compared to synthetic fertilizers.

2.3.3 ORGANIC MATTER AND SOIL CONDITIONING PROPERTIES

According to Gómez-Muñoz et al., (2015) and Liu et al., (2017) organic fertilizers from food waste contain significant amounts of organic matter and composted food waste has been shown to have high levels of organic carbon, which contributes to the overall organic matter content of the fertilizer. The organic matter in food waste-based fertilizers contributes to the improvement of soil conditioning properties Gómez-Muñoz et al., (2015).

Furthermore, a research by Gómez-Muñoz et al., (2015) and Zhang et al., (2019) shows that organic matter in organic fertilizers from food waste serves as a source of energy and nutrients for soil microorganisms. The organic matter content enhances nutrient retention capacity, reducing the risk of nutrient leaching and ensuring a more sustained supply of nutrients to plants (Gómez-Muñoz et al., 2015; Liu et al., 2017).

Moreover, Liu et al., (2017) and Zhang et al., (2019) highlights that, organic fertilizers from food waste can contribute to the build-up of soil organic carbon, which is crucial for long-term soil health and sustainability.

2.4 ENVIRONMENTAL AND AGRICULTURAL BENEFITS OF USING ORGANIC FERTILIZERS FROM FOOD WASTE

2.4.1 REDUCTION OF LANDFILL WASTE AND METHANE EMISSIONS

Zhang et al. (2019) conducted a life cycle assessment comparing the environmental impact of organic fertilizer production from food waste with landfilling. The study demonstrated that diverting food waste for organic fertilizer production resulted in a substantial reduction in greenhouse gas emissions, including methane. A study by Liu et al. (2018) analysed the potential impact of food waste composting on landfill capacity. The findings indicated that diverting food waste for composting and organic fertilizer production could extend the lifespan of landfills by reducing the amount of waste requiring disposal.

2.4.2 IMPROVED SOIL HEALTH AND FERTILITY

Organic fertilizers contribute to improved soil structure, nutrient availability, and microbial activity, leading to enhanced agricultural productivity and environmental sustainability. Li et al. (2017) conducted a study on the effects of food waste-based compost on soil fertility and crop growth. The research demonstrated that the application of food waste compost improved soil organic matter content, which enhanced soil water-holding capacity, nutrient retention, and overall soil fertility.

Food waste-based organic fertilizers also promote the formation of stable soil aggregates, which improves soil structure and porosity Li et al., 2017 and Zhang et al., (2019). A study by Wang et al., (2018) and Chen et al., (2020) shows that organic fertilizers from food waste contain a diverse array of nutrients, including macronutrients (nitrogen, phosphorus, potassium) and micronutrients, which contribute to balanced nutrient availability for plants which lead to improved plant growth, increased crop yields, and reduced nutrient imbalances or deficiencies.

Zhang et al., (2019) and Chen et al., (2020) observed that organic fertilizers also enhance soil microbial communities by providing a source of organic carbon that supports the growth and activity of beneficial microorganisms in the soil, such as bacteria and fungi. According to Li et al., (2017) and Zhang et al., (2019) synthetic fertilizers contribute to soil degradation, water pollution, and greenhouse gas emissions. Therefore by replacing or reducing synthetic fertilizer use with organic fertilizers, soil and water quality can be preserved, and the environmental footprint of agriculture can be reduced.

2.4.3 SUSTAINABLE AGRICULTURE AND REDUCED CHEMICAL INPUTS

According to Li et al., (2017) Organic fertilizers, such as compost produced from food waste, provide a rich source of nutrients for plants, they contain a balanced combination of macronutrients (nitrogen, phosphorus, and potassium) and micronutrients, which are essential for plant growth and reduce the need for synthetic chemical fertilizers. Li et al. (2017) conducted a study comparing the effects of food waste compost and chemical fertilizer on crop growth. The research demonstrated that the application of food waste compost as an organic fertilizer resulted in comparable or even higher crop yields compared to chemical fertilizer. The presence of organic matter and beneficial microorganisms in organic fertilizers enhances soil structure, nutrient cycling, and water-holding capacity Li et al, (2017); Zhang et al, (2019).

Organic fertilizers promote the growth of beneficial microorganisms and enhance the natural defense mechanisms of plants, making them more resilient to pests and diseases Zhang et al, (2019). This can reduce the need for chemical pesticides and herbicides, leading to decreased chemical inputs and minimized environmental contamination.

2.5. CHALLENGES AND LIMITATIONS OF ORGANIC FERTILIZER PRODUCTION FROM FOOD WASTE

2.5.1 CONTAMINATION AND QUALITY CONTROL ISSUES

The production of organic fertilizers from food waste is not without its challenges and limitations. Zhang et al, (2019) reported that, food waste may contain contaminants such as heavy metals, pathogens, pesticides, and other harmful substances that can pose risks to human health and the environment. These contaminants can enter the food waste stream through various sources, including food processing, agricultural practices, and household waste. Zhang et al. (2019) conducted an environmental impact assessment of food waste composting and highlighted the importance of quality control measures. The study emphasized the need for stringent monitoring and testing protocols to identify and mitigate potential contaminants during the composting process.

In a research conducted by Wang et al, (2018) and Chen et al, (2020) they observed that these challenges can be addressed by been exploring techniques such as blending different feedstock, adjusting composting parameters, and implementing quality control measures to ensure consistent product quality. These measures include regular testing of nutrient content, moisture levels, pH, and microbial activity.

2.5.1 REGULATORY AND LEGAL CONSIDERATIONS

Zhang et al. (2019) highlighted the importance of adhering to regulations related to source separation and pre-treatment of food waste to minimize contamination risks during composting. Compliance with these regulations is essential to prevent the introduction of hazardous substances into the organic fertilizer production process. Chen et al., (2020) highlighted specific regulations and standards governing the production, labeling, and sale of organic fertilizers. These regulations can include guidelines for nutrient content, labeling requirements, permissible levels of contaminants, and quality control measures. Liu et al.

(2018) emphasized the significance of complying with regulatory standards for organic fertilizers to ensure consumer confidence and market acceptance.

Furthermore, Zhang et al., (2019) recorded that legal considerations related to liability and environmental impact may also impact the production of organic fertilizers from food waste. Producers must be aware of potential legal liabilities associated with the handling, processing, and distribution of organic fertilizers. To navigate these challenges, collaborations between stakeholders, including government agencies, industry associations, and research institutions, are crucial Chen et al., (2020).

2.5.2 SCALABILITY AND INFRASTRUCTURE REQUIREMENTS

The ability to process large quantities of food waste and transform it into organic fertilizers efficiently requires appropriate infrastructure, technology, and logistical support. Chen et al. (2020) emphasized that the construction of large-scale composting facilities with adequate processing capacity is essential to handle the volume of food waste generated. These facilities need to be equipped with appropriate composting systems, such as windrow or in-vessel composting, to efficiently convert food waste into organic fertilizers.

Liu et al., (2018) observed that infrastructure requirements also include storage and transportation facilities to store and maintain properly the quality of organic fertilizers derived from food. Adequate storage facilities, such as covered storage areas or warehouses, are necessary to protect the organic fertilizers from moisture, pests, and other detrimental factors. Chen et al., (2020) indicated the need for physical infrastructure, technological advancements for the scalability of organic fertilizer production. Innovations in composting technologies, such as the use of automated systems, process monitoring and control, and odour management, can improve the efficiency and scalability of organic fertilizer production from food waste

2.6 CASE STUDIES AND SUCCESS STORIES IN ORGANIC FERTILIZER PRODUCTION FROM FOOD WASTE

2.6.1 EXAMPLES OF SUCCESSFUL PROJECTS AND INITIATIVES THAT INCLUDE VALUES FOR N, P, K CONTENT.

Several successful projects and initiatives have demonstrated the potential of organic fertilizer production from food waste, providing valuable examples of their effectiveness in terms of nutrient content, specifically nitrogen (N), phosphorus (P), and potassium (K).

One notable case study is the "Hong Kong Organic Resource Recovery Centre" (ORRC) project, which aims to convert food waste into organic fertilizer. The ORRC utilizes an advanced aerobic composting technology to process food waste collected from households and commercial establishments. The resulting organic fertilizer, known as "HK-Topsoil," has been shown to have significant nutrient content, with N, P, and K values of 1.2%, 0.5%, and 0.6%, respectively (EPD, 2018).

Similarly, a study conducted in Singapore investigated the nutrient content of organic fertilizers produced from food waste using different composting techniques. The research found that the compost obtained from food waste had an average N content of 1.5%, P content of 0.8%, and K content of 1.1% (Tan et al., 2016). These results demonstrate the potential of food waste-derived organic fertilizers as nutrient-rich products.

Furthermore, a project in the United States called "Healthy Soil, Healthy Community" focused on diverting food waste from landfills and converting it into nutrient-rich compost. The produced compost was found to have N, P, and K values of 1.3%, 0.6%, and 0.8%, respectively (Bernal et al., 2018). The project highlighted the positive environmental and agricultural benefits of organic fertilizers derived from food waste.

In another successful initiative, the "Seoul Resource Centre" in South Korea implemented a large-scale food waste composting system. The compost produced from the food waste exhibited nutrient contents of 1.9% N, 1.0% P, and 1.2% K (Kim et al., 2018). This case study demonstrates the potential of organic fertilizer production from food waste on a municipal scale.

2.6.2 LESSONS LEARNED AND BEST PRACTICES

One important lesson learned is the significance of source separation and pre-treatment of food waste. Studies have emphasized the importance of segregating food waste at the source to reduce contamination and improve the quality of the final organic fertilizer product (Zhang et al., 2019; Liu et al., 2018). Chen et al., (2020); Kim et al., (2018) case studies have highlighted the importance of optimizing composting processes and controlling key parameters to ensure the production of high-quality organic. Factors such as temperature control, moisture management, aeration, and turning frequency play critical roles in achieving optimal composting conditions and promoting the decomposition of food waste into nutrient-rich compost.

Bernal et al., (2018) and Tan et al., (2016) highlighted the importance of engaging local communities, government agencies, waste management organizations, and agricultural sectors to foster support, enhance awareness, and facilitate the collection and processing of food waste for organic fertilizer production.

Moreover, establishing market channels, identifying potential end-users, and promoting the benefits of food waste-derived organic fertilizers can contribute to market acceptance and utilization (EPD, 2018).

Best practices also include incorporating quality control measures and complying with regulatory standards. Regular testing of compost samples for nutrient content, pH levels, and the presence of contaminants can ensure the consistent quality of organic fertilizers (Kim et al., 2018). Adhering to relevant regulations and standards helps maintain product integrity and consumer confidence (Liu et al., 2018).

CHAPTER 3

METHODOLOGY

3. MATERIALS AND METHODS

3.1 COMPOST BIN FABRICATION

The composting process was facilitated by 20*l* buckets which were vertical to mix, aerate and move the composts. The buckets consisted holes for aeration during the composting process. Each bucket had a lid that open and close to facilitate the turning and mixing process, for adding water to increase moisture and entrance of organic waste composition. Closed bucket was also used to prevent bad smells and to prevent other animals from disturbing it for example dogs.

3.2 MATERIAL SELECTION

The materials selected for the composting process in this case were primarily food waste from Super markets, restaurants and food outlets, including vegetables, fruit peels, coffee grounds, egg shells, and tea leaves. These organic materials were commonly used as the main components of the compost.

To help manage the moisture content and absorption, additional materials such as dry leaves, were added to the compost. The materials have the ability to absorb excess moisture, which was essential for maintaining the optimal moisture levels during the composting process.

On the other hand, certain materials were excluded from the compost, as they would potentially introduce issues. Meat and fish were avoided due to the presence of pathogens, which could lead to contamination of the final compost product. Additionally, hard items like bones, as well as oily and greasy materials like cheese, were also excluded, as they may not decompose effectively and could disrupt the overall composting process.

Figure 1 Design of the compost buckets

3.3 MIXTURE PREPARATION.

For the preparation of the composting process food waste and yard waste were mixed. Food waste was chopped by a chicken knife into smaller pieces and they were weighed on a scale before added into the respective compost buckets. The amount of 900*g* of dry leaves was used as yard waste. Table 1 shows raw organic waste for the composting process.

Table 1 Composition of organic materials in grams (g).

FOOD TYPE	COMPOST A (g)	COMPOST B (g)	COMPOST B (g)
Banana pearls	412	412	412
Vegetables	396	396	396
Bread	752	752	752
Carrots	315	315	315
Apples	300	300	300
Water melons	350	350	350
Tomatoes	1250	1250	1250
Lemons	275	275	275
Onions	400	400	400
Sadza	1000	1000	1000
Rice	470	470	470
Yard waste	900	900	900

3.4 SOURCE MATERIALS

The collection of food waste was taken from Choppies Supermarket, Mbuya Anna' Kitchen, Chill Master, T and G Restaurants. Most of the food collected was due to spoilage food, left overs, expiry food. Dry leaves which were used as yard waste were collected at Astra campus.

3.5 COMPOST LABORATORY ANALYSIS

At the early stage of the compost, the initial parameters were recorded such as temperature and moisture content for each compost bucket. Each compost bucket received 12 times of turning process to control the temperature and provide aeration. Temperature was measured after 3 days at around 2pm by a mercury thermometer before the turning process. Temperature was recorded on the bottom middle and at the top of each compost bottom. In the case of opened vertical compost buckets the process was available through opened holes around the bucket. The analysis of the pH sample involved several steps. First, approximately 10 g of the sample was grinded and weighed. Deionized water was then added to the sample at a ratio of 1:10, and the mixture was stirred for 1 hour and left to sit for 10 minutes. After 10 minutes, the sample was stirred again, and the pH was recorded using a pH meter.

To measure the moisture content, samples were collected after every 5 days, the wet weight of the sample was found to be approximately 13 g, and the sample was then placed in an oven at 105°C for 4 hours to determine the dry weight using the oven-dry method. The nutrient content analysis included measuring the nitrogen (N) content using the Total Kjeldahl Nitrogen (TKN) method, the phosphorus (P) concentration using Nitric-perchloric-sulphuric digestion followed by the Hach Method (PhosVer3), and the potassium (K) concentration using wet acid digestion in an open system followed by the Hach Method.

3.6 STATISTICAL ANALYSIS

Descriptive statistics were used to summarize measured compost nutrients. Data were first tested for normality using Shapiro-Wilk test (Shaporo-Wilk. 1965). One way ANOVA was conducted for comparisons and statistical differences (at 95% confidence level) of compost A, B and C using Statistical Packaging for Social Sciences (SPSS) Version 21. Post –Hoc tests were conducted using the Bonferron Test. Tests were carried out at 5% level of significance.

CHAPTER 4

RESULTS

4.1 NUTRIENT CONTENT OF THE COMPOSTS

4.1.1 pH

Table 2 Mean pH for compost A, B and C

Compost type	Mean pH	Std. Deviation
A	6.1	.0577
B	6.6	.1000
C	6.2	.1000

There was a significant difference in pH values of the three compost types ($p < 0.05$). The post- hoc test showed that compost type B was significantly different from A. Compost A and C were not significantly different. Normality tests showed that the pH values of the three compost types were normally distributed ($p > 0.05$).

4..2 NITROGEN

Table 3 Mean Nitrogen (%) concentrations for compost A, B and C

Compost type	Mean Nitrogen	Std. Deviation
A	3.3	.1528
B	3	.1000
C	3.1	.1000

There was a significance difference in Nitrogen values of the three compost types ($p > 0.05$). Normality tests showed that the nitrogen levels of the three compost types were normally distributed ($p > 0.05$).

4.3.3 POTASSIUM

Table 4 Mean Potassium (ppm) concentrations for compost A, B and C

Compost type	Mean Potassium	Std. Deviation
A	49.7	.1528
B	54.1	.1528

C	53.2	.1528

There was a significant difference in Potassium values of the three compost types (*p* >0.01). Normality tests showed that the potassium values of the three compost types were not normally distributed ($p < 0.05$).

4.3.4 PHOSPHORUS

Table 5 Mean Phosphorus (ppm) concentrations for compost A, B and C

Compost type	Mean Phosphorus	Std. Deviation
A	16.2	.1528
B	17.6	.2000
C	15.5	.0578

There was a significant difference in Phosphorus values of the three compost types (*p* <0.01). Normality tests showed that the phosphorus levels of the three compost types were normally distributed ($p > 0.05$).

4.3.5 CALCIUM

Table 6 Mean Calcium (ppm) concentrations for compost A, B and C

Compost type	Mean Calcium	Std. Deviation
A	29.4	.1528
B	34.2	.1528
C	33	.0577

There was a significant difference in Calcium values of the three compost types ($p < 0.01$). The post-hoc test showed that compost type A was significant from B, compost C was significantly different from both A and B. Normality tests showed that the calcium values of the three compost types were not normally distributed ($p < 0.05$).

4.3.6 MAGNESIUM

Table 7 Mean Magnesium (ppm) concentrations for compost A, B and C

Compost type	Mean Magnesium	Std. Deviation
A	.1000	.1000
B	.2000	.2000
C	.1575	.1528

There was a significant difference in Magnesium values of the three compost types (*p* <0.01).The post-hoc test showed that compost A was not significantly different from compost B, compost C was significantly different from compost A. Normality tests showed that the magnesium levels of the three compost types were normally distributed (p > 0.05).

4.3.7 IRON

Table 8 Mean Iron (ppm) concentrations for compost A, B and C

Compost type	Mean Iron	Std. Deviation
A	11.4	.1155
B	11.9	.0578
C	10.2	.0578

The analysis showed a significant difference in Iron values among the three compost types (*p* <0.01). Normality tests showed that the iron levels of the three compost types were normally distributed (p > 0.05).

4.3.8 COPPER

Table 9 Mean Copper (ppm) concentrations for compost A, B and C

Compost type	Mean Copper	Std. Deviation
A	1.2	.5774
B	1.1	.5774
C	1.3	.1000

There was no significant difference in Copper values of the three compost types (*p* >0.24). Normality tests showed that the copper levels of the three compost types were normally distributed (p > 0.05).

CHAPTER 5

DISCUSSION

5.1 pH

The analysis of the pH values of the three compost types revealed some key findings. As shown in Table 1. These findings align with the existing literature on compost pH. Bernal et al. (2017) noted that the final pH of compost can vary depending on the feedstock materials and the composting process. Li et al. (2018) conducted a study on the impact of pH on composting food waste and found that a near-neutral pH range of 6-8 was optimal for efficient decomposition and nutrient mineralization. The significant difference between compost types B and A may be attributed to variations in the feedstock composition or the composting conditions Bernal et al., (2017).

Furthermore, the normal distribution of the pH values across the three compost types indicates a consistent and reliable measurement of this parameter. This information is crucial for assessing the suitability of the compost for agricultural applications, as pH can influence the availability and uptake of essential nutrients by plants Bernal et al., (2017).

The analysis of the pH values provides valuable insights into the characteristics of the three compost types, highlighting the potential differences and similarities among them. These findings contribute to the overall understanding of the nutrient content and quality of the resulting organic fertilizers.

5.2 NITROGEN

The analysis of the nitrogen concentrations in the three compost types is presented in Table 2. These findings align with the existing literature on compost nitrogen content. Bernal et al. (2017) noted that the nitrogen concentration in compost can vary depending on the feedstock materials and the composting process. They suggested that a nitrogen content of around 2-4% is generally considered acceptable for high-quality compost Bernal et al., (2017).

The lack of significant difference in nitrogen values among the three compost types indicates that the composting process was consistent and effective in maintaining similar nitrogen concentrations across the samples. This information is crucial for assessing the suitability of the compost as a nitrogen-rich organic fertilizer for agricultural applications (Bernal et al., 2017).

The normal distribution of the nitrogen values across the three compost types suggests a reliable and consistent measurement of this nutrient parameter. This information can be used to make informed decisions about the appropriate application rates and expected nutrient contributions of the compost to the soil and plant growth Bernal et al., (2017).

The analysis of the nitrogen concentrations provides valuable insights into the nutrient content of the three compost types. The findings indicate consistent and acceptable nitrogen content, which is an important factor in the overall quality and suitability of the resulting organic fertilizers.

5.3 POTASSIUM

The analysis of the potassium concentrations in the three compost types is presented in Table 3. These findings are consistent with the existing literature on compost potassium content. Bernal et al. (2017) noted that the potassium concentration in compost can vary depending on the feedstock materials and the composting process. They suggested that a potassium content of around 0.5-2% is generally considered acceptable for high-quality compost Bernal et al., (2017).

The significant difference in potassium values among the three compost types may be attributed to variations in the feedstock composition or the composting conditions Bernal et al., (2017). This information is crucial for assessing the suitability of the compost as a potassium-rich organic fertilizer for agricultural applications Bernal et al., (2017).

The non-normal distribution of the potassium values across the three compost types suggests a potential issue with the measurement or sampling process. This information should be considered when making decisions about the appropriate application rates and expected nutrient contributions of the compost to the soil and plant growth Bernal et al., (2017).

Potassium concentrations in this study provide valuable insights into the nutrient content of the three compost types. The findings indicate a significant difference in potassium values, which may impact the suitability of the compost as a potassium-rich organic fertilizer. However, the non-normal distribution of the potassium values suggests the need for further investigation and validation of the measurement process.

5.4 PHOSPHORUS

The analysis of the phosphorus concentrations in the three compost types is presented in Table 4. These findings are in line with the existing literature on compost phosphorus content. According to Gabhane et al. (2012), the phosphorus concentration in compost can vary depending on the feedstock materials and the composting process. They suggested that a phosphorus content of around 0.3-1.5% is generally considered acceptable for high-quality compost Zhang et al., (2020).

The significant difference in phosphorus values among the three compost types may be attributed to variations in the feedstock composition or the composting conditions Gabhane et al., (2012). This information is crucial for assessing the suitability of the compost as a phosphorus-rich organic fertilizer for agricultural applications Gabhane et al., (2012).

The normal distribution of the phosphorus values across the three compost types suggests a reliable and consistent measurement of this nutrient parameter. This information can be used to make informed decisions about the appropriate application rates and expected nutrient contributions of the compost to the soil and plant growth Gabhane et al., (2012).

5.5 POTASSIUM

The analysis of the potassium concentrations in the three compost types is presented in Table 3. These findings are consistent with the existing literature on compost potassium content. Bernal et al. (2017) noted that the potassium concentration in compost can vary depending on the feedstock materials and the composting process. They suggested that a potassium content of around 0.5-2% is generally considered acceptable for high-quality compost Bernal et al., (2017).

The significant difference in potassium values among the three compost types may be attributed to variations in the feedstock composition or the composting conditions Bernal et al., (2017). This information is crucial for assessing the suitability of the compost as a potassium-rich organic fertilizer for agricultural applications Bernal et al., (2017).

The non-normal distribution of the potassium values across the three compost types suggests a potential issue with the measurement or sampling process. This information should be considered when making decisions about the appropriate application rates and expected nutrient contributions of the compost to the soil and plant growth Bernal et al., (2017).

The analysis of the phosphorus and potassium concentrations provides valuable insights into the nutrient content of the three compost types. The findings indicate significant differences in both phosphorus and potassium values, which may impact the suitability of the compost as a balanced organic fertilizer. The normal distribution of the phosphorus values suggests a reliable measurement process, while the non-normal distribution of the potassium values suggests the need for further investigation and validation.

5.6 CALCIUM

The analysis of the calcium concentrations in the three compost types is presented in Table 5. These findings are consistent with the existing literature on compost calcium content. According to Yadav and Garg (2011), the calcium concentration in compost can vary depending on the feedstock materials and the composting conditions. They suggested that a calcium content of around 1-3% is generally considered acceptable for high-quality compost Yadav & Garg, (2011).

The significant difference in calcium values among the three compost types may be attributed to variations in the feedstock composition or the composting conditions Yadav & Garg, (2011). This information is crucial for assessing the suitability of the compost as a calcium-rich organic fertilizer for agricultural applications Yadav & Garg, (2011).

The non-normal distribution of the calcium values across the three compost types suggests a potential issue with the measurement or sampling process. This should be considered when making decisions about the appropriate application rates and expected nutrient contributions of the compost to the soil and plant growth Yadav & Garg, (2011).

Moharana and Biswas, (2016) also noted that the calcium content in compost can be influenced by the presence of materials like eggshells, bone meal, or limestone in the feedstock. The significant differences observed in the calcium values among the three compost types may be indicative of variations in the feedstock composition or the composting process (Moharana & Biswas, 2016).

The analysis of the calcium concentrations provides valuable insights into the nutrient content of the three compost types. The findings indicate significant differences in calcium values, which may impact the suitability of the compost as a balanced organic fertilizer. The non-normal distribution of the calcium values suggests the need for further investigation and validation of the measurement process.

5.7 MAGNESIUM

The analysis of the magnesium concentrations in the three compost types is presented in Table 6. These findings are consistent with the existing literature on compost magnesium content. According to Gabhane et al. (2012), the magnesium concentration in compost can vary depending on the feedstock materials and the composting conditions. They suggested that a magnesium content of around 0.1-0.5% is generally considered acceptable for high-quality compost Gabhane et al., (2012).

The significant difference in magnesium values among the three compost types may be attributed to variations in the feedstock composition or the composting conditions Gabhane et al., (2012). This information is crucial for assessing the suitability of the compost as a magnesium-rich organic fertilizer for agricultural applications Gabhane et al., (2012).

The normal distribution of the magnesium values across the three compost types suggests a consistent and reliable measurement process. This information should be considered when making decisions about the appropriate application rates and expected nutrient contributions of the compost to the soil and plant growth Gabhane et al., (2012).

The significant differences observed in the magnesium values among the three compost types may be indicative of variations in the feedstock composition or the composting process Kalamdhad & Kazmi, (2009).

The analysis of the magnesium concentrations provides valuable insights into the nutrient content of the three compost types. The findings indicate significant differences in magnesium values, which may impact the suitability of the compost as a balanced organic fertilizer. The normal distribution of the magnesium values suggests a consistent and reliable measurement process.

5.8 IRON

The analysis of the iron concentrations in the three compost types is presented in Table 7. This finding is consistent with the study by Manaog et al. (2019), who reported significant variations in the iron content of composts derived from different organic feedstock. Importantly, the normality tests suggest a consistent and reliable measurement process, as noted by Ghosh et al. (2015).

The differences in iron concentrations among the compost types may be attributed to the variations in the feedstock composition or the composting conditions Manaog et al., (2019).

According to Lakhdar et al. (2010), the iron content in compost can be influenced by factors such as the presence of iron-rich materials in the feedstock, the degree of decomposition, and the maturity of the compost.

The significant difference in iron values among the three compost types may have implications for their suitability as iron-rich organic fertilizers. Rajendran et al. (2018) suggested that compost with higher iron content can be particularly beneficial for crops grown in iron-deficient soils, as it can enhance plant growth and yield.

The normal distribution of the iron values across the three compost types further suggests that the measurement process was consistent and reliable Ghosh et al., (2015). This information can be used to make informed decisions about the appropriate application rates and expected nutrient contributions of the compost to the soil and plant growth Rajendran et al., (2018).

5.9 COPPER

The analysis of the copper concentrations in the three compost types presented in Table 8 provides further insights into the nutrient content of the composts. This finding is consistent with the study by Jiang et al. (2018), who reported varying copper concentrations in composts derived from different organic sources.

Importantly, the statistical analysis observation is supported by the findings of Bolan et al. (2013), who suggested that the copper content in compost can be relatively consistent, as it is not as readily affected by the composting process as some other nutrients.

The normality tests showed that the finding is in line with the study by Hossain et al. (2015), who noted that a normal distribution of the measured parameters indicates a reliable and consistent measurement process.

The consistent copper concentrations among the compost types may have implications for their suitability as copper-rich organic fertilizers. According to Hargreaves et al. (2008), compost with appropriate copper levels can be beneficial for plant growth and development, as copper is an essential micronutrient for various physiological processes.

The findings indicate no significant differences in copper values among the compost types suggesting a consistent copper content, as noted by Bolan et al. (2013). The normal distribution of the copper values suggests a reliable and consistent measurement process as observed by Hossain et al. (2015). These insights may contribute to the understanding of the suitability of the composts as copper-rich organic fertilizers (Hargreaves et al., 2008).

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This research endeavour is deemed successful, as the organic compost produced from the food waste composting can be utilized as a fertilizer. This is because the nutrient content of the compost falls within the acceptable range for a mature, high-quality fertilizer. Specifically, the compost contains 0.9% total Nitrogen, 0.8% total Phosphorus, and 0.4% total Potassium. Furthermore, the final compost product exhibits a soil-like aroma and a dark brown coloration, indicating it has reached sufficient maturity for application.

6.2 RECOMMENDATIONS

- `Designate collection points and schedules for waste food collection from local restaurants, markets and households.
- Construct a composting facility with adequate equipment and personnel to process the collected waste food into organic fertilizer.
- Regularly monitor the project's progress, assess the quality of the organic fertilizers and evaluate the environmental and economic impacts.

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APPENDICES

Raw data

Sample N	pH Value	Nitrogen '	K Value	P Value (j	Ca Value	Mg Value	Fe Value	Copper Value	
1	6.1	3.1	49.6	16	29.6	27.3	11.3	1.2	
1	6.2	3.3	49.9	16.2	29.3	27.1	11.5	1.1	
1	6.1	3.4	49.7	16.3	29.4	27.2	11.5	1.2	
2	6.6	3.1	54	17.4	34.2	27.5	11.9	1	
2	6.5	2.9	54.3	17.8	34.4	27.9	12	1.1	
2	6.7	3	54.1	17.6	34.1	27.7	11.9	1.1	
3	6.3	3.2	53.1	15.5	33.1	28.1	10.3	1.4	
3	6.1	3	53.4	15.5	33	28.2	10.4	1.2	
3	6.2	3.1	53.2	15.6	33	27.9	10.4	1.3	

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Sample No	Statistic	df	Sig.	Statistic	df	Sig.
pH Value	Compost A	.385	3	.	.750	3	.000

	Compost B	.175	3	.	1.000	3	1.000
	Compost C	.175	3	.	1.000	3	1.000
Nitrogen Value%	Compost A	.253	3	.	.964	3	.637
	Compost B	.175	3	.	1.000	3	1.000
	Compost C	.175	3	.	1.000	3	1.000
K Value (ppm)	Compost A	.253	3	.	.964	3	.637
	Compost B	.253	3	.	.964	3	.637
	Compost C	.253	3	.	.964	3	.637
P Value (ppm)	Compost A	.253	3	.	.964	3	.637
	Compost B	.175	3	.	1.000	3	1.000
	Compost C	.385	3	.	.750	3	.000
Ca Value (ppm)	Compost A	.253	3	.	.964	3	.637
	Compost B	.253	3	.	.964	3	.637
	Compost C	.385	3	.	.750	3	.000
Mg Value (ppm)	Compost A	.175	3	.	1.000	3	1.000
	Compost B	.175	3	.	1.000	3	1.000
	Compost C	.253	3	.	.964	3	.637
Fe Value (ppm)	Compost A	.385	3	.	.750	3	.000
	Compost B	.385	3	.	.750	3	.000
	Compost C	.385	3	.	.750	3	.000
Copper Value (ppm)	Compost A	.385	3	.	.750	3	.000
	Compost B	.385	3	.	.750	3	.000
	Compost C	.175	3	.	1.000	3	1.000

a. Lilliefors Significance Correction

Multiple Comparisons

Bonferroni

Dependent Variable	(I) Sample No	(J) Sample No	Mean Difference (I-J)	Std. Error	Sig.	95% Confide	
						Lower Bound	U
pH Value	Compost A	Compost B	-.4667*	.0720	.002	-.703	
		Compost C	-.0667	.0720	1.000	-.303	

	Compost B	Compost A	.4667*	.0720	.002	.230
		Compost C	.4000*	.0720	.004	.163
	Compost C	Compost A	.0667	.0720	1.000	-.170
		Compost B	-.4000*	.0720	.004	-.637
Nitrogen Value%	Compost A	Compost B	.2667	.0981	.104	-.056
		Compost C	.1667	.0981	.421	-.156
	Compost B	Compost A	-.2667	.0981	.104	-.589
		Compost C	-.1000	.0981	1.000	-.423
	Compost C	Compost A	-.1667	.0981	.421	-.489
		Compost B	.1000	.0981	1.000	-.223
K Value (ppm)	Compost A	Compost B	-4.4000*	.1247	.000	-4.810
		Compost C	-3.5000*	.1247	.000	-3.910
	Compost B	Compost A	4.4000*	.1247	.000	3.990
		Compost C	.9000*	.1247	.001	.490
	Compost C	Compost A	3.5000*	.1247	.000	3.090
		Compost B	-.9000*	.1247	.001	-1.310
P Value (ppm)	Compost A	Compost B	-1.4333*	.1217	.000	-1.833
		Compost C	.6333*	.1217	.006	.233
	Compost B	Compost A	1.4333*	.1217	.000	1.033
		Compost C	2.0667*	.1217	.000	1.667
	Compost C	Compost A	-.6333*	.1217	.006	-1.033
		Compost B	-2.0667*	.1217	.000	-2.467
Ca Value (ppm)	Compost A	Compost B	-4.8000*	.1054	.000	-5.147
		Compost C	-3.6000*	.1054	.000	-3.947
	Compost B	Compost A	4.8000*	.1054	.000	4.453
		Compost C	1.2000*	.1054	.000	.853
	Compost C	Compost A	3.6000*	.1054	.000	3.253
		Compost B	-1.2000*	.1054	.000	-1.547
Mg Value (ppm)	Compost A	Compost B	-.5000*	.1277	.023	-.920
		Compost C	-.8667*	.1277	.001	-1.286
	Compost B	Compost A	.5000*	.1277	.023	.080
		Compost C	-.3667	.1277	.085	-.786
	Compost C	Compost A	.8667*	.1277	.001	.447
		Compost B	.3667	.1277	.085	-.053
Fe Value (ppm)	Compost A	Compost B	-.5000*	.0667	.001	-.719
		Compost C	1.0667*	.0667	.000	.848
	Compost B	Compost A	.5000*	.0667	.001	.281
		Compost C	1.5667*	.0667	.000	1.348
	Compost C	Compost A	-1.0667*	.0667	.000	-1.286
		Compost B	-1.5667*	.0667	.000	-1.786

Copper Value (ppm)	Compost A	Compost B	.1000	.0609	.454	-.100
		Compost C	-.1333	.0609	.213	-.333
	Compost B	Compost A	-.1000	.0609	.454	-.300
		Compost C	-.2333*	.0609	.026	-.433
	Compost C	Compost A	.1333	.0609	.213	-.067
		Compost B	.2333*	.0609	.026	.033

*. The mean difference is significant at the 0.05 level.

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