The Utilization of Banana Peel in the Fermentation Liquid in Food Waste Composting

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Abstract: Municipal solid waste in Malaysia contains a high amount of organic matters, particularly food waste. Food waste represents almost 60% from the total municipal solid waste disposed in the landfill. Food waste can be converted into useful materials such as compost. However, source separation of food waste for recycling is not commonly practiced in Malaysia due to various constraints. These constraints include low awareness among the waste generators and low demand of the products produced from the food waste such as composts. Composting is one of the alternatives that can be used in food waste disposal from Makanan Ringan Mas. The aim of the study is to convert food waste generated from Makanan Ringan Mas which is a medium sale industry located at Parit Kuari Darat, Batu Pahat by using composting method. The parameters which include temperature, pH value, NPK (Nitrogen, Phosphorus, Potassium) values has been examined. Banana peel is being used as the fermentation liquid whilst soil and coconut husk were used as the composting medium. Based on the results during the composting process, most of the pH value in each reactor is above 5 and approximately at neutral. This shown that the microbial respiration in the well controlled composting reactor was inhibited and had approached the mature phase. On the other hand, during the period of composting, the overall temperature range from 25 °C to 47 °C which shown the active phase for composting will occurred. As for NPK content Nitrogen value range is 35325 mg/L to 78775 mg/L, Phosphorus, 195.83 mg/L to 471 mg/L and potassium is 422.3 mg/L to 2046 mg/L which is sufficient to use for agricultural purpose. The comparison was made with available organic compost in the market and only showed slightly difference. Nevertheless, in comparison with common fertilizer, the NPK value of organic compost are considerably very low.

Keywords: Composting, food waste, fermentation liquid, banana peel.

1. Introduction
Composting practice is an alternative sustainable waste management practice to transform organic waste into valuable commodity. Composting benefits the environment because manure nutrients are converted to more stable forms and are less likely to reach groundwater or move in surface runoff[1].
Compost is valued for its organic matter content, and is typically used as a soil amendment to enhance the chemical, physical and biological properties of soil. Composting practice is an alternative sustainable waste management practice to transform organic waste into valuable commodity. Composting benefits the environment because manure nutrients are converted to more stable forms and are less likely to reach groundwater or move in surface runoff [1]. Compost is valued for its organic matter content, and is typically used as a soil amendment to enhance the chemical, physical and biological properties of soil.

Medium scale industry is specifically on food play an important role in developing the economy to establish, expand and strengthen the basic structure of industrial development of the country. There are more than 9000 food processing factories in Malaysia, of which 95% are classified as small-scale industry [2]. Many types of small scale industry such as frozen food and processed food are focusing on food production and generate food waste. One of the small scale industry in Parit Raja is Makanan Ringan Mas which is located at Parit Kuari Darat. Makanan Ringan Mas is a small scale industry that produced food products that come from the raw materials which are coconut, banana and tapioca peel. This small scale industry are facing the same problem and generated high amount of food waste for example coconut husk, tapioca peel, banana peel and others. Nevertheless, all the food waste management is not in a proper way because there are no facilities provided to manage the waste properly. At Makanan Ringan Mas, they generates very high level of processed and raw food waste daily and most of the waste were thrown in the river or by burning through open burning which leads to environmental pollution.

The goal of this study was to compost the food waste generated at Makanan Ringan Mas and determine the physical parameters which are temperature, pH and chemical parameters which are Nitrogen (N), Phosphorous (P) and Potassium (K). This study also to compare between NPK concentration produce from the composting process using banana peel as fermentation liquid with the chemical fertilizers.

2. Materials and Methods

2.1 Preparation of the starch fruit (banana peel) fermentation liquid

In order to fully utilize the food waste generated at Makanan Ringan Mas, the preparation for fermentation liquid is by using banana peel to replace fermented food and coconut candy to replace sugary water. Banana peel is an organic waste that highly rich in nutrient especially K, that could support the microbial growth in fermentation phase [3]. Using banana peel as fermentation liquid or waste in composting is considered as good as it stimulates soil microbial growth and activity with the subsequent mineralization of plant nutrients [4].

As replacement of brown sugar in common fermentation liquid, uses of candy which serves as food source for the microbes. Three (3) liters of water was mixed with 250 gram candy and 250 gram banana peel from Makanan Ringan Mas. Fermentation was occurred when bubbles starts to form, which normally occurs on the second day. Ideally, fermentation should take no longer than 7 days. Fermentation liquid was completed when the banana peel floats and the liquid settles at the bottom. During the fermentation process, the lid of the bottle should be loosened once a day to remove the gas that trapped in the bottle. The sweet and sour smell produced indicates that the fermentation liquid is successfully conducted.

2.2 Preparation of composting medium

Six (6) reactors were set up, one reactor act as control and other reactors were consisted of different types of food waste. Each reactor was filled with 250 g of food waste daily according to the type of waste on the reactors as shown in Table 1. shows the flow research work and the phases of the research.
Table 1. Reactors with different types of food waste.

| Reactor | Classification food waste | Types of food waste |
|---------|----------------------------|---------------------|
| x       | Control                    | -                   |
| A       | Processed food waste       | Candy + chips       |
| B       | Raw food waste             | Banana peel + tapioca peel + coconut husk |
| A+B     | Processed food waste + Raw food waste | Candy + chips + tapioca peel + banana peel + coconut husk |
| C       | Processed food waste + Raw food waste (Product A) | Candy + coconut husk |
| D       | Processed food waste + Raw food waste (product B) | Chips + tapioca peel + banana peel |

2.3 Parameter Measurement

DR 6000 Spectrophotometer was used to analyze the concentration value of N and P, while Atomic Absorption Spectrophotometer (AAS) was used to get the concentration of K, by according to method in APHA Water and Wastewater. pH meter was used to measure the pH value of the reactor every week whether it is acid or alkali and thermometer was used to measure temperature every day.

3. Results and Discussions

3.1 Temperature

The temperatures of each reactor were measured before disposing any food waste into the reactor. The changes of temperature during the first month of the composting process. The highest temperature averages between 45°C to 47°C. The increase of temperature during the composting procedure is due to the high temperature generated by the microorganisms through respiration activities and decomposition of organic materials. The temperature of composted matter determines the rate of many biological processes and plays a basic role in microorganism succession understood as a change in the quantitative and qualitative composition of microorganism population [5].

The temperature pattern showed that there was a rapid rise from the initial mesophilic phase to the thermophilic phase for all reactors in the first three months, which lead to a high proportion of readily degradable substances. In that respect is no common definition of mesophilic and thermophilic, but more frequently than not refers to temperature up 40°C, and thermophilic temperatures are from 45°C up to 70°C. When the temperature reaches 40°C to 50°C, both phase microorganism takes place [6]. It is the active phase of composting. Most of the reactors reach the second phase in those three months of the composting process which the rates of temperature between 40°C to 47°C.

The most active reactor between these six months was reactor A that contain process of food waste (candy and chips) and reactor D (chips + tapioca peel + banana peel). This explains the findings that the microorganisms can withstand one extreme environmental factor, or which is high temperature [7]. Up till the final month of composting, most of the time, Reactor A and Reactor D always shows an increasing rate of temperature.

After the thermophilic phase which corresponds to a peak of degradation of fresh organic matter, the microbial activity decreases, as does the temperature especially in the Reactor B whereas less than control. This is called the cooling phase. This is supported by drop of the temperature below 40°C as the number of fungi in the composted mass increased. The compost maturation phase begins when the compost temperature falls to that of the ambient air.
3.2 pH value

The initial pH during week one among the six reactors is 5.10 to 7.32 as shown in Figure 1. In general, in the composting process, the pH falls below neutral in the beginning due to the formation of organic acid and later rise above neutral because the acids are consumed [8]. Most of the pH value in each reactor is above 5. The reason for this was the microbial respiration in the well-controlled composting reactor that was inhibited [8]. The highest pH obtained between six reactors was reactor B, when the composting process entered its thermophilic phase. The pH increase from week one followed by week two and three, however, by the end of week four, the value of pH decrease to 4.99. The decrease of pH value at the end of composting process may also obtained due to the increase of carbon dioxide (CO2) emissions from organic acids [8, 9].

![Figure 1. Changes in pH of composting mixtures against time.](image)

3.3 Nitrogen (N) Concentration

Most of the reactors were not reached the matured phase of composting by week four especially for reactor A, reactor B and reactor D because the degradation of wastes is still taking place as shown in Figure 2. The mature phase which is the organic material continue to decompose and are converted to biologically stable humic substance In addition, the increase in the N value at the end of the composting period of all reactors might occur due to the usage of N by microorganism to build up cells, thus reducing the N, and some of the organisms will eventually die, which is recycled as N and thus contribute to increase the value [10].

![Figure 2. Nitrogen content in composting mixtures against time.](image)
3.4 Phosphorus (P) concentration
In general, the trends of P concentration in the reactors are slightly increase within week four. P content in Reactor B gradually increased during the composting process as shown in Figure 3. The highest concentration was obtained in Reactor B and the lowest concentration was demonstrated in Reactor A. According to previous researcher, concentration of phosphorus increased during the composting process, and the water solubility of phosphorous decrease with humification so that the phosphorous solubility during the decomposition was subjected to further immobilization factors [11,12].

![Figure 3. Phosphorus value in composting mixtures with weeks.](image)

3.5 Potassium (K) concentration
Reactor A decrease from week one to week two but slightly similar from week three until week four. The same condition was demonstrated by Reactor A+B, Reactor C and Reactor D as shown in Figure 4. The concentration of K in Reactor B is slightly increased from week one until week four. This might due to high inherent content in banana peels [13].

![Figure 4. Potassium value in composting mixtures against time.](image)

3.6 Comparison between organic compost and chemical fertilizer
Table 2 shows the comparison been NPK value from organic compost with chemical fertilizer. On the other hand, Table 3 shows the comparison of the organic compost from this study with the valueable organic fertilizer in the market. Nutrient compositions in chemical fertilizer are high to ensure the amount is sufficient to assist plant to grow well. Chemical fertilizers are produced synthetically from inorganic materials. Since these chemical fertilizers are prepared from inorganic materials artificially, it may have some harmful acid that could affect the plant growth. As for the food waste organic fertilizer, the values shown potential as this value will be increased once all the food waste are fully degrade in the compost and matured enough to become fertilizer. Nevertheless, The comparison between organic compost and fertilizer shows similar results.
Table 2. Percentage of N-P-K value of the food waste composting.

| Sample          | N (%) | P (%) | K (%) |
|-----------------|-------|-------|-------|
| Reactor A       | 3.2   | 0.02  | 0.07  |
| Reactor B       | 5.7   | 0.04  | 0.16  |
| Reactor A+B     | 4.3   | 0.02  | 0.08  |
| Reactor C       | 5.5   | 0.03  | 0.07  |
| Reactor D       | 0.5   | 0.02  | 0.08  |
| Chemical Fertilizer [14] | 20   | 40   | 25    |

Table 3. Percentage of N-P-K values for organic compost.

| Organic materials | N(%) | P(%) | K(%) |
|-------------------|------|------|------|
| Cow dung          | 1.30 | 0.58 | 2.15 |
| Cassava peeling compost | 1.70 | 0.86 | 1.50 |
| Rabbits dropping  | 1.04 | 0.99 | 2.05 |

Source: [15]

4. Conclusions

In this composting study, temperature and pH value during the composting process was found to reach the level of the proposed range of 40°C to 47°C, 5.1 to 8.6 and surpassed 90%. N content ranges from 35325 mg/L to 78775 mg/L, P from 195.83 mg/L to 471 mg/L and K from 422.3 mg/L to 2046 mg/L. Reactor B showed the most effective composting process in this composting study. Reactor B which consists of banana peel waste is easily decomposed and the nutrient produced in compost is much faster and higher than others. This is probably due to the oxygen and supplementary nutrient supply that could promote specific growth of microorganism essential for mineralization of organic substance. High K and N content in banana peel compost reactor is to assist in obtaining high potential K and N nutrient source in the soil. The concentration of N showed increased slightly between each reactor by week. On the other hand, the concentration of P and K are more focus on reactor B that are greater than other reactor. The different concentration indicated that presence of food waste added will differ amount of NPK due to microbial activity that produce microbes. There is a potential for this organic food waste from this composting study to be used as an organic fertilizer. Eventhough the NPK value is considerably low in comparison to chemical fertilizer, the NPK value from this study were found to be comparable with organic fertilizer. The results indicate that the value will be increased steadily as the compost process is fully matured.

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