Food Waste Composting Study from Makanan Ringan Mas

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Abstract: The poor management of municipal solid waste in Malaysia has worsened over the years especially on food waste. Food waste represents almost 60% of the total municipal solid waste disposed in the landfill. Composting is one of low cost alternative method to dispose the food waste. This study is conducted to compost the food waste generation in Makanan Ringan Mas, which is a medium scale industry in Parit Kuari Darat due to the lack knowledge and exposure of food waste recycling practice. The aim of this study is to identify the physical and chemical parameters of composting food waste from Makanan Ringan Mas. The physical parameters were tested for temperature and pH value and the chemical parameter are Nitrogen, Phosphorus and Potassium. In this study, backyard composting was conducted with 6 reactors. Tapioca peel was used as fermentation liquid and soil and coconut grated were used as the fermentation bed. Backyard composting was conducted with six reactors. The overall results from the study showed that the temperature of the reactors were within the range which are from 30° to 50°C. The result of this study revealed that all the reactors which contain processed food waste tend to produce pH value within the range of 5 to 6 which can be categorized as slightly acidic. Meanwhile, the reactors which contained raw food waste tend to produce pH value within the range of 7 to 8 which can be categorized as neutral. The highest NPK obtained is from Reactor B that process only raw food waste. The average value of Nitrogen is 48540 mg/L, Phosphorus is 410 mg/L and Potassium is 1550 mg/L. From the comparison with common chemical fertilizer, it shows that NPK value from the composting are much lower than NPK of the common chemical fertilizer. However, comparison with NPK of organic fertilizer shown only slightly difference value in NPK.

Keywords: Food waste, backyard composting, npk, organic compost, tapioca peel.

1. Introduction
According to the Solid Waste Management Act 2007, Act 672[1], solid waste is defined as any unwanted substance; material or product that is broken, contaminated or worn out that required by the authority to be disposed. In Malaysia, landfill is the most common method of solid waste disposal and up to 50% of landfill is containing with food waste. Inarguably, the generation of Municipal Solid Waste is highly dependable on the food waste generation. Based on research by Saeed, et.al [2], the food waste generation rate is up to 60% from MSW. Basically food waste is generated from many different sources. Agriculture, household, commercial, institutional, industrial have all contributes to the food waste production.
Essentially, all of the mentioned sources are producing food waste but in different quantity. Therefore it is highly important to also include MSW management plan for all these different sources. There are many options in disposing food waste. There are by composting, sanitary landfills and incineration. However, this study is only focusing on composting.

Composting is a natural process that turns food waste into compost that is rich with nutrients for the soil. Composting the food wastes is able to reduce the food waste being disposed in landfill and also help the food industries in managing their wastes. As a result, the new organic fertilizer can be made. Li et.al.[3] stated that composting helps to improve the soil structure and fertility. According to Chang and Hsu [4], the chemical changing process and the complex metabolic processes of various microorganisms vary with the composition of the material composting. Particularly, the outcome of the composting is depending on the waste characteristic. Composting is an easy, economical and natural biodegradation process that takes organic waste usually food waste and turns into nutrient rich food for plants. Composting is a biochemical process converting various components in organic waste into relatively stable humus-like substances that can be used as a soil amendment or organic fertilizer [3].

Composting usually used for organic farming, occurs by allowing organic waste to sit in one place for months until microbes decompose it. Composting is one of the best method of waste disposal as it can turn unsafe organic into safe compost. Nevertheless, disadvantages of composting are it is a slow process and takes a lot of space. According to Hanc, Szakova, & Ochecova [5], the advantages of composting are that it minimizes damage to the environment and produces economically valuable products from the bio-waste.

In this study, Makanan Ringan Mas industry have been chosen as sampling area because the area is far away from the main road, so the solid waste management in the area needs to be done own their own without collection and facilities provided. Solid waste generation from Makanan Ringan Mas Industry is mostly food waste. The food waste were burned and dumped into the river by the workers and that affect our environmental sanitation thus causing air and water pollution.

Due to the improper waste management at Makanan Ringan Mas Industry, investigation on food waste composting as an alternative disposal method was in need to be conducted to obtain a good practice of food waste management.

2. Materials and Methods

2.1 Collection of food waste

Food waste samples were collected from Makanan Ringan Mas, a small and medium industry producing food waste such as chips, coconut candy, coconut grated and fruit peels. It is located approximately 13.5 km away from Universiti Tun Hussein Onn Malaysia (UTHM). The collected food wastes were tapioca peel, banana peel, banana chips, coconut candies and grated coconut. The food wastes were collected twice a week in 6 months period throughout the study and the collected food wastes were weighed accordingly.

2.2 Preparation for fermentation liquid

For this study, tapioca peels were used as fermented food as a substitute for fermented soybeans product that are normally used and coconut candy were used to replace brown sugar. The tapioca peel were mixed with 250 gram coconut candy with 3 liter of water for 5 to 7 days to produce the fermentation liquid. The container was closed loosely because of the gases that produced during the fermentation process. The sweet and sour smells produced indicate that the fermentation liquid is a success.

2.3 Preparation for fermentation bed

The material that was used for the fermentation bed was grated coconut waste from the industry. Makanan Ringan Mas small scale industry has always producing a lot of grated coconut. To fully utilize the waste produce at Makanan Ringan Mas, the grated coconuts were used as the fermented bed material. To make the
fermented bed, 2 kg soil and 1 kg grated coconut were mixed. The grated coconuts were used to substitute the rice husks as nitrogen source and soil as the carbon source in the fermented bed.

2.4 Preparation of the reactors
Baskets were used as reactors to carry out the process of composting. The baskets were covered with carpet to prevent the compost spilled and insect infestations. The reactors were then covered with breathable fabric for ventilation. Each reactor was labelled according to the type of food waste as shown in Table 1.

| Reactor | Classification of food waste | Types of food waste |
|---------|------------------------------|---------------------|
| CONTROL | Control                      | -                   |
| A       | Processed food waste         | Chips + candy       |
| B       | Raw food waste               | Banana peel + tapioca peel + grated coconut |
| A+B     | Processed food waste + raw food waste | Candy + chips + tapioca peel + banana peel + grated coconut |
| C       | Processed food waste + raw food waste (Product A) | Candy + grated coconut |
| D       | Processed food waste + raw food waste (Product B) | Chips + tapioca peel + banana peel |

Each reactor was filled with 3 kg fermented beds that have been mixed with fermentation liquid. The reactors were covered with breathable fabrics for 3 to 5 days under room temperature (27°C). In addition, the reactors were placed indoor at Micropollutant Research Center (MPRC) to avoid any water from outside from entering the reactors. After 5 days, food wastes were added into the reactors. The food wastes were cut into smaller sizes to make it easier to compost. Afterwards, the mixtures were stirred once a day to allow air to improve the composting process. When the fermented bed started to dry, water was added to ensure the right moisture for the bacteria in the reactor. The compost process would take up 3 to 6 months to become matured and could be used as organic fertilizer.

2.5 Physical and chemical parameters
All the compost samples from each reactor in this study were tested for physical and chemical parameters every week with two replicate of samples for every reactors.

   In physical parameter, the pH value, and temperature from each reactor was measured. The pH values of the compost were determined by mixing the compost into distilled water. Ten gram of waste was weighed and 25 mL distilled was measured and put in a beaker. The samples were stirred for 10 minutes. After 3 minutes or when the samples have settled, the samples were tested with pH meter to get the reading.

   The temperature was taken every day for each reactor to record the changes in temperature during composting. Each reactor temperature was taken three times at different places to have the average value of each of the reactors.

   The chemical parameters were carried out according to standard APHA method. The chemical parameter including Nitrogen, Phosphorus and Potassium were conducted in this study. Nitrogen and phosphorus concentration was analyzing using DR6000 Spectrophotometer, while potassium concentration was analyzing using Atomic Absorption Spectroscopy (AAS).

3. Results and Discussions
3.1 Analysis on pH value
In this study, the pH values were measured during 5 month of composting process. It is to be highlighted from the Figure 1, the reactor A, C and D was below pH 7 which indicating that the waste samples were acidic. Acid pH values indicate a lack of maturity due to short composting time or occurrence of anaerobic conditions. The waste in reactor A contained processed food waste which are chips and candy. Reactor C contained processed
and raw waste which are chips, candy, tapioca peel, banana peel and grated coconut waste. Meanwhile, Reactor D contained waste candy and grated coconut. Based on the result, the pH value for reactor control is neutral between 7 and 8. It is because there is no waste insert in the reactor. As for Reactor B, the pH value was in range of 7 and 9. This is because the wastes are raw food wastes which are only tapioca peel and banana peel.

Figure 1. Analysis on pH value of every reactor.

3.2 Analysis on temperature
The temperature of composting for different reactors for the first month of the study increase significantly besides reactor control. At 20th November, the temperature recorded was the highest with 48°C. This indicates that the microorganisms such as bacteria and fungi are responsible on heat generation during composting cause in lost moisture content [6]. However, then the temperature began to fall slightly. As for the reactor control, the temperature did not have major changes because there is no waste added.

The temperatures were observed when Tapioca peel is utilized in the fermentation liquid from December 2014 to February 2015. Based on previous study by Tweib et al, [6], the initial temperature was 26.5°C and increased up to 58°C. Above all, all the temperature showed the same pattern. Based on these figures, the average temperature of the compost in all the reactors was between 30°C and 52°C from December 2014 until February 2015. There were certain weeks that the recorded temperature increases dramatically because each reactor was sprayed with water once a week. The water was added to the waste to attain the desired moisture level. Apparently, the waste did not produce enough moisture in order for the microbial activity to take place. The food waste are being disposed and mixed every day.

The temperature continued to show the same pattern for all the months except in March, 2015 where the temperature was ranging from 26°C to 35°C. In March, all the activity including waste inserted, water added and compost mixture were stopped to allow the compost in each reactor to mature and age. The drop in temperature also was mentioned in a study by Fatin et. al, [7] which stated that the temperature decrease as the activity of the microorganisms slowed, indicating that the compost was nearing its mature phase.

3.3 Nitrogen
Figure 2 shows the result of nitrogen for four weeks at the 5th month of composting. The graph shows the comparison of Nitrogen between the food waste reactors with the control. Reactor A was inserted with processed food waste from Makanan Ringan Mas such as chips and coconut candy. It showed that the nitrogen decreased steadily until it rises up at week four with 56000 mg/L. Meanwhile, Reactor B was inserted with raw food waste which is banana and tapioca peel. This reactor showed that the nitrogen value increased slowly and then significantly increased at the fourth week. Reactor B has the highest Nitrogen value by 96200 mg/L compared to other reactors. Reactors A+B was inserted with mixture of all food waste. The results showed that the nitrogen value fluctuated but as for the fourth week, the reactor continued to increase with the recorded value of 71400 mg/L. As for Reactor C, the inserted wastes were based on all types of coconut waste from Makanan Ringan Mas Industry. The graph was skewed-left. The highest Nitrogen recorded was at the third week which is 57200 mg/L. Reactor D was inserted with banana and tapioca wastes. Based on the graph, it showed that the result pattern was increased significantly until week four. The highest nitrogen value recorded was 57000mg/L.
As a conclusion, the pattern of nitrogen value on all of the reactors showed the highest value of nitrogen in week four except for reactor C. Reactor C obtained the highest nitrogen value was in week three. According to Huang et. al 2004, the reactors that have highest Nitrogen at the last week because, the Nitrogen fixing bacteria might also have contributed to the increase in Nitrogen in the later stage of composting.

![Figure 2. Nitrogen result.](image)

### 3.4 Phosphorus

The result from the study indicate that the Reactors A and C shows a high level of phosphorus at the third week. However, for the whole four weeks, reactor B produced the highest phosphorus compared to other reactors. Reactor A+B did not show any big difference for the whole four weeks. On the other hand, reactors D results shows that the Phosphorus value increase steadily for all weeks.

![Figure 3. Phosphorus result.](image)

Figure 4 shows potassium result of food waste reactors compared to control. Reactor A did not show any drastic changes from control reactor. Reactor B shows the highest potassium recorded for the first week with 1997 mg/L but then it drops to 1328 mg/L at the fourth week. Reactor A+B shows decreasing but then increasing steadily and recorded highest potassium at the week four. However, reactor C did not shows any drastic changes for three weeks until it increase strongly at week four. On the other hand, reactor D recorded the highest potassium at week 2 with 861 mg/L and then decrease to 652 mg/L at week four.
3.5 Comparison of Nitrogen, Phosphorus and Potassium with chemical fertilizer

Table 2 shows the comparison of NPK between the chemical fertilizers with compost from the food waste composting. From the table it shows that the NPK value of chemical fertilizer is higher than NPK produced from the compost. Based on previous study by [7], Table 3 shows the nutrient from several of organic compost. From the tables it shows the NPK percentage is different between compost. However the comparison with other studies on organic compost only shown slightly difference in NPK compared with chemical fertilizer. The nutrient that being produced varied according to the type or organic compost and wastes that was used. From the table 2 it shows that reactor B with raw type of waste have produced the highest NPK than the rest of the reactors. Even though chemical fertilizers have high percentage in NPK, organic fertilizers are still the best fertilizers because of their micronutrient content and their ability to be both fertilizer and regenerate poor soil condition.

Table 2. Comparison of Nitrogen, Phosphorus and Potassium with chemical fertilizer.

| Sample         | Nitrogen, N (%) | Phosphorus, P (%) | Potassium, K (%) |
|----------------|-----------------|-------------------|------------------|
| Chemical fertilizer [8] | 20              | 40                | 25               |
| Reactor Control   | 2.93            | 0.020             | 0.041            |
| Reactor A         | 3.92            | 0.023             | 0.045            |
| Reactor B         | 4.85            | 0.041             | 0.155            |
| Reactor A+B       | 4.68            | 0.027             | 0.057            |
| Reactor C         | 4.39            | 0.025             | 0.050            |
| Reactor D         | 4.00            | 0.027             | 0.070            |
Table 3. Chemical analysis for organic compost.

| Sample                  | Nitrogen, N (%) | Phosphorus, P (%) | Potassium, K (%) |
|-------------------------|----------------|------------------|-----------------|
| Cow dung                | 1.3            | 0.58             | 2.15            |
| Poultry manure          | 2.21           | 2.98             | 2.05            |
| Cassava peelings compost| 1.7            | 0.86             | 1.50            |
| Rabbit droppings        | 1.04           | 0.99             | 2.05            |
| Cane rat droppings      | 1.95           | 2.06             | 3.30            |

4. Conclusion
This study shows that composting process is one of the alternative ways to reduce food waste generation at Makanan Ringan Mas Industry. It can be concluded that from the results that obtained, all parameters have different value due to different wastes that were being used in each reactors. Primarily, every reactor showed different value in temperature. This can be assumed that, each reactor had a different temperature range due to the different in food wastes used. Higher in temperature revealed that there was a high microbial activity. Nevertheless, the temperature must be within the range of 30°C to 50°C. The overall results from the study showed that all of the reactors were within the range.

As for the pH value, the result of this study revealed that the reactors which contain processed food waste tend to produce pH value within the range of 5 to 6 which can be categorized as slightly acidic. Meanwhile, the reactor which contained raw food waste tend to produce pH value within the range of 7 to 8 which can be categorized as neutral. As for Reactor B pH value is 7 to 8 nearest to neutral which is the optimum value for composting. It can be concluded that different food wastes will results in different pH value.

The results also indicate that each waste produce different value of NPK. Moreover, the value of NPK in composting reactor did not showed significantly difference when it is compared with NPK in reactor control. From this study, it showed that tapioca peel can be used as the fermentation liquid in food waste composting, although it shows different value of NPK from the reactors. The highest NPK obtained is from reactor B that process only using raw food waste. The average value of Nitrogen is 48540 mg/L, Phosphorus is 410 mg/L and Potassium is 1550 mg/L. From the study it shows that the NPK compost only increases slightly when compared with reactor control. Longer observation is recommended to monitor the NPK value and more time was given for the compost to mature. The comparison with common chemical fertilizer shows that food waste composting from Makanan Ringan Mas determine lower NPK value. However, the comparison with available organic compost only shown slightly difference value in NPK. Nevertheless organic compost is much better because it is one of the alternative ways to treat waste that is more environmentally friendly. In addition composting can improve soil structure and soil fertility.

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