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Turmeric As Adjuvant in Converting Food Wastes into Organic Fertilizer

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Abstract

According to the Malaysia Ministry of Housing and Local Governance, up to 38,000 tons of solid trash are produced daily by Malaysians; of that number, 17,000 tons are food waste, accounting for 44.5 percent of the total composition of solid waste. Most food waste ends up in landfills, where it releases methane gas, which contributes to the greenhouse effect. In order to prevent food waste from being dumped, food waste is transformed into organic fertilizer in this research by integrating turmeric. Turmeric's well-known properties as a natural insecticide and plant wound healer may increase the effectiveness of organic fertilizers. In the cafeteria and canteen of Politeknik Kuching Sarawak (PKS), food waste samples such as eggshells, shells, and green vegetables are collected. These samples are then placed in a compost bin and covered with dry leaves, soil, water, and turmeric. Research is performed on the organic fertilizer's composition and pH levels. Therefore, a comparison is made between the effectiveness of chemical and organic fertilizers. In summary, the growing growth of chili trees has been efficiently supported by the addition of turmeric to organic fertilizer made from food waste collected from the cafeteria and canteen at Politeknik Kuching Sarawak (PKS).

Keywords: - Organic fertilizer, eggshell, carbonyl group (C=O), amine group (N-H), carboxylic acid group (O-H)

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1. Introduction

Food waste is a worldwide problem that crosses across national boundaries and has a significant impact on society, the economy, and the environment. Global production of biodegradable trash is estimated to be 38 billion metric tons annually. According to the study conducted by SWCorp showed that Malaysians generated 38,000 tons of solid waste daily in 2016, of which 15,000 tons was food waste (Hamid et al., 2019). This staggering wastage occurs at various stages, from the fields and farms where crops are grown to the processing, distribution, retail, and consumer levels. Dumping food wastes may have an adverse effect on the environment because organic matter breaks down in landfills to produce methane, a greenhouse gas that accelerates climate change.

Using food waste as organic fertilizer is a sustainable practice that helps recycle nutrients and reduces the environmental impact of discarded foods. If properly managed, food waste can be transformed into valuable compost, enriching soil fertility and promoting plant growth. Additionally, organic fertilizer has less negative impact on the soil as compared to chemical fertilizer. Food waste can be converted into organic fertilizer through a natural process known as composting. Composting is the controlled decomposition of organic materials, including food waste, by microorganisms such as bacteria, fungi, and other decomposers. The composting process includes collection, separation, layering, mixing, maturation, screening, and application to soil.

Turmeric can offer some indirect benefits to soil and plants, such as natural pesticides, disease resistance, and nutrient content, including essential elements like nitrogen, phosphorus, and potassium. In this research, turmeric is mixed in a compost bin to increase the quality of the organic fertilizer produced.

Food wastes from cafeterias, including vegetables, fruit peels, coffee grounds, eggshells, and tea leaves, are utilised as raw materials for composting, according to a study by Hamid et al. (2019). To lessen excess moisture, soil, shredded paper, and newspaper are added to the composting process in addition to dry leaves. Because of their capacity to absorb, certain materials can take in water. Likewise, since cooked food, meat, and fish contain pathogens that could contaminate the compost, they shouldn't be added to the compost. Additionally, greasy and oily materials like cheese or hard objects like bones shouldn't be composted.

In composting process, greens and browns are needed as the basic source as the composting materials for Carbon and Nitrogen source. Table 1 shows the source of Carbon and Nitrogen to be put into the composting process.

Table 1. List of Carbon and Nitrogen source (Hamid et al., 2019)

Nitrogen source	Carbon source
Discarded vegetables or vegetable peels	Dry leaves
Fruit peels	Soil
Coffee and tea grounds	Shredded paper and newspaper

During the composting process, pH value is recorded to ensure the organic fertilizer in the range satisfactory value of pH 7 to 8.5. Based on Nordin et al. (2022) research, the changes in soil pH have a significant impact on plant growth. The ideal range for bacterial development in the soil to facilitate decomposition is in the centre of the pH scale. The breakdown process releases nutrients and minerals into the soil, allowing plants and shrubs to use them. The acidic phase varied from pH 2.0 to 6.5 until day 24. On the 25th day, the pH value rose to 7.0 and maintain in neutral stage until the end of the composting process at pH 7.5. The pH rose after a period because the acids were consumed (Hamid et al., 2019). The pH rise also can be explained by the generation of ammonia from ammonification and mineralization of organic nitrogen through microbial activities (Huang et al., 2001).

In addition to pH value, the composition of the organic fertiliser is very important to confirm the existence of important substances such as nitrogen, phosphorus, and potassium. To study the composition of the organic fertilizer, Fourier transform infrared spectroscopy (FTIR) analysis is required because the results of the FTIR spectrum reveal the soil's general chemical composition as well as information on its organic and mineral components.

The amount of yeast, eggshells, and banana peels acceptable for the organic fertilizer combinations in the chili plant is listed in Table 2, according to a study by Nordin et al. (2022). In Addition, the result of the FTIR analysis of Sample B in this study also showed that Sample B has compounds that displayed clear peaks in the spectrum. In the FTIR spectrum of Sample B, the sharp peak at 1030.804 cm-1 appeared to be responding to phosphate molecules with medium intensity. The small peak at 1420.923 cm-1 exposes a carbonyl group (C=O) with a low intensity band. The medium absorption peak at 1628.084 cm-1 corresponds to the amine group (N-H) with medium intensity. The final peak is at 3276.291 cm-1, exposing a wide and strong absorption band that can be related to the carboxylic acid group (O-H) and amine group (N-H). These peaks in the FTIR spectrum of Sample B indicate that the carboxyl, nitrogen, and phosphate compounds are presented in banana peel, eggshells, and yeast (Nordin et al., 2022).

Table 2. Amount of fertilizer in every chili plant (Nordin et al., 2022)

Sample	Banana peel (g)	Eggshell (g)	Yeast (g)
1	1.6	6.0	1.0
2	3.2	12.0	2.0
3	4.8	18.0	3.0
4	6.4	24.0	4.0

2. Methodology

2.1 Materials Collecting Process

Before the composting process, materials are collected in designated area. For eggshell, shells and green components food waste such as vegetables are collected at canteen and cafeteria in Politeknik Kuching Sarawak. Container for green vegetables, eggshell and shell wastes is provided to the workers at the canteen and cafeteria to help them separate the wastes easier. Dry leaves are collected at Politeknik Kucing Park (Poliku Park).

2.2 Composting Process

The dry leaves, green components, eggshell and shell are spread on the newspaper sheet under sunlight for drying process. The drying process time will take around three days. Then, the eggshell is breaking down inside a plastic bag by beating it using gardening fork. All the materials will be placed layer by layer in containers as shown in Fig. 1. Two containers are prepared as organic fertilizer samples with turmeric and without turmeric. Below are the steps to fill the compost container:

Step 1: The bottom container was filled with the thick layer of soil.

Step 2: Dry leaves was placed on the soil and layer with green vegetables husk.

Step 3: Then, the soil was layered and followed by some eggshells on the top of soil.

Step 4: Soil was layered again and shells was placed on the top.

Step 5: Turmeric and some water was sprinkled on top of the fertilizer and the container was sealed with a tape.

Step 6: All the steps was repeated for another container but without turmeric.

The composting period is one month. The pH of the organic fertiliser will be tested weekly. The ideal range for bacterial development in the soil to facilitate decomposition is at the centre of the pH scale. The breakdown process releases nutrients and minerals into the soil, allowing plants and shrubs to use them. The pH of the soil determines its fertility.

After one month, the organic fertilizer with and without turmeric is tested on chilli trees for one month. The plant growth, including height and number of leaves, is recorded and compared with the chemical fertilizer on the market.

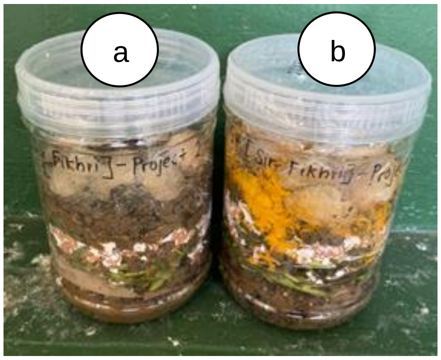
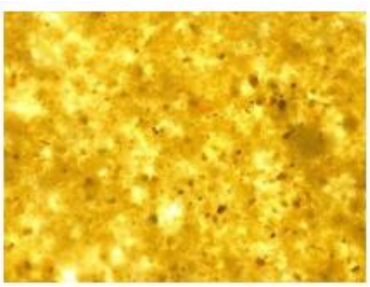


Fig. 1. Organic fertilizer samples (a) without turmeric and (b) with turmeric

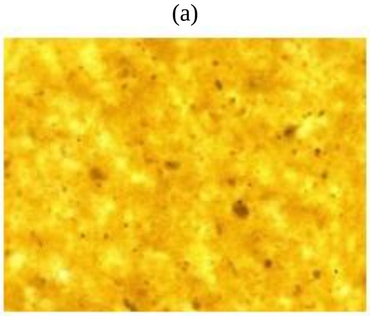
3. Result and Discussion

3.1 Microscope Observation

After a month of composting, conditions between organic fertilizer with turmeric and without turmeric are observed in detail under a microscope, as shown in Fig. 2. The microscope observation of organic fertilizer with turmeric is a bit dark and yellowish compared to organic fertilizer without turmeric.



(a)

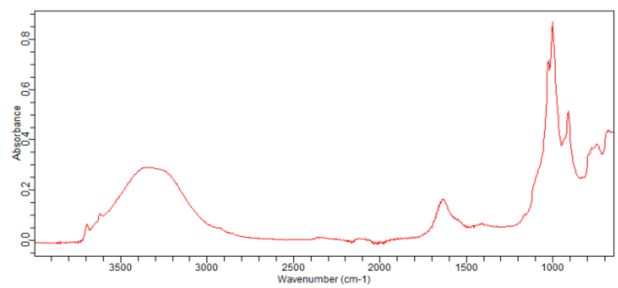


(b)

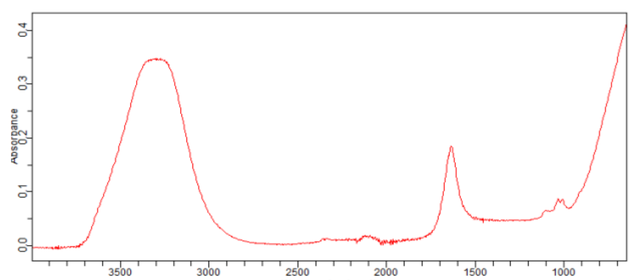
Fig. 2. Microscope observation (10x zoom) organic fertilizer (a) with turmeric and (b) without turmeric

3.2 FTIR Analysis

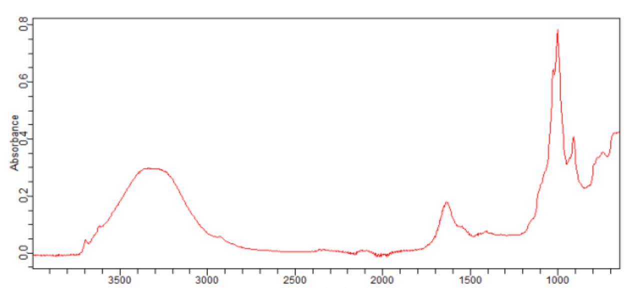
Fourier Transform Infrared (FTIR) spectroscopy is a powerful analytical technique used to identify and characterise chemical compounds based on their molecular vibrations. In the context of organic fertilizers, FTIR analysis can provide valuable information about the composition and structure of the organic matter present in the fertilizer. Different functional groups in molecules absorb infrared radiation at characteristic frequencies, allowing analysts to identify the presence of specific chemical bonds. Based on a study by Majee et al. (2020), the peak at 3300 cm−1 exposing a wide and strong absorption band. This can be related to the hydroxyl (OH) and amine (NH) group (Domínguez et al., 2006). The small peak with a low-intensity band at 2345 cm−1 corresponding with the N-H stretching of an amine group (Sulaiman et al., 2010). The signal at 1658 cm−1 respecting to C=O bond of the carboxylic group (Smidt et al., 2002) and the band at 1450 cm-1 revealing the deep and long peak which corresponding to CH and NH (amide II) groups, are related to the presence of proteins in the peak, which organic fertilizer (Bailey et al., 1998). In this research, FTIR analysis is applied to check the composition of organic fertilizer produced. Fig. 3 shows all FTIR results for with and without fertilizer in solid and liquid form.



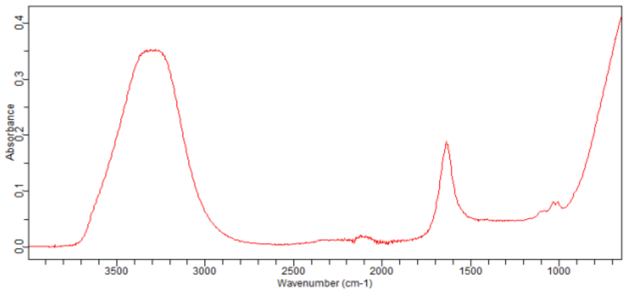
(a)



(b)



(c)



(d)

Fig. 3. FTIR spectrum organic fertilizer samples (a) without turmeric (solid form), (b) without turmeric (liquid form), (c) with turmeric (solid form) and (d) with turmeric (liquid form)

Based on Fig. 3, it showed that organic fertilizer has the compound that displayed clear peaks in the spectrum. The functional group of every peak is identified by comparing with result from a study by Nordin et al. (2022). Based on the observation, the FTIR spectrum for organic fertilizer with and without turmeric sample have the same peaks in liquid and solid form. For all samples, the peak can be observed at wavenumber 1030 cm^{-1}, 1600 cm^{-1} and wide peak between 3000 cm^{-1} to 3500 cm^{-1}. The peak at 1030 cm^{-1} appeared responding to phosphate molecules. For the peak at 1600 cm^{-1} is refer to amine group (N-H) while the wide peak between 3000 cm^{-1} to 3500 cm^{-1} can related with the carboxylic acid group (O-H) and amine group (N-H). These peaks in the FTIR spectrum showed that the carboxyl, nitrogen, phosphate compounds are presented in green vegetables, eggshells and mussel shells.

3.3 pH Analysis

pH, or the potential of hydrogen, is a measure of the acidity or alkalinity of a solution. In the context of organic fertilisers and agriculture, pH plays a crucial role in the effectiveness of the fertiliser and the overall health of the soil and plants. The range of pH is very important to determine the nutrient availability, microbial activity in the composting process, and biological diversity. According to previous research by Bratovcic et al. (2018), organic compost has a little bit lower pH value (6.37) but remain neutral. The pH value of organic fertiliser was determined by a pH meter. The pH metre probe was placed into the compost container containing organic fertiliser with and without turmeric. The pH reading is taken every week for one month to observe the pH value variation, as shown in Table 3.

Table 3. pH value sample organic fertilizer with and without turmeric

Week	pH Value Sample Organic Fertilizer with Turmeric	pH Value Sample Organic Fertilizer without Turmeric
1	6.56	5.96
2	6.32	5.91
3	6.44	5.87
4	6.52	5.94

Based on Table 3, the pH value of organic fertiliser without turmeric is slightly acidic compared to organic fertilizer with turmeric. The pH value reading is decreasing from week 1 to week 3 and increasing at week 4 for both samples. Based on previous research (Nordin et al., 2022), the ideal pH value for a chilli plant is around 5.5 to 6.8. The neutral pH value is very important because composting is a biochemical process that converts various components in organic waste into relatively stable humus-like substances that can be used as a soil amendment or organic fertilizer. If the pH value is too acidic or alkaline, it will affect the microbial activity during the composting process, which may cause organic fertiliser production.

3.4 Effectiveness of Organic Fertilizer with and Without Turmeric

Plant fertilising is a fundamental practise aimed at optimising plant growth, health, and productivity by supplying essential nutrients. While soil naturally contains some of the necessary elements for plant development, these nutrients can become depleted over time, hindering the plant's ability to reach its full potential. To observe the effectiveness of the organic fertiliser produced, the fertilizer is tested on chilli plants. Chili plant growth, such as the height of the chilli tree and the number of leaves per chilli tree, were recorded as shown in Fig. 5 and Fig. 6. Three chilli trees were planted in different colours of pots, like in Fig. 4. Every pot will be fertilised using organic fertilizer with turmeric (sample A), organic fertilizer without turmeric (sample B), and chemical fertilizer (sample C) two times per week for one month.

Sample A Sample B Sample C

Fig. 4. Picture of sample A, B and C

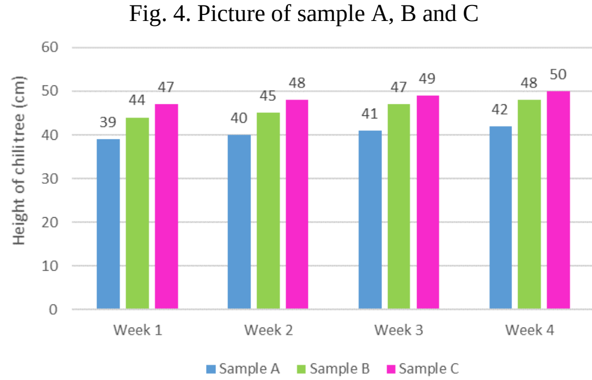


Fig. 5. Height of chili tree (cm) for sample A, B and C

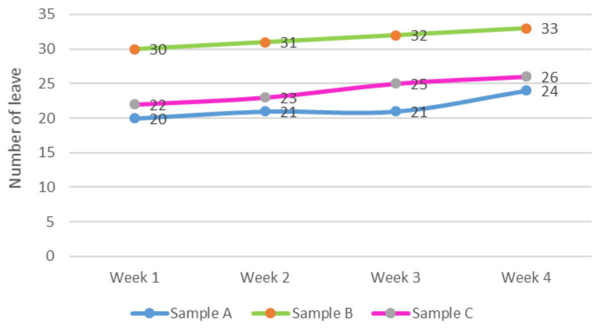


Fig. 6. Number of leave per chili tree for sample A, B and C

Based on Fig. 5 and 6, the height of the chilli tree and the number of leaves per chilli tree are increasing from week 1 to week 4 for the three samples. For the height of chilli trees, sample B has the highest difference between weeks 4 and 1, which is 4 cm, while samples A and C show the highest difference between weeks 4 and 1 for the number of leaves per tree. The result obtained showed that the turmeric component is acceptable as an addition to organic fertilizer because the growth (the difference height and number of leave between week 1 and 4) of sample A is always the same as that of samples B and C without any sign of stunted growth.

4. Conclusion

In conclusion, the addition of turmeric to organic fertilizer based on food wastes such as green vegetables, eggshells, and shells from the cafeteria and canteen in Politeknik Kuching Sarawak (PKS) has effectively increased the growth (the difference height and number of leave between week 1 and 4) of chili trees. With the addition of turmeric, organic fertilizer may benefit in terms of natural pesticides, disease resistance, and nutrient content, including essential elements like nitrogen, phosphorus, and potassium. Based on the FTIR and pH analysis results, it was also shown that turmeric organic fertilizer properties are appropriate to be applied in agriculture with carboxyl, nitrogen, phosphate compounds appeared in FTIR analysis result while pH range from 6.32 to 6.56 is measured for four weeks. By using the food waste as organic fertilizer, the dumping of food waste can be reduced, economically save costs, and may replace the chemical fertilizer that contains ammonia and nitrogen, which have a non-desired impact on the environment and cause water pollution.

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References

Bailey, A. J., Paul, R. G., & Knott, L. (1998). Mechanisms of maturation and ageing of collagen. *Mechanisms of ageing and development*, *106*(1-2), 1-56.

Bratovcic, A., Zohorovic, M., Odobasic, A., & Sestan, I. (2018). Efficiency of food waste as an organic fertilizer. *International Journal of Engineering Sciences & Research Technology*, *7*(6), 527-530.

Domínguez, A., Menéndez, J. A., Inguanzo, M., & Pís, J. J. (2006). Production of bio-fuels by high temperature pyrolysis of sewage sludge using conventional and microwave heating. *Bioresource technology*, *97*(10), 1185-1193.

Hamid, H. A., Qi, L. P., Harun, H., Sunar, N. M., Ahmad, F. H., Muhamad, M. S., & Hamidon, N. (2019). Development of organic fertilizer from food waste by composting in UTHM campus Pagoh. *Journal of Applied Chemistry and Natural Resources*, *1*(1).

Huang, G. F., Fang, M., Wu, Q. T., Zhou, L. X., Liao, X. D., & Wong, J. W. C. (2001). Co-composting of pig manure with leaves. *Environmental technology*, *22*(10), 1203-1212.

Majee, S., Halder, G., Krishnaraj, R. N., & Mandal, T. (2020). Development and formulation of an organic fertilizer from industrial and agricultural waste to study the growth of marigold (tagetes) plant. *International Journal of Mathematical, Engineering and Management Sciences*, *5*(3), 395.

Nordin, N. A., Najwa, N. A., Fatihah, N., & Syazwani, N. (2022). Development of organic fertilizer from banana peel, egg shell and yeast for the effective growth of chili plant. *Multidisciplinary Applied Research and Innovation*, *3*(2), 302-311.

Smidt, E., Lechner, P., Schwanninger, M., Haberhauer, G., & Gerzabek, M. H. (2002). Characterization of waste organic matter by FT-IR spectroscopy: application in waste science. *Applied Spectroscopy*, *56*(9), 1170-1175.

Sulaiman, O., Mohamad Amini, M. H., Rafatullah, M., Hashim, R., & Ahmad, A. (2010). Adsorption equilibrium and thermodynamic studies of copper (II) ions from aqueous solutions by oil palm leaves. *International Journal of Chemical Reactor Engineering*, *8*(1).