

Food Waste Composting: Natural Fermentation Method

Gary Teoh Kiang Hong, Mohd Armi Abu Samah, Kavitha Nowroji, Sravutt Som Chet

ABSTRACT---The scale of food waste globally has become an urgent environmental issue to address. Food and Agriculture Organization (“FAO”) of the United Nations estimated that about one third of the food production in the world is wasted. The purpose of this study is to show how raw food waste (RFW) can be composted naturally at source. Since 2014, AUTO-CITY Management has been composting RFW segregated and collected from its tenants. It uses a natural fermentation method which can conveniently compost and transform the RFW including meat, bones, shells, skins, vegetables, fruit peels, oil and sauces into matured food waste (MFW) compost within days. Semi-automated system is used to facilitate the composting process. From 2015 to 2018, the AUTO-CITY Management has produced about 105 tons of MFW compost. The MFW compost, which contains many types of nutrients and minerals, is used in the research on natural farming of vegetables at AUTO-CITY. The result shows that MFW compost can improve fertility of red earth soil and when the MFW compost is at least 30% of the total soil volume, vegetables can grow healthily with good yield. Red earth soil was chosen over other soils because of its low pH 3.5, poor nutrients, drainage and aeration. When demand for organic vegetables increases, it will naturally increase the demand for MFW compost and thus will encourage the composting of food waste. In conclusion, food waste composting using the natural fermentation method is a viable solution to address the global environment issue caused by food waste.

Index Terms: food waste, compost, natural fermentation.

I. INTRODUCTION

The world population is about 8 billion people and still growing. Their livelihoods are sustained by food produced from agriculture. A lot of resources, namely land, water, labor, energy, money, time, fertilizer, transportation, storage are invested to produce the food. Yet, a finding by FAO of the United Nations estimated that about one third of the food production in the world is wasted [1].

The RFW, when not being managed properly, actually decays and pollutes our air, land and water source. It contributes to the increase of methane gas in the air and greenhouse warming; it contaminates our ground water, rivers and seas; and it attracts flies, rats, birds that can spread diseases [2,3]. However, when the RFW is managed properly, the pollution can be greatly reduced. Importantly, the RFW can be transformed into natural composts that can rejuvenate the fertility and health of our soil for agricultural farming and produce abundance of crops [4].

This study shows how the AUTO-CITY Management has been managing and transforming its RFW, which is segregated and collected from its Food & Beverage (F&B) outlets, into valuable MFW compost using natural fermentation method. Semi-automated system comprising of mixer, shredder and rotary drum is used to expedite the composting process which goes through the mesophilic, thermophilic, cooling and curing phases within days [5]. The MFW compost is then sieved into high grade compost and ready for use.

II. LITERATURE REVIEW

Natural fermentation composting using an aerobic process can hasten the transformation of biodegradable food waste into very rich organic compost which can nourish plants and soils and thus be very useful for farming of crops for human consumption [4]. The aerobic process, when compared with anaerobic process, is faster and less odoriferous. It provides favorable condition for the growth of microorganisms and their microbial activities to speed up the decomposition process [6]. The various factors which influence the rate of decomposition of organic materials during any composting process include the carbon/nitrogen (C/N) ratio, moisture content, particle size, temperature and pH control [7].

For many years, microbiologists have tried to culture beneficial microorganisms for use as soil inoculants to overcome the harmful effects of phytopathogenic organisms, including bacteria, fungi, and nematodes. Natural fermentation composting by using mixed cultures of beneficial microorganisms have considerable potential for suppressing and controlling the phytopathogenic organisms and thus providing a more favorable soil environment for plant growth and protection [8].

Organic compost, when applied to the top level of the soil, can retain and release its nutrients slowly to the roots of the crops unlike inorganic fertilizer which can dissolve quickly when come in contact with water and thus travel deep into the ground, resulting in most of it not being captured by the roots of the crops. Therefore, the organic compost has beneficial effect on soils by improving the soil quality and producing crops with better yield and quality. The organic compost, when applied correctly, does not contaminate and pollute the groundwater sources, rivers and seas and thus it is a preferred alternative to conventional NPK based chemical fertilizers [9].

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III. MATERIALS AND MACHINERY

This study has been carried out since 2014 whereby the AUTO-CITY Management started its initiative to compost the RFW collected from its tenants who operate F&B outlets. Prior to this, the tenants did not segregate their RFW and thus all solid wastes including the RFW were carted away to be dumped in landfill. Therefore, it is important that the criteria of segregating and collecting the RFW must be done in a simple and convenience way for the tenants to follow. The criteria for the process of composting the RFW must be natural and fast within days. The Auto-City Management designed and fabricated its own composting machinery to facilitate the composting process.

A. Participating F&B outlets

The 30 F&B outlets which are committed and involved in this project include McDonald, PelitaNasiKandar, Secret Recipe, Shelaiton Chinese Restaurant, Tavern Bistro & Bar, HaaganDazs, Coffee Bean Cafe, Wave Restaurant & Bar, Jiro Japanese Steamboat, One de Land Restaurant, Golden Triangle Indochine Restaurant, San Francisco Café, Swensen Restaurant, Sakae Sushi Japanese Restaurant, Tao Asian Cuisine Restaurant, Starbucks Café, Nando's Restaurant, Korean BBQ Chicken Restaurant, OldtownKopitiam, KFC Restaurant, Winter Warmer Café, Subway, Sushi King Japanese Restaurant, Pentagon Café, Seoul Garden Restaurant, Takehana Japanese Restaurant, KaffaKafe, Brew Café, Idealite Vegetarian Restaurant, Pizza Hut Restaurant and Kim Garden Food Court.

B. RFW collection

The F&B outlets send their segregated RFW to the food waste collection center located within the AUTO-CITY Development. The RFW is placed inside respective containers allocated for the F&B outlets. For their convenience, the F&B outlets can dispose of their RFW at any time of the day. Therefore, the RFW from the F&B outlets are segregated daily. The average amount of RFW collected daily varies because it depends on the season and business of the F&B outlets as well as the eating behavior of customers.

C. Criteria for segregating RFW and composting process

The criteria is that any type of organic matters including meat, bones, shells, vegetables, skins, fruit peels, oil and sauces can be composted so as to simplify the segregation process. The composting process must be fast within days and natural without the use of any heat or chemicals. The operation and maintenance must be simple and low cost.

D. Machinery for composting

The machinery used for composting the RFW are namely; (a) a Mixer machine to evenly mix the RFW with coco peat, (b) a Shredder machine to break down the RFW into smaller pieces so as to expedite the composting process, (c) a Rotary Compost Drum to continuously turn the shredded RFW, and (d) a Sieving machine to sieve the fine matured compost from the coarse MFW compost.



Fig. 1: The (a) Mixer and Shredded machine; (b) shredded food waste, (c) feeding shredded food waste into Rotary Compost Drum and (d) Rotary Compost Drum.

IV. METHOD

Fig. 2 shows the overall process of food waste composting by natural fermentation. Firstly, the RFW, which was collected from the F&B outlets, was poured into a strainer to drain the leachate from the RFW. The RFW was screened to eliminate any plastic, metal, wood, glass, and paper. The screened RFW was then mixed with coco peat and sprayed with the 'Oommi' probiotic. The 'Oommi' probiotic is a registered trade name given to a blend of cultured microbes. It was diluted in ratio of 1:3 (1 liter of Oommi to 3 liters of water) and administered using a Sprayer. The function of the coco peat is to absorb any excess water in the RFW and to achieve the necessary C/N ratio for composting. The well mixed RFW was then shredded into smaller sizes to speed up the composting process.

Thereafter, the shredded RFW was transferred into a Rotary Compost Drum. The leachate which was collected earlier was then mixed with dried MFW compost and also transferred to the Rotary Compost Drum. The MFW compost already has coco peat and thus this approach can eliminate the unnecessary use of additional new coco peat. The Rotary Compost Drum has a capacity of 500 kg and is operated at about 2/3 capacity for 20 to 24 hours, depending on the condition of the RFW. Thereafter, the semi-composted food waste, which is darker in color and drier in texture with no stinky smell, was discharged from the Rotary Compost Drum. It was then packed into gunny or plastic sacks for further fermentation through four phases: (1) mesophilic (2) thermophilic, (3) cooling and, finally, (4) curing. At the end of the fermentation process, the RFW has transformed into MFW compost. The ungraded MFW compost was further sieved to separate out the fine MFW compost which is considered as premium MFW compost.

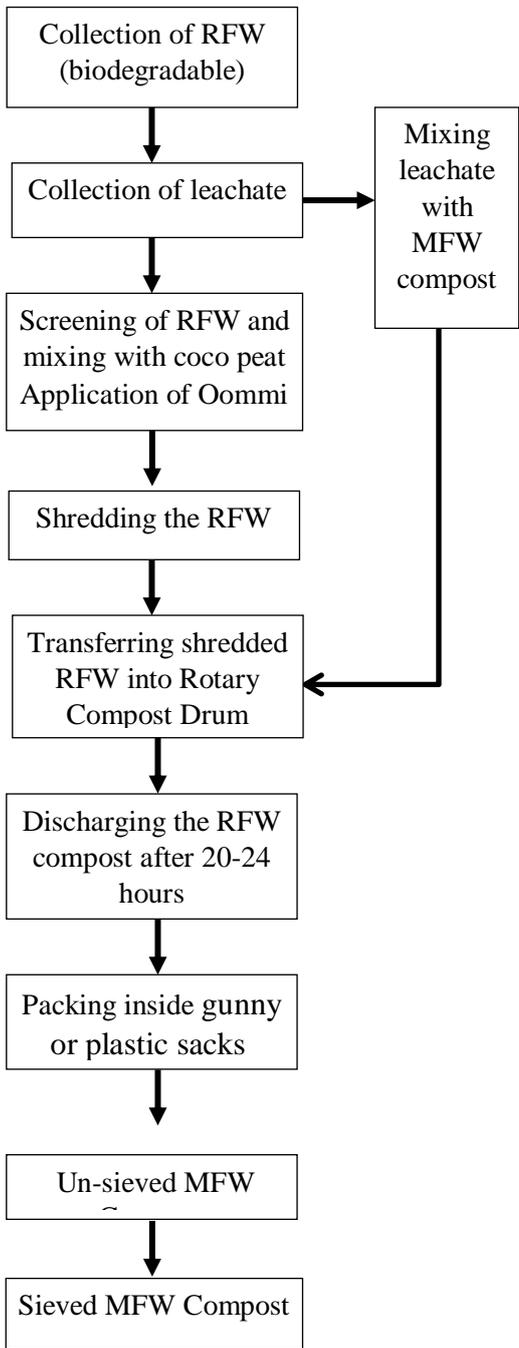


Fig. 2: The flowchart represents the process of food waste composting by natural fermentation method.

V. RESULTS AND DISCUSSIONS

As shown in Table I, the peak temperature achieved was about 60 °C on the composting Day 5 and Day 6 which is important to kill any pathogen bacteria. As all the RFW and leachate were fully treated, there was zero discharge and pollution in this natural fermentation method, which can transform the RFW into MFW within 10 days. As the fermentation process goes through the entire four phases of mesophilic, thermophilic, cooling and curing, the RFW became fully mature at the end of the process and ready for use.

Table I: The temperature of the compost inside the Rotary Compost Drum and gunny sack.

Composting Day	Inside Gunny Sack					
	1 (20-24 hours inside rotary drum)	2	3-5	6-7	8-9	10-11
Temperature in Degree Celsius	30-40	40-50	50-60	60-50	50-40	40-30

The fermentation process includes four correlated factors: (a) metabolic heat generation, (b) temperature, (c) ventilation, and (d) moisture content. During the fermentation process, the microbial activity generates heat and its level of intensity is reflected by the temperature level [5].

For effective fermentation process, it is important to control and maintain the intensity of the microbial activity within a desirable range and this is reflected by the range of the temperature. By proper control of the microbial activity, growth rate of the microorganisms and moisture of the food waste, the fermentation process of the food waste can be optimized as the result of the fast enzymatic production by the microorganisms and high degradation rate of the food waste. High degradation rate can release more energy, increase the temperature of composting and enhance the process of composting [9]. However, it is important to have adequate ventilation to prevent the heat and temperature from becoming too excessive as it can inhibit the fermentation process.



Fig. 3: (a) The un-sieved Matured Food Waste (MFW) Compost and (b) Sieved MFW Compost.

The natural fermentation method described above demonstrated that the period of the decomposition process from RFW to MFW can be hasten to about ten days as compared to the unaided process of decomposition which can take at least three months. The un-sieved MFW does not show any of the original food waste and it has a pleasant earthy smell and brown color texture which will darken as it ages as shown in Fig. 3(a). For longer storage, the MFW can

be packed in double layer bags with an inner layer of plastic to maintain the consistency of the NPK and nutrients of the MFW. For farming of vegetables, the un-sieved MFW can be mixed with the soil to fertilize it. However, for growing seedlings, it is recommended to use the sieved MFW, which has fine texture and high grade as shown in Fig. 3 (b) [10].

Table II: Auto-City’s MFW Compost Production Record from 2015 to 2018.

Year Month	MFWcompost produced (kg)			
	2015	2016	2017	2018
January	-	2,123	2,384	2,584
February	2,023	1,920	1,993	2,447
March	2,105	2,519	2,240	2,335
April	2,050	2,214	2,200	1,937
May	1,778	2,947	2,645	1,217
June	1,535	2,698	2,605	1,417
July	2,037	1,760	2,640	1,095
August	2,580	2,494	2,851	1,152
September	1,853	1,865	2,511	1,717
October	2,091	2,418	2,572	1,546
November	2,308	2,422	2,380	1,295
December	2,275	2,318	2,664	1,136
Total	22,635	29,714	31,702	21,896

The MFW compost produced for years 2015, 2016, 2017 and 2018 are 22,635kg, 29,714kg, 31,702kg and 21,896kg respectively as shown in Table II. The drop in the production of MFW compost for year 2018 was due to the drop in RFW generation as the result of a campaign entitled “Makansampaihabis” (literally translated as “Eat till finish”). The campaign was to educate customers of the F&B outlets to only order what they needed and to pack the unfinished food to take home. The natural fermentation method is flexible to be modified and adopted for bigger and/or smaller scale food waste composing. However, for the bigger scale, the machinery used can be expanded to handle bigger amount of RFW and it can even be fully automated to minimize human handling. Similarly, for smaller scale, the machinery can be reduced to handle smaller amount of RFW.

As the MFW compost is composted from food that is fit and suitable for human consumption, it is the safest and of the best quality when compared to chemically synthesized fertilizer and compost made from animal dungs and poultry droppings. MFW contains a good spread of nutrients and minerals that are naturally composted from a variety of food waste, namely meat, vegetables, shells, skins, fruits and bones. The lab tests indicated that values for Nitrogen (N) can range from 3 to 5, Phosphorous (P) from 1 to 2 and Potassium (K) from 2 to 3 [9]. Furthermore, the AUTO CITY Management uses the MFW compost for its research on natural farming of vegetables. MFW compost can enhance the fertility of poorly organic red earth soil. The result showed that when the MFW compost constituted at least 30% of the total soil volume, the vegetables grew healthily with good yield. The AUTO-CITY Management also collaborates with an herb farm which uses the MFW

compost to grow and donate out its healthily grown medical herbs to needy patients on charitable basis. Also, for patients recuperating from surgeries or health issues, it is important that the herbs they consume are farmed naturally without chemicals and pesticides [11]. Thus the MFW compost is very suitable for growing herbs.

VI. CONCLUSION

In Malaysia, it is still cheaper and easier to just dispose of the food waste into the landfill than to compost the food waste. There are no by-laws to make it compulsory to do so. Thus it is up to own initiative of a company or organization to compost its food waste. The AUTO-CITY Management has taken its own initiative to compost its RFW into MFW compost which can then be used for its natural farming of vegetables. It can serve as a showcase to educate and train people from other companies or organizations to follow suit. In its effort to encourage natural farming of vegetables and families to purchase the organic produce, the AUTO-CITY Management has collaborated with local farmers to organize a Grow Market as a platform for small farmers to come together to sell their fresh organic produce directly to families at reasonable prices. This market-driven approach of promoting and increasing the demand of organic vegetables and herbs can increase the demand for food waste compost. Thus, this can encourage more organizations and companies to segregate and compost their food waste and help to reduce pollution and improve the environment. Local authorities can play a vital role in the food waste composting and benefit in term of financial, environmental and social responsibility. By having localized collecting centers and composting food wastes at source within the residential, commercial, industrial, recreational areas and educational institutions, the local authorities can save on costs of transportation and land fills as well as purchase of chemical fertilizers for the public landscape. Overall, the environment can be greener, cleaner and healthier.

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AUTHORS' PROFILE



Gary Teoh Kiang Hong is the Founder and Managing Director of the AUTO-CITY Group whereby he and his wife Ong Bee Lee, are responsible for the conceptualization, marketing, development and management of

AUTO-CITY in Penang, Malaysia. Known for being the first of its kind development in Malaysia, AUTO-CITY is being developed as the 1-Stop for Automobile, Food, Entertainment, Banking, Shopping and Eco-tourism and is endorsed as a tourism destination by the Penang State Government. Gary Teoh has over 30 years of working experience in various businesses, including research and development in green practices and farming, agriculture and plantation, real estates, property development and management, project management, construction, event management, manufacturing, wholesaling, retailing, food and beverages, entertainment, education, training, consultancy and tourism. In his academic achievements, Gary Teoh was educated as a Civil Engineer in Canada with a Bachelor's Degree in Civil Engineering and a Master's Degree in Building Engineering in the early 1980's. In the late 1980's, he was also trained as an Accredited Gemologist in Thailand and he was awarded a Diploma in Gemological Science. In the mid 90's, Gary graduated with a Master's Degree in Business Administration from University of Portsmouth, UK and a postgraduate Diploma from the Chartered Institute of Marketing, UK.



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Dr. Kavitha Nowroji received her Ph.D. degree and Master's Degree in Molecular Medicine from the Institute for Research in Molecular Medicine (INFORMM), Universiti Sains Malaysia (USM) in 2013 and 2018, respectively. She has experience for 7 years

in the research-based lab and theoretical practices throughout the period of completing her Master's study in the field of antiparasitic research related to Toxoplasmosis disease and Ph.D. in breast cancer research correlated with miRNA studies. Since 2010, she has been involved in the publication of more than 20 articles includes journals, proceedings, chapter in books as the main author and also co-author. She was invited as an "Invited Speaker" for 5th Euro-India International Conference on Holistic Medicine in 2015 and also been awarded as "Ph.D. Best Thesis Award" 2nd prize winner by Royal Society of Chemistry in 2016 at Banaras Hindhu University, Varanasi, India. Moreover, she has gained 2 years of industrial experience in functional food and beverages manufacturing company as a Product Specialist and involved in Public Speaking on Health-Related Talk and Food Safety as well as a Chairperson for health-related programs and Wellness Centre of the company. Currently, she is working as a Researcher/Educator with AUTO-CITY Management, whereby she is involved in the research of green practices and projects.



Sravutt Som Chet is a graduate from Universiti Malaysia Terengganu with a Bachelor's Degree in Fisheries Science. In his earlier years, Sravutt had worked and gained hands-on experience in

freshwater and marine aquaculture farms as well as in a factory manufacturing aqua feed. Thereafter, he developed his passion in agriculture and green practices and involved in various related projects, including the food waste composting in the AUTO-CITY development. He has opportunity to study and conduct further research on the food waste composting and application of food waste compost for agriculture.