Evaluation of the effect of cocopeat in continuous thermophilic composting (CTC) of kitchen waste

N. Chandramali[a], K. Ranasinghe[b]*

[a, b]Department of Chemical Sciences, Faculty of Applied Sciences, South Eastern University of Sri Lanka

(nadeenachandramali5@gmail.com[a], ranasinghek@seu.ac.lk[b])

Keywords: Kitchen waste valorization, cocopeat, continuous thermophilic compositing.

Introduction

Effective waste management is important in reducing the negative environmental impact caused by urbanization, industrialization, and population growth. Like most other developing countries, less attention is paid to waste treatment in Sri Lanka, while the focus is mainly on waste collection. Most municipalities of Sri Lanka practice the collection of kitchen waste (KW) separately at the household level but the collected KW mainly end up in a neglected composting yard and no further steps taken to utilize KW in producing value-added product/s [1].

The conversion of biodegradable waste into compost, has been practicing worldwide for decades now [2]. However, the production and application of composting have two major problems, longer processing time and nutrient status dependency on the method of composting and on the composition of the initial substrates used. Over the years, many solutions have been proposed for these issues [3, 4]. One simple efficient method to accelerate the composting process is Continuous Thermophilic Composting (CTC) in which the waste is incubated in moderately high temperatures, synthetically creating the thermophilic composting phase throughout the process. According to literature, CTC can reduce the composting cycle of KW to 14 days while a regular cycle can be last up to 60 days [3]. However, drawback of artificially accelerated composting processes is the lowered quality or maturity of the product.

Cocopeat is abundantly available in Sri Lanka for low cost. As a bulking agent in composting, cocopeat increases the porosity of the substrate thereby promotes the aeration, while it's high water-holding capacity supports to maintain optimal moisture content. The addition of cocopeat promotes microbial growth and accelerates the aerobic digestion of substrates. The current study proves that the integrated thermophilic composting process with cocopeat as an additive valorizes KW into high-quality compost via a rapid and economically feasible route.

Methodology

Kitchen waste (KW) was collected from the canteen of FAS, South Eastern University of Sri Lanka, Sammanthurai. The KW substrates were initially shredded to lengths of 1–2 cm. Compost inoculants were obtained from a facility owned by the urban council in Ampara. Cocopeat was obtained from a commercial cocopeat production site in Embilipitiya. Composting was carried out in aluminum pots. Each pot was suitably modified for air circulation by drilling 10 mm holes on the pots in three layers. The pots were kept on shallow containers to facilitate leach collection from the bottom.

Mixed waste (MW) was prepared by mixing inoculated kitchen waste (KW) with cocopeat in a 1:3 ratio. Four types of samples with two different compositions and with the intension to keep at two different temperature conditions were designed (Table 1). Each sample type was duplicated. All the samples were subjected to composting for 43 days. During composting, first two sample types, KW_{30} and MW_{30}, were kept out in open space to allow natural aeration. The other two sample types, were placed in an incubator at 50 ^oC. The compost samples were manually turned in every 24 h to facilitate aeration. Approximately 10 g wet weight was collected once a week from the middle of each drum immediately after manual turning.

Table 1. Composition and temperature conditions of each waste sample type.

Sample Type	Composition (per 1 kg)		Temperature (°C)
	KW	Cocopeat	
KW_{30}	1	-	RT[b]
MW_{30}	0.75	0.25	RT
KW_{50}	1	-	50 °C
MW_{50}	0.75	0.25	50 °C

The powdered oven-dried samples were used to analyze total organic matter (TOM) by 'loss on ignition' method [5]. Evolution of the maturity of the compost samples over the testing period was monitored by determining seed germination index (GI) [6]. A One-Way Analysis of Variance (ANOVA) was conducted for TOM data.

Results and Discussion

1. Monitoring composting process - Total Organic Matter (TOM) content. The initial TOM content of all the sample types (~85 %) was similar. Among the four sample types, KW_{30} and MW_{30}, which were kept at RT, showed relatively low rates of TOM degradation, whereas CTC samples (KW_{50} and MW_{50}) showed significantly higher rates (Figure 1) indicating that the microbial activity of the latter types is higher than the former sample types. A drastic drop of TOM can be observed for all the samples during the first week of composting, which can be attributed to the decomposition of simple sugars and other easily digestible components.

Within the analyzed period (~6 weeks), TOM of KW_{30} and MW_{30} decreased to ~55% and composting route in both KW and MW. This observation can be attributed to the higher activity of the prominent thermophilic microbes, who decompose the complex organic molecules; fats, proteins, and carbohydrates.

The addition of cocopeat could be expected to increase the initial TOM of MW compared to KW, however the observations imply that the added amount of cocopeat (25% by weight) might not be enough to showcase a significant difference in initial TOM content. However, based on the observations, when combined with CTC condition, the added amount of cocopeat is adequate to significantly enhance the microbial growth as reflected by the faster degradation in MW_{50}.

2. Maturity evaluation – Germination Index (GI). The GI values of the samples were determined every other week to monitor the compost maturation. As shown in Figure 2, GI values in all of the samples were very low during the early phase of composting due to high quantities of volatile fatty acids and NH_4^+ salts produced, which are toxic to seed germination). Over time, GI of all the sample types increased gradually, but MW_{50} always exhibited distinctly higher GI values with respect to the other samples.

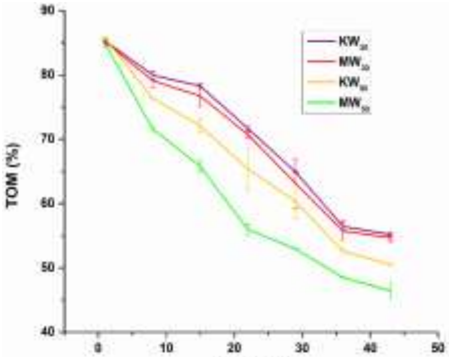

Figure 1. Weekly changes of TOM (%) in the four sample types.

In general, a compost sample is considered to be matured when the GI value is higher than 90% [3]. Accordingly, MW_{50} exhibits adequate maturity after 36 days and more than 100% GI value for the samples collected on 42nd day (Avg. 104.15%). This result indicated that by the end of the analyzed period, the phytotoxins present within the compost produced via the MW_{50} route is minimal to none. In contrast, none of the other three sample types attained 90% of GI within the analyzed time period, indicating that either the composting process is not completed or the resultant compost has relatively lower quality in those samples. The progression of the GI graphs clearly indicates that at any given point, the highest maturity out of the four sample types is shown by MW_{50}.

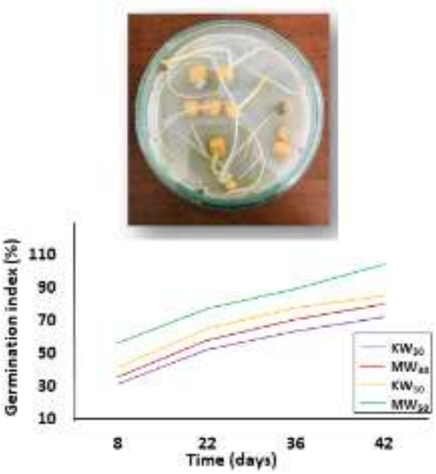

Figure 2. Top: Biweekly changes of GI% in the four sample types. Bottom: Germinated seeds of MW_{50} sample on 42nd day.

Conclusion

This investigation combined continuous thermophilic composting (CTC) with the addition of a locally available bulking agent, cocopeat, to produce high-quality compost from kitchen waste through a shorter composting cycle. Based on the high TOM reduction rates compared to the control sample types, it can be concluded that the proposed route requires shorter period of time to produce compost. Importantly, GI values clearly showcase significantly higher maturity in the compost produced through the proposed method compared to the controls. Overall, this study concludes that cocopeat may influence the key parameters such as aeration and porosity of composting mixture, thereby facilitated a higher microbial activity within the composting substrate under manipulated thermophilic condition.

Acknowledgment

The authors wish to thank the Faculty of Applied Sciences, South Eastern University of Sri Lanka for financial support.

References

[1] Menikpura, S.N.M., S.H. Gheewala, and S. Bonnet, Sustainability assessment of municipal solid waste management in Sri Lanka: problems and prospects. J. Mater. Cycles Waste Manag., 2012. 14(3): pp. 181-192.

[2] Awasthi, S.K., et al., Changes in global trends in food waste composting: Research challenges and opportunities. Bioresour. Technol., 2020. 299: pp. 122555.

[3] Xiao, Y., et al., Continuous thermophilic composting (CTC) for rapid biodegradation and maturation of organic municipal solid waste. Bioresour. Technol., 2009. 100(20): pp. 4807-4813.

[4] Schroeder, J.T., A.L. Labuzetta, and T.A. Trabold, Assessment of Dehydration as a Commercial-Scale Food Waste Valorization Strategy. Sustainability, 2020. 12(15).

[5] Manu, M.K., R. Kumar, and A. Garg, Performance assessment of improved composting system for food waste with varying aeration and use of microbial inoculum. Bioresour. Technol., 2017. 234: pp. 167-177.

[6] Awasthi, M.K., et al., Evaluation of thermophilic fungal consortium for organic municipal solid waste composting. Bioresour. Technol., 2014. 168: pp. 214-221.