EFFECTIVENESS OF MICROBIAL INOCULANTS FROM TEMPEH AND TAPAI IN HOME SCALE COMPOSTING

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ABSTRACT

This study evaluated the effectiveness and necessity of microbial inoculants on home scale composting (food waste: rice bran: dried leaves 2:1:1) with the attempt to divert food waste from the landfill. In this study, the feedstock was inoculated with three formulations of microbial inoculants (MI) and one control, namely 100% *Tempeh* solution, 100% *Tapai* solution, Effective Microorganism™ (EM™) and water as control. Various physico-chemical properties and enzymatic activities were evaluated during the composting process. The quality of the end composts was evaluated by the physico-chemical properties, bioassays responds, characteristics of humic acid, nutrients content and pathogens content. It was found that the temperature of all three feedstock treated with MI can be heat up to higher level (>50^{o}C) and did not produced foul odour compared to the control. However, for most of the monitored parameters of all treatments (with MI and control) during the composting process showed similar changes without significant differences. For the end composts (week 8), no significance difference was identified for the characteristics including pH (~7), EC (~3 dS/m), C: N (<14), organic matter content (~70%), colour (dark brown), potassium content (1-3-1.7%), phosphorus content (0.3-0.4%), odour (earthy smell), pathogen content (pass) and germination index (>100%) but all indicating well matured. Nevertheless, composts with MI showed higher content of nitrogen than the control. In comparison with composts treated with EM™, MI from *Tempeh* produced compost with higher nitrogen and humic content; MI from *Tapai* showed compost with better ability to raise the temperature to a higher degree. This study concludes that MI produced from *Tempeh* and *Tapai* showed comparable performance as the commercial brand, the Effective Microorganism™ as microbial inoculants.

ABSTRAK

Kajian ini menilai keberkesanan dan keperluan inokulan mikrob untuk kompos pada skala rumah (sisa makanan: dedak padi: daun kering 2: 1: 1) dalam usaha mengalihkan sisa makanan daripada tapak pelupusan. Dalam kajian ini, bahan mentah yang telah dirawat dengan tiga formulasi inokulan mikrob (MI) dan satu kawalan, iaitu 100% cecair *Tempeh*, 100% cecair *Tapai*, Effective Microorganism™ (EM ™) dan air sebagai kawalan. Pelbagai sifat fiziko-kimia dan aktiviti enzim telah dinilai semasa proses pengkomposan. Kualiti kompos yang dihasilkan telah dikenal-pasti oleh sifat-sifat fiziko-kimia, respon bioassei, ciri-ciri asid humik, kandungan nutrien dan kandungan patogen. Didapati bahawa suhu ketiga-tiga bahan mentah yang dirawat dengan MI boleh mencapai suhu yang lebih tinggi (> 50^{o}C) dan tidak menghasilkan bau yang busuk berbanding kawalan. Walau bagaimanapun, kebanyakan parameter yang dipantau semasa proses pengkomposan bagi semua rawatan (dengan MI dan kawalan) menunjukkan perubahan yang sama tanpa perbezaan yang ketara. Bagi kompos akhir yang dihasilkan (minggu 8), tiada perbezaan yang nyata dapat dikesan terhadap ciri-cirinya yang termasuklah pH (~ 7), EC (~ 3 dS / m), C: N (<14), kandungan bahan organik (~ 70%), warna (coklat gelap), kandungan kalium (1-3-1.7%), kandungan fosforus (0.3-0.4%), bau (bau tanah), kandungan patogen (lulus) dan indeks percambahan (> 100%) tetapi semua rawatan telah menunjukkan kompos yang matang. Walau bagaimanapun, kompos dengan MI menunjukkan kandungan nitrogen yang lebih tinggi daripada kawalan. Berbanding dengan kompos yang dirawat dengan EM ™, MI dari tempeh menghasilkan kompos dengan kandungan nitrogen dan humik yang lebih tinggi; MI dari tapai menunjukkan kompos mempunyai keupayaan yang lebih baik untuk meningkatkan suhu ke tahap yang lebih tinggi. Kajian ini menyimpulkan bahawa MI hasilan daripada tempeh dan tapai menunjukkan prestasi setanding dengan jenama komersial, Effective Micoorganism™ sebagai inokulan mikrob.

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LIST OF ABBREVIATIONS

EM™	-	Commercial Effective Microorganism™
EM	-	Effective Microorganism
TE	-	*Tempeh*
TA	-	*Tapai*
eq	-	Equation
h	-	Hour
g	-	Gram
d	-	Day
t	-	Tones
OM	-	Organic matter
MRS	-	Man, Rogosa and Sharpe agar
DRBC	-	Dichloran Rose Bengal Chloramphenicol agar
NPK	-	Nitrogen, Phosphorus, Potassium
U/g	-	Microgram (µg) per minute per gram
%/wt	-	Percentage by weight
EC	-	Electrical conductivity
GI	-	Germination Index
N	-	Normality
rpm	-	Revolutions per minutes
C: N	-	Carbon to nitrogen ratio
cfu	-	Colony forming unit
MPN	-	Most probable number
K_d	-	Degradation rate of fat
R^2	-	Simple linear regression
dS/m	-	deciSiemens per metre
^oC	-	Degree celcius

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

Effective management of solid waste is a tedious challenge in many developing countries. In Malaysia, solid waste is generated at an alarming rate and far beyond the handling capacities of agencies and governments. According to the statistics reported by The Star, each Malaysians produce 0.5 kg to 1.8 kg of solid waste per day (Ravindran, 2015) as the waste recycling rate only hovers at around 10 to 15 % (Johari *et al*., 2014) with most of the waste ending up in landfills. In contrast, other countries such as France, the second biggest producer of waste in the European Union recovers 64 % of its waste (Suez Environment, 2013). The waste production in Malaysia is expected to rise more than 30 % by the year 2020 (Sreenivasan *et al*., 2012) where food waste makes up half of the generated municipal solid waste. Therefore, it is essential to lessen the impact of food waste on the planet through notions of recovery.

Based on the Malaysia Solid Waste and Public Cleansing Management Act 2007 (Act 672), solid waste could be disposed of by any means of destruction, incineration and deposit or decomposing. However, in Malaysia, landfill is still the predominant method because of its simplicity and low cost (Manaf *et al*., 2009). Currently, Malaysia has considered incineration process as part of the solutions due to limited land in the cities for new development (Hassan *et al*., 2001). However, both landfilling and incinerator are not appropriate as the food waste has high moisture, organic matter and nutrients content. Incineration of food waste will cause combustion energy loss and formation of undesirable by-product such as dioxin-related compounds (Sakai *et al*., 2001). In addition, the breakdown of rich organic matter releases polluting leachate and greenhouse gas (GHG) notably the methane gas (CH_4) (COM, 1996) in landfills under anaerobic condition. Landfill is the main source of GHG emission, notably the CH_4 that has 21 times the global warming potential (GWP) of CO_2 (Abushammala *et al*., 2010). It was reported that 1.6 kg of carbon is released per kg of MSW disposed of in the landfill (Wang and Geng, 2015). In Korea, direct disposal of untreated food waste which was categorized as active waste has been banned since the year 2005.

Among the waste processing mode, composting specifically on-site composting is a recycling approach represents the second most ideal technique comes after source reduction and reuse. However, at home scale, the composting process has been scarcely studied from a scientific view (Colón *et al*., 2010). On-site composting offers the least carbon emission and recommended to avoid pollutants emitted from landfill and transportation during waste collection (Kumar *et al*., 2009). In addition, GHG can be mitigated as the end product (compost) can be used on land and lessen the use of chemical fertilizer and pesticide (Favoino and Hogg, 2008; Barrena *et al*., 2014). The Malaysian government has recently imposed the mandatory waste separation at source from September 2015. This action is expected to advocate and facilitate the implementation of composting based on the segregated food waste at source.

In this study, modified Takakura composting method was studied to facilitate home composting. Takakura composting method is widely employed in the regions of South-East Asia due to its simple methodology as well as practical implementation. It is a simple, fast, inexpensive, sanitary and odourless composting method by mean of cultivation of indigenous microorganisms from the local fermented food product. The decomposition is expected to be speed up by the use of micro-organisms, inoculants or activators such as enzymes but without involving isolation of certain microorganisms. Using fermented food as microbial inoculants has not received intensive research attention up to now and there was still a lack of scientific studies on its contribution towards the composting process. Thus, this study attempted to evaluate the effectiveness of microbial inoculant developed from the locally available fermented food, *Tempeh* and *Tapai* for the composting of food waste at home scale.

To determine the potential of fermented food as a source of MI, the physicochemical properties and biological changes during the composting process as well as the end compost quality were measured and compared with the composting process carried out with the commercial microbial inoculants (Effective Microorganisms™) and that without any microbial inoculants as a control. There are two extreme opinions on the uses of microbial inoculants (MI) during composting as the inoculation efficiency was likely to be affected by the type of feedstock, compatibility of microorganism as well as the settings of composting process. Some of them believe that inoculation of beneficiary microorganisms is able to increase enzymatic activities (Hubbe *et al*., 2010; Payel *et al*., 2011), promote biodegradation of organic matter (Xi *et al*., 2005; Patidar *et al*., 2012) and accelerate the process (Xi *et al*., 2005; Saad *et al*., 2013). In contrast, part of them suggests that microbial community naturally present in the wastes is able to carry out degradation satisfactorily when optimum environmental conditions were given (Stabnikova *et al*., 2005; Nair and Okamitsu, 2010; Abdullah *et al*., 2013). As the role of MI for composting remains unclear, the overall composting performance carried out with and without MI is the key focus of this study to investigate the necessity of MI on home scale food waste composting.

1.2 Problem Statement

With the rise of global population and development, the productions of wastes also increase simultaneously. This aggravates the disposal issues particularly for food wastes which are inappropriate to discard either by landfilling or incineration. Composting can serve as a technology that carries less adverse impact, it is effective on waste reduction, stabilization and sanitation and has gained increased research attention.

In comparison to the industrial composting (centralized), home scale composting (decentralized/ onsite) is a lack of scientific study and with a higher possibility of failure as the undersized scale fail to retain sufficient heat for composting. Commercial Effective Microorganisms™ has been introduced to ease the operation and encounter the problems of composting but it is not readily accessible and incurred certain costs of consumables (eg. cost of MI). On the other hand, Takakura home composting methods that use indigenous microorganisms from common fermented food as inoculants received not much research attention. Therefore, in this study, the effectiveness of the MI prepared from *Tempeh* and *Tapai* that represents a simple technique for the layman is assessed.

The traditional composting process is time-consuming. In order to utilize the composting process efficiently, MI can be applied to reduce the time for composting, to assist in foul odor control and improving the quality and stability of the end compost. In spite of the plenty positive results using this technique, there is still very few studies research that shows the necessity of MI for composting. Up to date, there are no general consensus and definition on the scenarios (type of condition or resources limitation, composting system and waste composition) where the addition of MI is necessary.

Although composting is presumably the most promising method to handle food waste by converting it into humus-like substances for soil amendment and replace chemical fertilizers, immature or low-quality compost arises from incomplete and the improper composting process will harm the growth of plant and the health of soil. For that reasons, various physico-chemical properties, biological changes and quality of end compost have to be assessed to discover the effectiveness of MI and its necessity in the home-scale composting.

1.2 Objectives

The aim of the study is to assess the effectiveness of microbial inoculants (MI) prepared from the local fermented food, *Tempeh* and *Tapai* for home-scale food waste composting.

1.4 Scope of Study

The research scopes of this study are as follow:

i. To investigate the physicochemical properties (temperature, pH, odour, colour, C: N ratio, fat content, structural of humic acid) and biological properties (population of fungal and lactobacillus; amylase, cellulase, lipase and protease activity) during the home-scale food waste composting.

ii. To evaluate the quality of the end composts produced by different MI treatments based on pH, colour, odour, C: N ratio, pathogen content, organic matter content (OM), electrical conductivity (EC), nitrogen content (N), phosphorus content (P), potassium content (K), humic acid content and germination index (GI).

1.5 Significance of Study

This study is significant to provide a solution to utilize microorganisms from an economical and easy available fermented food as MI to potentially enhance the quality of the home composting process and producing compost with acceptable quality. This research is expected to contribute significantly in reducing food waste at source through home composting as well as the development of matured compost in a simple and friendly manner for layman. In such a way, households do not have to solely rely on the commercial MI to assist the composting process, notably in terms of odor control which was found to be significantly contributed by MI in this study.

It is expected to benefit the area of inoculation composting by providing some insight on the necessity of MI for home-scale food waste composting through the determination of various composting parameters. The composting and quality parameters that can be enhanced by MI were identified. The long-term goal is to establish a clearer understanding of the relationship between the characteristics of composting and the necessity of MI.

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