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UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS

JUDUL: Chemical Characterization of Vermicomposted Durian Husk Using Perionyx excavatus.

IJAZAH: Bachelor of Agriculture Science with Honours.

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SESI PENGAJIAN: 2006/2010

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CHEMICAL CHARACTERIZATION OF VERMICOMPOSTED DURIAN HUSK USING *Perionyx excavatus*

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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF
AGRICULTURE SCIENCE WITH HONOURS

CROP PRODUCTION PROGRAMME
SCHOOL OF SUSTAINABLE AGRICULTURE
UNIVERSITI MALAYSIA SABAH
2010

DECLARATION

I hereby declare that this dissertation is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that no part of this dissertation has been previously or concurrently submitted for a degree at this or any other university.

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ACKNOWLEDGEMENT

First of all I want to take this opportunity to thank my supervisor Dr. Mohamadu Boyie Jalloh for directing, guiding and giving me advice which really helped me a lot. It was a good experience and also a great pleasure working under him as a student for the final year project. I also want to take this opportunity to thank Tn. Haji Mohd. Dandan @ Ame Bin Hj. Alidin for highlighting the mistakes I have done to improve my dissertation. I would like to thank the School of Sustainable Agriculture (SAA) for providing assistance in terms of laboratory facilities and funds to conduct the project. I would also like to express my appreciation to Dr. Punimin Abdullah of Department of Veterinary Services and Animal Industry in Sabah, for allowing me to join the trip with the Livestock Production students to collect my experimental materials. I would also like to thank Mr. Benny from "Korporasi Agrojuta" and his team for valuable advice and information on vermicomposting and earthworms. Lastly, my greatest gratitude and thanks to my fellow course mates, Miss Bavani, Miss Fizan, Miss Aza, Miss Cassandra and Miss Yeoh for their patience and assistance in sharing their experiences and opinion regarding the final year project laboratory work and also the writing. Last but not least is my teammate in this final year project, Mr Kuan for his support in my final year project. Sincere gratitude from the bottom of my heart, Thank you all.

ABSTRACT

Vermicomposting as a form of recycling and adding value to waste is now a widespread activity in agriculture. This preliminary study was conducted to evaluate different types of durian husk waste materials namely, fresh shredded (FS), dry shredded (DS), fresh chipped (FC) and fresh whole (FW) durian husks (un-processed) vermicomposted using local blue worms, *Perionyx excavatus*, with and without cow dung. The objectives of the study were to produce vermicomposts from the wastes, characterize the chemical properties of the composts and evaluate the composting efficiency (CE). The experiment was carried out in the vermished at the Field Laboratory of School of Sustainable Agriculture, Universiti Malaysia Sabah. Each treatment (i.e the various durian husk wastes, with and without cow dung) was replicated three times in a completely randomized design (CRD). The parameters of the study were nitrogen (N), carbon (C), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and pH of the vermicompost as well as composting efficiency. The chemical analysis of the vermicomposts was done after eight and half weeks of vermicomposting. All data were analyzed using two-way ANOVA and Tukey's test was used for means separation. In comparison to the raw materials, after vermicomposting, pH, N, K, Mg and Ca content of the compost increased by 9 to 13 %, 76 to 93 %, 64 to 75 %, 120 to 167 %, 178 to 265 % respectively while OC decreased by 23 to 34 %. The results of pH, CE, N, OC, P, K, Ca and Mg for FS vermicompost was 6.7, 85.68 %, 0.64 %, 41.5 %, 79.5 mg kg^{-1}, 124.5 mg kg^{-1}, 215 mg kg^{-1} and 81.5 mg kg^{-1} respectively. In the case of DS vermicompost, the results were 7.01, 26.35 %, 0.09 %, 42.5 %, 77.3 mg kg^{-1}, 142 mg kg^{-1}, 203 mg kg^{-1} and 69.5 mg kg^{-1} respectively. For FC vermicompost, the results were 7.3, 53.98 %, 0.096 %, 38.23 %, 55.24 mg kg^{-1}, 89.3 mg kg^{-1}, 320.5 mg kg^{-1} and 75.5 mg kg^{-1} respectively. The study indicated that treatments amended with cow dung were more suitable for vermicomposting. The shredded durian husk and amended with cow dung resulted in a better compost compared to the other treatments.

PENCIRIAN KIMIA DALAM VERMIKOMPOS KULIT DURIAN MENGGUNAKAN *Perionyx excavatus*

ABSTRAK

Proses vermikompos ialah suatu kitaran semula serta menambah nilai kepada sisa dimana ianya kini menjadi tersebar di dalam bidang pertanian. Kajian telah dijalankan dengan menilai empat jenis sisa kulit durian iaitu dicabik-segar (FS), dicabik-kering (DS), diserpih-segar (FC) dan segar-seluruh (FW) (tidak terproses) yang telah divermikompos dengan menggunakan cacing biru tempatan, *Perionyx excavatus*, dengan dan tanpa najis lembu. Objektif kajian adalah untuk menghasilkan vermikompos daripada sisa, mengenal pasti ciri-ciri kimia vermikompos dan menilai kecekapan pengomposan (CE). Kajian ini telah dijalankan di rumah cacing di Makmal Ladang Sekolah Pertanian Lestari, Universiti Malaysia Sabah. Setiap perlakuan (cthnya kepelbagaian jenis kulit durian, dengan dan tanpa najis lembu) telah direplikasikan tiga kali dalam Reka Bentuk Rawak Penuh (CRD). Parameter-parameter dalam kajian ialah nitrogen (N), carbon (C), phosphorus (P), kalium (K), Kalsium (Ca), magnesium (Mg) dan pH pada vermikompos serta CE. Penganalisaan kimia pada vermikompos dijalankan selepas lapan dan setengah minggu proses vermikompos. Data-data telah dianalisa dengan menggunakan ANAVA dua hala dan ujian Tukey digunakan untuk pembahagian mean. Dibandingkan dengan sisa organik, selepas proses vermikompos, peningkatan pada pH, N, K, Mg dan Ca masing-masing ialah 9 % hingga 13 %, 76 % hingga 93 %, 64 % hingga 75 %, 120 % hingga 167 %, 178% hingga 265 %, manakala penurunan pada OC ialah 23 % hingga 34 %. Hasil vermikompos FS untuk pH, CE, N, OC, P, K, Ca dan Mg masing-masing ialah 6.7, 85.68 %, 0.64 %, 41.5 %, 79.5 mg kg^{-1}, 124.5 mg kg^{-1}, 215 mg kg^{-1} dan 81.5 mg kg^{-1}. Pada vermikompos DS pula, hasilnya masing-masing ialah 7.01, 26.35 %, 0.09 %, 42.5 %, 77.3 mg kg^{-1}, 142 mg kg^{-1}, 203 mg kg^{-1} dan 69.5 mg kg^{-1}. Pada vermikompos FC, hasilnya ialah 7.3, 53.98 %, 0.096 %, 38.23 %, 55.24 mg kg^{-1}, 89.3 mg kg^{-1}, 320.5 mg kg^{-1} dan 75.5 mg kg^{-1}. Kajian ini menunjukkan bahawa rawatan yang ditambah dengan najis lembu lebih sesuai untuk vermikompos. Kulit durian yang telah dicabik serta ditambah dengan najis lembu menghasilkan kompos yang lebih baik berbanding rawatan-rawatan lain.

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LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

ANOVA	Analysis of variance
C	Carbon
Ca	Calcium
C:N	Carbon to nitrogen ratio
DS	Dry shredded durian husk
FC	Fresh chipped durian husk
FS	Fresh shredded durian husk
FW	Fresh whole (un-processed durian husk)
K	Potassium
Mg	Magnesium
mg kg^{-1}	Miligrams per Kilogram
N	Nitrogen
P	Phosphorus
ppm	Parts per million
RM	Ringgit Malaysia
SAS	Statistical Analysis Solfware
SMS	Spent mushroom substrate
TN	Total Nitrogen
UMS	Universiti Malaysia Sabah

CHAPTER 1

INTRODUCTION

1.1 Background

The cost of incineration and landfill is soaring especially with energy and land shortage. The present way of dumping some waste especially organic wastes without proper handling is causing many environmental problems. Organic wastes which possess some beneficial uses are mounting. The management, conversion and utilization of these wastes have become major activities around the world. Organic wastes such as livestock manure and other agricultural wastes are known to be important sources for maintaining soil organic matter and to sustain soil productivity (Goyal *et al.*, 2005). Proper utilization of these wastes could improve soil properties and environmental quality as well as provide nutrients for plants.

Seasonal fruiting and consumption of Durian, a very popular fruit in Malaysia, causes some form of waste disposal problems in local markets. The local production of durian has been increasing since year 2005 and the planted area has also increased (Table 1.1). For durian, only the soft mass inside the fruit is consumed and the remaining hard spiky husk is disposed as it has no economical value. Durian husk like any other organic waste is biodegradable and can be composted. Therefore, composting is a suitable way of converting this waste into a more valuable material which can also help in reducing environmental and waste disposal problems (Chandra *et al.*, 2007).

Table 1.1 Planted area and production of Durian in Malaysia in 2005 to 2008

Item	Year			
	2005	2006	2007	2008
Planted area (ha)	110,615	105,388	102,390	99,410
Producing area (ha)	63,000	60,023	61,070	62,130
Mean yield (ton ha^{-1})	6.0	4.9	5.1	5.2
Production (tonnes)	378,657	292,681	311,460	323,080
Production value (RM '000,000)	800,8	917,4	976,3	1,012,7

Source: Malaysia Ministry of Agriculture and Agro-based Industry, 2009

Many concepts and methods have been developed to overcome organic waste environmental problems through vermicomposting of the waste instead of disposal. Composting has been adopted to convert the waste into a beneficial product such as conventional composting and the vermicomposting methods.

Vermicomposting, also known as the process of composting with the aid of worms has been extensively used in the stabilisation of urban and agriculture wastes. During vermicomposting, organic matter is stabilised by the enhanced decomposition in the presence of the earthworms. Monroy *et al.* (2009) reported that during vermicomposting, earthworms act as a mechanical blender, and by consuming the organic matter, they modify its biological, physical and chemical status. Furthermore, earthworms also gradually reduce the C:N ratio and increase the surface area exposed to microorganisms, making the waste much more favourable for microbial activity and further decomposition.

Several epigeic earthworms like *Eisenia fetida, Perionyx excavates and Eisenia Andrei* have been identified as detritus feeders and can be potentially used in vermicomposting potentially to decompose the anthropogenic waste from different sources.

1.2 Objectives of Study

This study was therefore conducted with the following objectives:

1. To vermicompost various durian husk waste materials using *Perionyx excavatus* (Blue worm).
2. To determine the nutrient content (C, N, P, K, Ca, and Mg) and the pH of the durian husk vermicompost.

CHAPTER 2

LITERATURE REVIEW

2.1 Composting and Vermicomposting

Composting and vermicomposting are two processes for the biological stabilisation of solid organic wastes. These two methods have been known to be useful in disposing and converting waste products into some useful produce like organic fertilizer. Compost, the generated product can be subsequently applied to soil to increase soil organic matter, which will release nutrients upon decomposition and also improve the soil structure and cation exchange capacity (Contreras-Ramos *et al.*, 2007).

2.1.1 Composting

Composting is the most economical and sustainable option for organic waste management as it is relatively easy to do and can be conducted in an enclosed space provided it is managed properly to produce a good quality end-product (Nair *et al.*, 2006). Composting is a natural process of organic waste treatment which is currently practiced with various modifications to the technology.

In composting, two phases can be distinguished, namely the thermophilic stage and the maturing stage. In the thermophilic stage, the decomposition proceeds more intensively which constitutes the active phase. The maturing stage is marked by a decrease in temperature to the mesophilic range and the remaining organic compounds are degraded at a slower rate (Lazcano *et al.*, 2008).

2.1.2 Vermicomposting

Vermicompost is the heterogeneous mixture of decomposing vegetable or food waste, bedding materials and pure vermicast produced during the course of normal vermiculture operation. Vermicomposting has been reported to be a viable, cost effective and rapid technique for the efficient management of the organic solid waste (Anonymous, 2009).

Vermicomposting is the stabilisation of organic material through the joint action of earthworms and microorganisms wherein microbes are responsible for biochemical degradation of organic matter. Earthworms are the important driver of the process by conditioning the substrate and altering the biological activities (Suthar, 2008). Earthworms have played a key in soil biology by serving as versatile natural bioreactors to harness and destroy soil pathogen, thus converting organic waste into valuable bio-fertilizer, enzyme, growth hormones and proteinaceous worm biomass.

Earthworms mainly feed on organic matter and utilize only a small amount for their body synthesis and excrete a large part of the consumed materials in a partially digested form as worm cast. The process involves physical/mechanical and biochemical activities. The physical/mechanical process includes mixing and grinding, whereas biochemical process includes microbial decomposition in the intestine of the earthworms (Loh *et al.*, 2005).

It has been shown that vermicomposting using earthworms results in a better end product than composting due to enzymatic and microbial activity that occur during the process (Bajsa *et al.*, 2002)

2.2 Ideal Environment for Vermicomposting

2.2.1 Temperature

In vermicomposting, the containers with the earthworms are kept in a dark room under identical ambient conditions with temperature around 25-28°C (Kaushik and Garg, 2003). While tolerance and preferences may vary from species to species, temperature requirements are generally similar.

2.2.2 Moisture Content

Earthworms require plenty of moisture in order to live and survive; they generally require moisture content around 70%-80% with surface spraying using water (Loh *et al.*, 2005). It is very important to moisten the dry bedding before putting them into the trays so that the optimum moisture condition is maintained.

2.2.3 pH

The pH environment for growing earthworms is different according to earthworm species. According to Tripathi and Bhardwaj (2004b), the optimum pH for the growth of *Eisenia feotida* is 6.5 and 7.5 for *Perionyx excavates (P. Excavates).*

2.3 Role of Earthworms in Organic Waste Recycling

Organic waste recycling is an efficient and environmentally friendly technology to convert wastes into value added products (Suthar, 2008). The conversion of waste into beneficial material is an important aspect of resource recycling and environmental cleaning (Tripathi and Bhardwaj, 2004a).

However, the increased interest in diverting organic wastes has raised concerns about the need to ensure that the end products are safe to use and meet minimum quality standards. One such concern is that strategies are adopted that minimizes the risk of spreading pest, plant disease and weeds in recycled organic waste (Norbu, 2002).

Earthworm, as a natural feeder and organic waste converter can help in promoting safe waste recycling in the environment. It has been reported that when earthworms are inoculated into organic waste materials, the microbial composition and activities in substrates are accelerated, which in turn enhances the nutrient transformation and altering of the biological properties (Suthar, 2007). Thus, the role played by earthworms in organic waste recycling is undeniable and very important to environmental and waste disposal issues.

2.3.1 Fragmentation and Breakdown

Fragmentation and breakdown are important processes in the initial phase of vermicomposting. Fragmentation and breakdown helps to improve the vermicomposting efficiency. The purpose of pre-composting is to soften and breakdown the organic waste so that during vermicomposting, earthworms are able to consume faster, thus facilitating in vermicomposting. According to Bityutskii *et al.* (2002), these processes are critical in the success of earthworms consuming and breaking down the waste with the help of microorganisms present in the waste and also in the gut of the earthworms.

Studies have shown that the density and biomass of earthworms had no significant correlation with the weight of litter loss, indicating that the role of earthworms was not remarkable at the early stages of litter decomposition (Li *et al.*, 2009). Thus, normal pre-treatment of organic waste before vermicomposting like the fragmentation and breakdown of organic matter is important so that during microbe breakdown in the initial process, the high temperature during the thermophilic stage of composting can be avoided (Bansal and Kapoor, 2000).

2.3.2 Consumption and Humification

It has been regarded that earthworms consume vigorously and require plenty of feeding material in a day, a normal consumption rate or feeding rate is approximately 0.75 kg feed kg^{-1} worms day^{-1} (Loh *et al.*, 2005). During the consumption through the gut of earthworms, the pools of dissolved organic carbon and nitrogen from the waste as well as mineral nitrogen are reduced (Aira and Domiinguez, 2009). Moreover, during the consumption, earthworms fragment the waste substrate and accelerate the rate of decomposition of the organic matter, leading to a composting effect in which unstable organic matter becomes stabilised (Garg *et al.*, 2006).

The consumption by the earthworms is mainly due to the consortium of earthworms, the microflora in their intestine and those in the growth medium which facilitates in enhancing the decomposition process (Ndegwa and Thomson, 2000). Organic matter ingestion or consumption rate can be very variable, depending on factors such as environment conditions for earthworm activity, food quality and palatability (Curry and Schmidt, 2007). Waste mineralisation and humification rates were found to be higher in bedding containing easily digestible bulk agents (Suthar, 2008).

2.3.3 Nitrogen Mineralization

As an aerobic process, vermicomposting leads to nitrogen (N) mineralization and the use of earthworms in composting increases and accelerates this N mineralization rate (Atiyeh *et al.*, 2000), thus assisting in the reduction of carbon:nitrogen ratio (C:N) and increase in mineral N (Bansal and Kapoor, 2000).

Results have also shown that earthworms reduce microbial biomass early in the process, but enhanced nitrogen mineralization and increased the rates of conversion of ammonium-nitrogen into nitrate (Atiyeh *et al.*, 2000).

2.3.4 Effects on C:N Ratio

Vermicomposting resulted in significant reduction in C:N ratio and increase in mineral N (Bansal and Kapoor, 2000). This is because earthworms initially accelerated the decrease in C:N ratio significantly, demonstrating much more rapid decomposition and rates of mineralization of the organic matter (Kaushik and Garg, 2004).

During vermicomposting, it was found that enzymes involved in the N cycle decreased and those involved in the C cycle tended to increase in the presence of earthworms, when litter with high C:N ratio was provided as food source (Ernst *et al.*, 2009).

A study by Aira and Dominguez (2008) also indicated that earthworms which live in low C:N ratio material are preferentially using more energy in growth and development rather than in reproduction. A study by Ndegwa and Thompson, (2000) also showed that a C:N ratio of 25 resulted in the highest stability of the product, the best fertilizer value of the product and also a product with the lowest potential for environmental pollution.

2.4 Chemical and Physical Properties of Vermicompost

2.4.1 Chemical Properties of Vermicompost

The chemical compostition of vermicompost is highly variable and depend on the initial vermicomposting material. In a study by Bansal and Kapoor (2000), they found out that the nutrient content of vermicompost differs greatly depending on the raw material. This is supported by the study of Pramanik *et al.*, (2007) who reported that the quality of compost depends on several factors, including type of substrate, aeration, humidity, pH, temperature and the earthworm species used during vermicomposting.

Changes in the total nitrogen level in vermicompost correlated with the total organic carbon inside the vermicompost. The C:N ratio, as one of the indicator for nitrogen changed and decreased with time as the C:N ratio gets narrower, the total nitrogen level increases due to the microbial decomposition of the organic matter inside the gut of the earthworms (Pramanik *et al.*, 2007). This finding is similar to that of Kaushik *et al.* (2003), who reported that a large fraction of organic carbon was lost as a result of mineralisation of the organic matter. To get significant nitrogen content, the initial earthworm feed or the organic wastes must possess significant amounts of nitrogen based wastes.

The organic carbon in vermicompost compared to the original waste decrease due to microbial activities in the vermicompost, which enhances the decomposition of the organic waste and lead to the reduction of the total organic carbon. The reduction in organic carbon contributes to the decrease in C:N ratio (Pramanik *et al.*, 2007).

For phosphorus, due to the microbial activities of earthworms gut, the complex substances are mineralized into more available phosphorus forms and also synthesize a whole series of biologically active substances through which phosphates in vermicompost increase as compared to raw materials (Pramanik *et al.*, 2007). Kaushik and Garg, (2004) attributed the increase in phosphorus to the direct action of earthworms gut enzyme and indirectly by stimulation of the microflora.

The amount of phosphorus increased during vermicomposting, but to achieve sufficient phosphorus, the initial feed mixtures should contain more phosphorus base waste. According to (Kaushik and Garg, 2004), feed mixtures having more cow dung content had more total phosphorus than the feed mixtures without cow dung.

In the case of potassium, acid production during organic matter decomposition by the microorganisms was the major mechanism for solubilisation of insoluble Potassium (Pramanik *et al.*, 2007). Moreover, data reviewed by Garg *et al.* (2006) showed that available phosphorus and total potassium increased significantly in all the substrate with worm inoculated waste than in normal composting without earthworms.

It has also been suggested that the processed product of vermicompost contain higher plant metabolites due to enhanced microbial activity during the process of vermicompst (Suthar, 2007).

2.4.2 Physical Properties of Vermicompost

The physical properties of vermicompost have many benefits especially to the growth of plants. In containerized production systems, vermicompost is used as an alternative soil amendment as a soil retention agent which could help reduce several problems associated with the use of conventional synthetic fertilizer such as excessive leaching loss of nutrients and salinity-induced plant stress (Chaoui *et al.*, 2003).

Vermicompost also improves soil properties because of some of its unique features.. Research by Azarmi *et al.* (2008) showed that the addition of vermicompost significantly increased or improved the physical properties of soil such as the bulk density and total porosity. Other than that, earthworms cast can improve soil porosity and thus provide a better root growth medium.

2.5 Earthworms Selection and Suitability

Earthworm selection is vital since the diversity of earthworm species varies with different agro-climatic conditions. It was found that the moisture requirement *for P. excavatus* at 25°C is around 75.2 – 83.2%. The moisture preferences of both juvenile and clitellate worms are around 81% (Hallatt *et al.*, 1992). Thus, *P. excavatus* , a local and tropical epigiec earthworm is suited to the local conditions as it can survive in tropical climate.

Results have also indicated that *P. excavatus* has the potential to efficiently convert organic waste into high-value useful plant growth material (Suthar, 2007), like organic fertilizer which has its own value and market recently due to the expansion of organic farming and the high demand of organic products.

2.5.1 The Growth of *Perionyx excavatus* During Vermicomposting

P. excavatus is an earthworm with high consumption ability and can produce higher earthworm biomass compared to other species of earthworms. It is also reported that *P. excavatus* is a better adapted species for vermicomposting amended with cow dung (Tripathi and Bhardwaj, 2004a).

P. excavatus is an oriental epigeic earthworm; mainly feeding near the soil surface, on plant litter or dead roots and other plant debris or on animal dung like cow dung. Cow dung, a natural food of *P. excavatus* was marginally better than a mixture with kitchen waste with regard to the rate of biomass increase and reproduction (Chaudhuri and Bhattacharjee, 2002).

Food quality and amount also affect the growth and development of earthworms like *P. excavatus* . Different types and amounts of food are critical in influencing not just the size and population of the earthworm but also will significantly influence species diversity, rate of growth and fecundity (Chaudhuri and Bhattacharjee, 2002).

The population of earthworms varies significantly with feed materials, Kaushik and Garg (2003) stated that with increasing supply of cow manure, the population of *P. excavatus and* Clitellated earthworms increased. Earthworms number increase significantly with the addition of cow dung as a result of increasing sources of food found in the cow manure. Suthar (2008) also reported that the growth pattern in composting earthworm depends on microbial population and nutrient pool availability in feeds.

2.6 Organic Wastes Used in Vermicomposting

In recent years, organic wastes are extensively increasing with increased human population, intensive agriculture and industrialization (Tripathi and Bhardwaj, 2004a). These wastes have caused disposal problem as more money and energy input are used to get rid of the waste.

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