



**EFFECTS OF FOOD WASTE SANDWICHED COMPOST ON BOK CHOY
SEEDS, PLANTS AND SOIL PROPERTIES**

By

PHOOI CHOOI LIN

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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January 2023

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Food waste contributes to greenhouse gas emissions and pollution when disposed of in landfills. Finding sustainable ways to reduce it is crucial. Sandwich compost, a modified form of Bokashi, is a promising solution that converts food waste into a nutrient source for plants.

The impact of sandwich compost on soil-plant growth is not well-known. To address this, a study had three objectives: (i) to evaluate the effect of sandwiched compost leachate as a priming solution on Bok Choy seed germination performance; (ii) to evaluate the effect of sandwiched compost substrate amendment on soil physical-chemical properties and enzyme activities; and (iii) to evaluate the effect of sandwiched compost amendment on nutrient composition and antioxidants in Bok Choy compared to commercially grown plants.

A self-made sandwich compost bucket was used in the study. Raw and cooked food waste, including plant and animal-based materials in a 3:2 ratio (raw:cooked), were collected locally. Alternate layers of sandwich compost bran and food waste were filled in the bucket, compacted, and covered tightly. The mixture was fermented for two weeks, and the resulting leachate and substrate were used in the research.

Bok Choy seeds were treated with three methods in the first study: T1-Bio-nutri-priming (0.2% of sandwiched compost leachate), T2-Hydropriming, and T3-Control (dry seeds) for 34 days. The experiment was designed using Completely Randomized Design (CRD) with three replications. The results showed that priming with sandwiched compost leachate improved germination time by 33.2%

and increased SPAD unit by 28.6%. However, there was no significant difference in root and shoot dry matter among the treatments.

Study 2 used a Completely Randomized Design to investigate soil-to-substrate ratios and incubation periods on soil properties and enzyme activities. Results showed that a 1:1 ratio for four weeks significantly improved soil quality, with substrate amendment playing a key role in improving soil-plant quality. This led to significant increases in soil urease activity, pH, and CEC compared to pre-amendment, and increased microbial activity positively affected nutrient availability, improving plant growth. The study suggests that sandwich compost can enhance soil quality as a soil amendment.

Study 3 investigated the use of sandwiched compost substrate as a soil amendment, seed priming solution, and liquid fertilizer for Bok Choy growth. Results showed high yield potential and a high SPAD unit (26.50-37.77). The third cycle produced the highest total leaf area (71.78-141.73 cm²), and the fourth cycle produced Bok Choy with high total carotenoid content (521.60 mg g⁻¹). However, root growth was not favorable, suggesting that Sandwiched compost may not be suitable for root crops in the first two growing cycles due to the possible presence of arbuscular mycorrhizal fungi.

Sandwiched compost substrate improves soil-plant quality, Bok Choy growth and nutrient content. Optimal soil-to-substrate incubation is 1:1 for four weeks. Sandwiched compost can be used as a soil amendment, seed priming solution, and liquid fertilizer. Further research is needed to determine its effectiveness for root crops.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN KOMPOS SANDWIC SISA MAKANAN TERHADAP SIFAT BIJI BENIH BOK CHOY, TUMBUHAN DAN TANAH

Oleh

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Sisa makanan menyumbang kepada gas rumah hijau dan pencemaran apabila dibuang di tapak pelupusan sampah. Mencari cara mampan untuk mengurangkan sisa makanan ini adalah penting. Kompos sandwich, bentuk yang diubah suai daripada Bokashi, adalah penyelesaian yang menjanjikan untuk menukar sisa makanan kepada sumber nutrien untuk tumbuhan.

Kesan kompos sandwich pada pertumbuhan tanah-tumbuhan tidak diketahui dengan baik. Untuk menangani ini, satu kajian mempunyai tiga objektif: (i) untuk menilai kesan air larut sandwiched compost sebagai larutan priming ke atas prestasi percambahan benih Bok Choy; (ii) untuk menilai kesan pembaikan substrat kompos sandwich ke atas sifat fizikal-kimia tanah dan aktiviti enzim; dan (iii) untuk menilai kesan pembaikan kompos sandwich ke atas komposisi nutrien dan antioksidan pada Bok Choy berbanding tumbuhan yang dibudidayakan secara komersil.

Penyelidik menggunakan baldi kompos sandwich buatan sendiri. Sisa makanan mentah dan dimasak, termasuk bahan tumbuhan dan haiwan dalam nisbah 3:2 (mentah:dimasak), dikutip secara tempatan. Lapisan bergantian dari bran kompos sandwich dan sisa makanan diisi dalam baldi, dipadatkan, dan ditutup rapat. Campuran tersebut difermentasikan selama dua minggu, dan air larut dan substrat yang dihasilkan digunakan dalam penyelidikan.

Benih Bok Choy dirawat dengan tiga kaedah dalam kajian pertama: T1-Bio-nutri-priming (0.2% air larut kompos sandwich), T2-Hydropriming, dan T3-Kawalan (benih kering) selama 34 hari. Eksperimen direka menggunakan Reka Bentuk Secara Rawak Lengkap (CRD) dengan tiga pengulangan. Keputusan menunjukkan bahawa priming dengan air larut kompos sandwich meningkatkan

masa percambahan sebanyak 33.2% dan meningkatkan unit SPAD sebanyak 28.6%. Walau bagaimanapun, tiada perbezaan yang ketara dalam berat kering akar dan pucuk di antara rawatan.

Kajian 2 menggunakan Reka Bentuk Secara Rawak Lengkap untuk mengkaji nisbah substrat tanah ke atas substrat dan tempoh inkubasi ke atas sifat-sifat tanah dan aktiviti enzim. Keputusan menunjukkan nisbah 1:1 selama empat minggu meningkatkan kualiti tanah secara ketara, dengan pembaikan substrat memainkan peranan penting dalam meningkatkan kualiti tanah-tumbuhan. Ini menyebabkan peningkatan aktiviti urease tanah, pH, dan CEC berbanding pra-pembaikan, dan aktiviti mikrob meningkatkan ketersediaan nutrien, meningkatkan pertumbuhan tanaman. Kajian tersebut menunjukkan bahawa kompos sandwich dapat meningkatkan kualiti tanah sebagai pembaikan tanah.

Kajian 3 mengkaji penggunaan substrat kompos sandwich sebagai pindaan tanah, larutan priming biji dan baja cecair untuk pertumbuhan Bok Choy. Keputusan menunjukkan potensi hasil yang tinggi dan unit SPAD yang tinggi (26.50-37.77). Kitaran ketiga menghasilkan kawasan daun total tertinggi (71.78-141.73 cm²), dan kitaran keempat menghasilkan Bok Choy dengan kandungan karotenoid total yang tinggi (521.60 mg g⁻¹). Walau bagaimanapun, pertumbuhan akar tidak menggalakkan, menggambarkan bahawa kompos sandwich mungkin tidak sesuai untuk tanaman akar dalam dua kitaran pertumbuhan pertama disebabkan kehadiran kulat arbuskula mikoriza yang mungkin ada.

Substrat kompos sandwich meningkatkan kualiti tanah-tumbuhan, pertumbuhan Bok Choy dan kandungan nutrien. Inkubasi tanah-ke-substrat yang optimum adalah 1:1 selama empat minggu. Kompos sandwich boleh digunakan sebagai pindaan tanah, larutan priming biji, dan baja cecair. Penyelidikan lanjut diperlukan untuk menentukan keberkesanannya pada tanaman akar.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CEC	Cation exchange capacity
°C	Degree Celsius
DMRT	Duncan's Multiple Range Test
DNA	Deoxyribonucleic acid
EC	Electric conductivity
EM	Effective microorganisms
ppm	Part per million
RNA	Ribonucleic acid
SPAD	Soil plant analysis development
SDG	Sustainable Development Goals
UPM	Universiti Putra Malaysia

CHAPTER 1

INTRODUCTION

1.1 Research background and problem statements

Many people have low consumption of nutrients and antioxidants that are rich in fruits and vegetables (M. M. Murphy et al. 2014), and even waste them. One-third of worldwide food production (1.3 billion tonnes of food worth around \$1 trillion) is wasted annually (UNSD 2020). In Malaysia alone, 3 kilo tonnes of edible food are disposed of into landfills daily (Bernama 2019), which is not sustainable in the food production system (Papargyropoulou et al. 2014). Food waste is a hazard to our environment by contributing to greenhouse gas emissions (from the production stage to the consumption stage), water footprint (contaminated groundwater with pesticides), and landfill shelf-life reduction (inducing transmitted human parasites) (Usmani et al. 2021).

Moreover, during food production, mineral fertilizers have been used to meet the world's food security, which brings several impacts as listed below. Indeed, mineral fertilizer does not improve soil properties or develop decent plant characteristics such as good root and shoot systems and nutritional characteristics (Chandini et al. 2019), as well as soil enzyme activity (Böhme and Böhme 2006). It affects food production more seriously than lower soil fertility. The dangerous and toxic chemicals produced by crops accumulate in the human body and harm us, which is not aligned with the Sustainable Development Goals (SDG) 2 (No Hunger) and SDG 3 (Good Health and Well-Being). Therefore, one of the strategies is a 50% reduction in pesticide use, a 20% reduction in mineral fertilizer use, and at least a 50% reduction in nutrient loss (Erdogan et al. 2021).

1.2 Justification

The best solution for food waste is to address it upstream in the food supply chain (Usmani et al. 2021). Nonetheless, education is needed, which takes time and may require government involvement. Composting food waste anaerobically with beneficial microbes is recommended (Usmani et al. 2021). versatile waste management method like Bokashi is needed to accept biowaste fractions such as organic household waste, animal by-products, and contaminated waste with the inoculation of effective microorganisms (EM) in an anaerobic and acidic environment (Margit Olle 2021). Sandwiched compost was adopted from the Bokashi method using the layering method with food waste and Bokashi bran. Sandwiched compost is considered an economical, safe, and eco-friendly organic fertilizer for the next growth cycle of food (Ginting 2019). For example, Sandwiched compost emits less greenhouse gas than composting (Margit Olle 2021) and mineral fertilizer (H. Wu et al. 2021). Proper waste management creates a clean and healthy city by reducing pollution sources, attracting more

tourists, and boosting the economy (SDG 11). The ultimate goal is to live in a healthy environment and have nutritious food. In addition, Sandwiched compost can generate high income (US\$ 576 per 150 tons per day) compared to other urban waste recycling methods, including cattle and goat fattening, worm protein, and mushroom production (SDG 8) (Wididana and Higa 2001). Furthermore, it helps to protect, restore, and reverse land degradation, meeting SDG 15 (Life on Land).

Among methods such as thermophilic composting and vermicomposting, which take months to obtain the end product, Sandwiched compost can produce beneficial microbes in a short period (7 to 21 days) (Quiroz and Céspedes 2019) and requires only a small space, making it suitable for household-scale use. Sandwiched compost is also odorless and has positive effects on soil and plant health, such as improved soil aggregate stability and enhanced microbial agents (Sodhi, Beri, and Benbi 2009; Cosentino, Chenu, and Le Bissonnais 2006). Sandwiched compost can be an alternative source of nitrogen (N) for plant growth (Quiroz and Céspedes 2019). The N concentration range (0.50-3.19%) depends on the raw material of Sandwiched compost (Quiroz and Céspedes 2019). Food waste as a raw material for Sandwiched compost is a common practice in communities, although there is a lack of scientific evidence. Additionally, the leachate produced during the composting process can be used as a seed priming solution and liquid fertilizer.

Brassica crops like Bok Choy provide people with phytonutrients, vitamins, minerals, and fiber (Xiaonan Li, Pang, and Piao 2017). Leafy vegetables have short growing cycles (3 to 4 weeks from planting to harvest) and are in high demand (Mawois, Aubry, and Le Bail 2011). Brassica species contain many health-promoting compounds, such as a spectrum of carotenoids and polyphenols, a unique group of compounds known as glucosinolates (a group of sulfur- and nitrogen-containing secondary plant metabolites) (Traka and Mithen 2009; Martínez-Ballesta, Moreno, and Carvajal 2013; Faller and Fialho 2009). These compounds play an important role in plant defense against microbial pathogens and herbivorous insects (Halkier and Gershenzon 2006; Augustine and Bisht 2015). In Malaysia, Brassica production was 0.15 Mt in 2019, accounting for 15% of total vegetable production (Jabatan Pertanian Malaysia 2019). Due to high demand for Bok Choy, it was selected as the test crop.

1.3 Objectives

Three studies are found here. The objective of study 1 is to evaluate the effect of Sandwiched compost leachate as a priming solution on Bok Choy seed germination performance compared to hydropriming. The objective of study 2 is to evaluate the effect of Sandwiched compost substrate amendment on soil physical-chemical properties and enzyme activities. The objective of study 3 is to evaluate the effect of Sandwiched compost amendment on nutrient composition and antioxidants in Bok Choy in comparison with commercially grown.

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