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Mini Food Waste Composter Machine

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Abstract

Food waste is a major environmental problem that contributes to greenhouse gas emissions and causes landfill overflow. In Malaysia, poor waste management at home leads to traditional harmful disposal methods like dumping and burning. In other hand, composting presents a sustainable solution by turning organic waste into nutrient-rich fertilizer; however, traditional composting methods is timely and require a lot of effort. This project aims to create a Mini Food Waste Composter Machine that automates the shredding and mixing processes for small users such as households and small cafes. The system combines mechanical, electrical, and control parts with a MOTION 2350 Pro microcontroller, a stainless-steel shredder, and a static mixer to enhance the composting process. Evaluation tests with 300 grams of food waste showed that soft waste was completely processed in 20 to 30 seconds, while fibrous waste took longer. While full automation was not achievable due to mechanical constraints, the semi-automated system worked well. In conclusion, this project offers a practical, low-cost, and sustainable solution for managing organic waste on a small scale.

1. Introduction

Food waste management represents a critical environmental and public health concern in modern society. In many developing and urban communities, food waste is still disposed irresponsibly by dumped at unauthorized sites, burned in open spaces, buried in the ground, or flushed into drains and waterways. These poor disposal habits are often linked to inefficient waste collection systems; when such systems fail, illegal dumping and pollution of soil and water become more prevalent [1]. Composting offers a sustainable and practical approach to mitigate these issues by converting organic waste into nutrient-rich compost, thereby reducing landfill burden and enriching soil fertility [2]. It is an aerobic process, meaning it requires exposure to air, unlike anaerobic fermentation, which occurs in low-oxygen conditions. Effective composting depends on achieving the right balance of four essential components—carbon, nitrogen, oxygen, and moisture. In practice, mixing nitrogen-rich materials such as food scraps (greens) with carbon-based materials like dried leaves or small branches (browns) yields quality compost. Within this balanced environment, microorganisms including bacteria, fungi, and protozoa

break down organic matter while eliminating harmful pathogens, resulting in safe compost suitable for agricultural and horticultural use [1][2].

Although composting is beneficial, traditional methods are time-consuming, physically demanding, and often unsuitable for compact urban spaces. To address this limitation, this project focuses on designing and developing a Mini Food Waste Composting Machine that incorporates the MOTION 2350 PRO microcontroller to automate key composting operations. The system integrates two core processes: shredding the food waste and mixing it with dry soil to improve aeration, control moisture, and maintaining an appropriate carbon-to-nitrogen ratio. These processes enhance microbial activity, thereby accelerating decomposition and improving compost quality. Experimental testing using household food waste samples demonstrated that the prototype effectively reduced composting time compared to conventional methods while consuming minimal energy. The machine is especially applicable for small-scale settings such as cafes, food courts, canteens, and small farms, although it is not designed to handle hard materials like bones due to blade limitations. The project aims to reduce household food waste by converting it into usable compost, encouraging sustainable waste practices, and improving overall soil health.

1.2 Emerging Technology Food Waste Management

Food waste management is continuously evolving and has become an innovative field within food science that integrates technological advancements to minimize environmental impacts. In Malaysia, local authorities continue to face major challenges in effectively managing and processing food waste. One persistent issue is the improper separation of food waste from general municipal solid waste, which contributes significantly to greenhouse gas emissions from landfills [3]. To address this, various awareness initiatives—such as the 3R (Reduce, Reuse, Recycle) campaign—have been launched through educational programs and incentive-driven policies. These efforts are designed to raise public awareness, encourage responsible disposal behavior, and promote more sustainable food waste management systems that can help decrease the overall amount of waste produced [4]. Among Malaysian households, traditional composting methods like thermal composting and vermicomposting are still widely practiced. As highlighted by W. J. Lim and colleagues [4], the thermal composting process typically includes a pre-composting stage lasting around nine days, followed by about two and a half months of vermicomposting. This combined approach is effective in producing safe compost with lower mass, pathogen levels, and moisture content. However, these techniques are often time-intensive and physically demanding. They also require careful maintenance of worms as biological decomposers, and the final stage—separating worms from the compost—must usually be done by hand or with large-scale machinery, making the method less convenient for household users.

To overcome these limitations, alternative small-scale approaches such as Bokashi composting have been introduced. The Bokashi method ferments organic materials using effective microorganisms mixed with molasses and water [6]. It offers several appealing advantages: a short processing period (about 7 to 21 days), minimal space requirements, and the flexibility to continuously add new waste to the container. These features make Bokashi particularly suitable for urban Malaysian households that produce smaller quantities of food waste and lack outdoor space for conventional compost piles [6]. Another key development in improving composting efficiency is the use of bulking agents, which are carbon-rich additives that enhance aeration, control moisture, and reduce unpleasant odors while maintaining the compost's structural integrity. Previous studies have explored the use of microbe sawdust, derived from decomposed sawdust through isolation and anaerobic digestion. When about 10% sawdust is incorporated, the composting process becomes more effective, accelerating carbon mineralization, nitrogen conversion, and overall degradation [6]. In addition, woodchips made from recycled wood are also commonly used to improve airflow and maintain pile structure [6]. Combining sawdust with woodchips increases the compost's bulk density, improves storage properties, and makes handling and transportation easier. Furthermore, integrating dairy powder waste during pelletization enhances compost manageability, reduces dust formation, and minimizes environmental pollution—making it suitable even for use in residential areas [5].

2. Methodology

This project focuses on the development of a Mini Food Waste Composter Machine designed to automate the composting process for small-scale users through three main stages: design and development, system integration, and performance testing. The development phase began with the conceptual design of a compact, efficient, and user-friendly composter structure suitable for household and small-scale industry applications.The machine was designed to perform two main functions, shredding food waste and mixing it with dry soil—to accelerate the decomposition process and enhance composting efficiency. A MOTION 2350 PRO microcontroller served as the main control unit to automate motor operation and timing, ensuring consistent performance and process reliability.

During the system integration phase, all electrical and mechanical components were assembled into a single prototype unit. The control system was programmed to regulate motor speed and operation based on sensor feedback, while a simple user interface featuring indicator LEDs and control buttons was incorporated to improve usability. Safety features such as overload protection and automatic shutdown mechanisms were also implemented to prevent motor damage and ensure operational safety. For performance evaluation, the prototype was tested using various types of household food waste, including vegetable scraps and fruit peels. The machine's effectiveness was analyzed based on composting time, temperature, moisture content, energy consumption, and final compost quality. Additionally, the machine was tested with different types of food waste to evaluate its subtlety and processing efficiency under varying conditions. The testing was divided into two case studies: Case Study I, which focused on validation testing for the shredder system, and Case Study II, which focused on validation testing for the mixer system.

2.1 System Design

Fig. 1 illustrates the operational flow of the Mini Food Waste Composter Machine, which automates the composting process from food waste preparation to compost production. Initially, excess water is removed from the food waste before it is inserted into the machine. The process starts when the user presses the "Start" button, and the system performs a safety check. If any issue is detected, the user can press the "Emergency" button to stop the system immediately. Once safety is confirmed, the food waste is shredded into smaller pieces and then added into the mixer that already contains soil. The shredded food waste and soil are mixed thoroughly for about three minutes to ensure even blending and optimal conditions for microbial activity. The mixture is then left for about five days to complete the composting process. After this period, the compost is ready to be used as a planting medium, showing the system's effectiveness in automating food waste management.

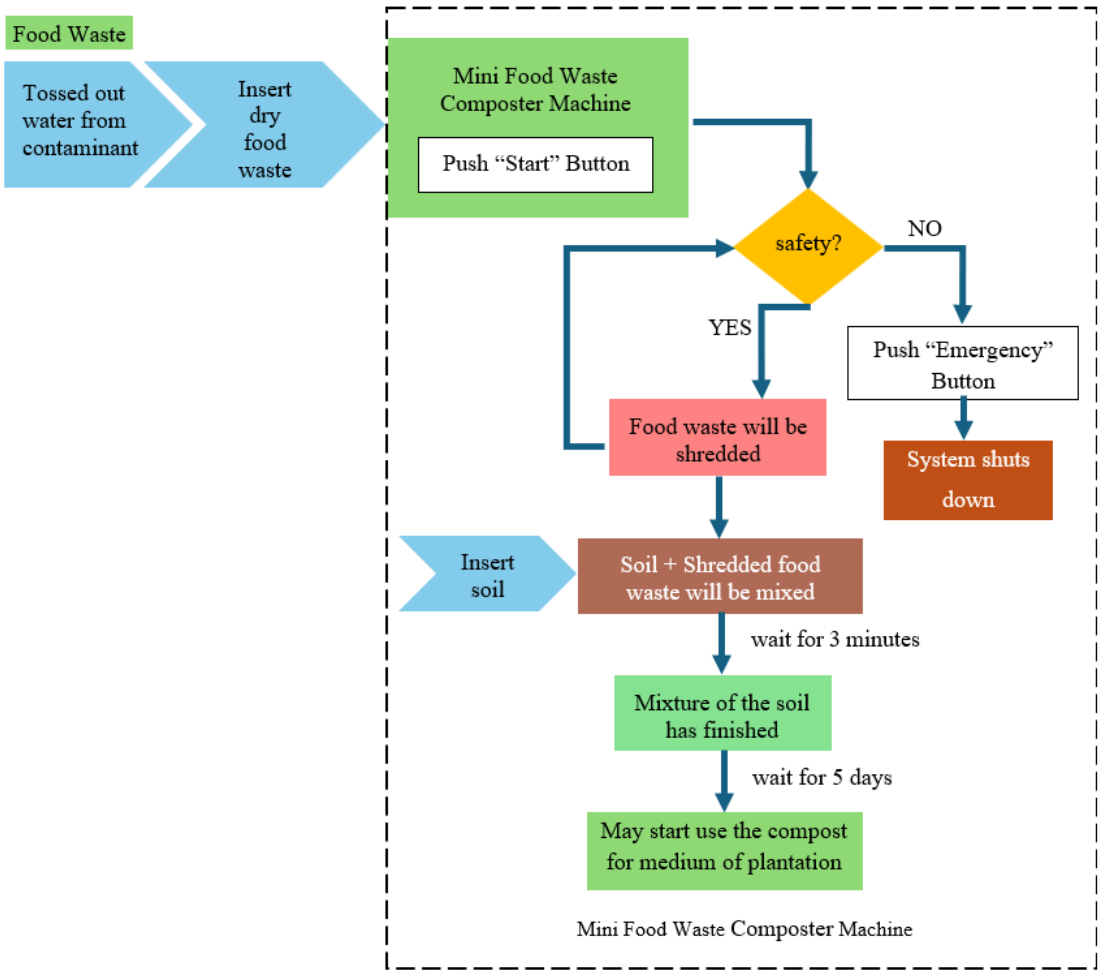

Fig. 1 *System Design Flowchart*

2.2 Main Components of Mini Food Waste Composter Machine

The development of the Mini Food Waste Composter Machine is based on a mechatronics system that integrates mechanical, electrical, and control subsystems to perform automated food waste composting. Each subsystem plays a crucial role in ensuring the machine operates efficiently and effectively throughout the composting process. The mechanical subsystem involves all the physical moving parts, the electrical subsystem provides power and actuation, and the control subsystem coordinates all operations through programmed logic. The integration of these three subsystems produces a functional, semi-automatic composting unit capable of shredding, mixing, and processing organic waste into compost.

Table 1 *Mini Food Waste Composter Machine main components*

Parts	Description
304 Stainless Steel Grinder	Used to shred food waste into smaller particles. It will then increase the surface area for microbial activity and accelerate the composting process.
Static Mixer	Used to mixing the food waste with medium and ensuring even distribution of moisture and microbes.
Ball Bearing	Acts as a support to rotate the shaft of the mixer. It also reduces friction and wear while allowing smooth motion during operation.
Stainless Steel Rod	Acts as a shaft that transmit mechanical power from the motor to the mixing paddles. It later enables the rotation needed to mix the food waste and medium.
Power Window Motor	Used to drive the shredder to move down automatically and mixer. It provides enough torque and rotation speed to move the shredder and mixing the food waste with medium.
MOTION 2350 Pro microcontroller	Used to control the motor and make the machine a fully automated system.

Table 1 shows the main components used in the Mini Food Waste Composter Machine and their functions. The 304 stainless steel grinder shreds food waste into smaller pieces to speed up composting. The static mixer mixes the food waste evenly with the medium, while the ball bearings help the mixer shaft rotate smoothly. The stainless-steel rod transfers power from the motor to the mixer, and the power window motor provides the force needed to run the shredder and mixer automatically. Finally, the MOTION 2350 PRO microcontroller controls the motor and automates the whole system.

2.3 Prototype Specification

To ensure the Mini Food Waste Composter Machine meets functional, safety, and user requirements, several technical and operational specifications were established. These specifications along with their justifications, highlighting important aspects such as geometric design, safety features, maintenance requirements, ease of use, and economic as well as environmental considerations.

Table 2 *Mini Food Waste Composter Machine specifications*

Mini Food Waste Composter Machine	
Specifications	Justifications
Geometric Limitations	● compact size is desired ● height by (30 cm), width by (30 cm), length by (46 cm) ● input capacity of food waste in limitation of 300 g.
Safety	● has no sharp edges on the surface and compost operation will be functioned in the machine's outside frame (body) ● has an emergency push button, just in case for any unnecessary accident or failure safety hazard.

Table 2 *Mini Food Waste Composter Machine specifications (cont.)*

Mini Food Waste Composter Machine	
Specifications	Justifications
Maintenance / Repair	• Restores functionality such as shredder system, mixture system or electrical system after something breaks. • The system of the machine should be easy to clean; 1. pouring one or two cups of antiseptic liquid 2. let it be for 30 seconds to cleanse all the harmful germs 3. rinse with clean water.
Ease of Use	• Simple to use; 1. Insert food waste 2. Machine operation will be start within minutes based on the capacity 3. Food waste compost can be taken out after the composting operation is finished.
Economic	• Utilise food waste can also save money on gardening expenses • Should not require any routine service other than cleaning
Pollution	• Does not cause any dangerous gas emission due to bulking agents, biochar.
Appearance	• Colour scheme to match current / popular appliance trends • Surface finish should be very smooth to facilitate cleaning

Table 2 presents the product specifications and justifications for the Mini Food Waste Composter Machine. The design emphasizes a compact geometric size with dimensions of 30 cm (height) × 30 cm (width) × 46 cm (length) and an input capacity of 300 g, making it ideal for small-scale or household use. For safety, the machine features smooth, rounded edges to prevent injury and includes an emergency push button to stop operation in case of malfunction or hazard. The maintenance and repair system is designed for simplicity, allowing users to restore functionality easily by cleaning with antiseptic liquid, letting it sit for 30 seconds, and rinsing with clean water. The ease of use is highlighted through an intuitive three-step process—insert food waste, start the machine, and collect compost after the process is complete. Economically, the machine helps reduce gardening expenses by converting food waste into compost and requires minimal maintenance. From an environmental standpoint, it produces no harmful gas emissions, ensuring safe operation. The appearance is designed with smooth surfaces and color options that align with modern appliance aesthetics, making it both practical and visually appealing.

3. Result and Analysis

The final prototype of the Mini Food Waste Composter Machine is shown in Fig. 2. The prototype features a compact and enclosed structure suitable for household and small-scale café applications. The outer casing provides a clean, safe, and durable design, while the internal view reveals the main mechanical components, including the shredder system, static mixer, transition mechanism, and control box. The overall configuration allows easy access for maintenance and cleaning while ensuring user safety through the inclusion of an emergency stop button and fully enclosed housing. Fig. 2(a) shows the outer body of the machine, whereas Fig. 2(b) illustrates the successful integration of all mechanical and electrical systems into a fully functional unit capable of automatically shredding and mixing food waste with soil to accelerate the composting process.

(a) **(b)**

Fig. 2 *Mini food waste composter prototype (a) Outer body (b) Internal structure*

3.1 Case Study I: Validation System for Shredder System

Case Study I was conducted to validate the performance of the shredder system using four different types of food waste: vegetables, grain foods, soft meat and bones, and a mixture of all. Each test used the same quantity of food waste, 300 g, but required different processing times to achieve optimal shredding results. The experiments were carried out at the Teaching Factory, Block K, Universiti Tun Hussein Onn Malaysia (UTHM).

Table 3 *Validation Testing for Shredder System*

Type of Food Waste	Quantity	Time Required		
		20 sec	30 sec	40 sec
Soft Waste	300 g	Partially Shredded	Fully Shredded	Fully Shredded
Hard Waste	300 g	Partially Shredded	Mostly Shredded	Fully Shredded
Mixed Waste	300 g	Partially Shredded	Mostly Shredded	Fully Shredded

Table 3 summarizes the validation testing results for the shredder system. Based on the findings, soft waste was fully shredded within 30 seconds, while hard waste and mixed waste required up to 40 seconds for complete shredding. These results demonstrate that the shredder system is capable of handling a wide range of food waste textures efficiently within a short duration.

3.2 Case Study II: Validation System for Mixer System

Case Study II aimed to validate the performance of the mixer system in blending shredded food waste with soil. Similar to the previous test, four types of food waste—vegetables, grain foods, soft meat and bones, and mixed waste—were used. Each trial used a fixed amount of 300 g of food waste and 500 g of soil, while the mixing duration varied. The tests were conducted at the Teaching Factory, Block K, Universiti Tun Hussein Onn Malaysia (UTHM).

Table 4 *Validation Testing for Mixer System*

Type of Food Waste	Quantity of Food Waste	Quantity of Soil	Time Required		
			20 sec	30 sec	40 sec
Soft Waste	300 g	500 g	Partially Mix	Fully Mix	Fully Mix
Fibrous Waste	300 g	500 g	Partially Mix	Mostly Mix	Fully Mix
Mixed Waste	300 g	500 g	Partially Mix	Mostly Mix	Mostly Mix

Table 4 presents the validation results for the mixer system. The findings indicate that soft waste achieved a fully mixed condition within 30 seconds, while fibrous and mixed waste required up to 40 seconds for a thorough

mixture. This confirms that the mixer system effectively combines different food waste types with soil, producing a uniform composting mixture in a relatively short time.

4. Conclusion

The Mini Food Waste Composter Machine did not fully achieve its objective of being fully automatic due to several issues encountered during the fabrication and testing stages. The main problem arose from the misalignment of the chain system, which created excessive tension and resistance between the sprocket gears of the shredder and the Power Window Motor. To overcome these issues, the system was modified from a fully automated to a semi-automated control system to ensure smoother, safer, and more stable operation. Despite this limitation, the machine remains functional and effective as a semi-automated composter unit. Through two validation tests, the shredder system validation and the mixer system validation was demonstrated that the machine performs efficiently with different types of food waste, including soft waste, fibrous waste, and a mixture of both. The findings revealed that the system can process up to 300 g of food waste within variable time durations depending on waste type. Specifically, soft waste required the shortest processing time, whereas fibrous waste took longer due to its denser and more fibrous structure. The integrated shredder and mixer systems enhanced microbial activity by increasing the surface area of waste and ensuring even distribution of moisture and nutrients. Additionally, the use of stainless steel and aluminum profiles provides a sturdy and corrosion-resistant frame suitable for long-term use in moist environments. In future development, it is recommended to replace the chain drive system with a belting system to improve alignment, reduce mechanical resistance, and enhance overall reliability. Additionally, integrating temperature and humidity monitoring functions is suggested to monitor the composting process and ensure optimal conditions throughout operation. In conclusion, this project provides a practical and sustainable small-scale solution for organic waste management, helping to minimize landfill waste, promote environmental conservation, and support sustainable urban agriculture through nutrient-rich compost production.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: ***study conception and design****: Muhammad Azri Othman and Mohamad Razif Mohamad Ismail;* ***data collection****: Uzma Nur Huda Muhammad Nazry, Nurul Hanis Mohd Jufri, Nurain Saliha Khairussalih;* ***analysis and interpretation of results****: Uzma Nur Huda Muhammad Nazry, Nurul Hanis Mohd Jufri, Nurain Saliha Khairussalih;* ***draft manuscript preparation****: Muhammad Azri Othman and Mohamad Razif Mohamad Ismail. All authors reviewed the results and approved the final version of the manuscript.*

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