Dual grinding and mixing machine for vermicompost and worm biomass production

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Abstract. Agricultural wastes come from different farming and planting activities that can be used as main material for organic fertilizers and compost. To improve the quality of the compost, it is better to include earthworms in the mixture to become vermicompost. Vermicompost is made up of enriched fertilizer with the production of earthworm known as worm biomass. The preparation of the vermicompost consists of grinding the waste in tiny bits and mixing manually which consumes a lot time and effort. This study focuses on the design of a dual grinding mixing machine intended for vermicompost and worm biomass production. The earthworm used in this study is African Night Crawler species. There are 13 testing vermicompost beds used for the experiment. The machine reduced the preparation time to one-third compared to manual operation. There is increase in the production of vermicompost by 87.5 kg and worm biomass by 3.5 kg, respectively, in monthly basis.

1. Introduction
Vermicomposting has many beneficial attributes in agriculture. Vermicompost promotes plant growth that is almost half percentage over the conventional and chemical fertilizer [1]. It provides more improvement on the crop yield compared to chemical fertilizers [2]. Simultaneously upon the production of vermicompost, yield of worm biomass can be obtained [3]. To produce vermicompost and worm biomass, vital processes are needed to facilitate such as making the feed materials smaller for easier consumption of the worms and proper combining of animal manure and feed materials.

The two processes essential in making vermicompost are grinding and mixing. Grinding process further reduces the particle size of the feeds for the earthworm to easily consume them. The mixing process on the other hand provides consistent texture and quality of feeds before placing them into beds [4]. There are few literatures highlighting the combination of grinding and mixing processes in vermicompost and worm biomass production. It is vital to still study on how to improve these processes to make better cycle time, lower production costs and produce enhanced yield on vermicompost and amount of worm biomass [5].
2. Materials and Methods

2.1. Dual grinding and mixing machine
The dual grinder and mixing machine as shown in Figure 1 has a total capacity of 40 kg on the mixer tub to combine the grinded materials and the animal manure. The mixer tub is made up of 3mm thick plastic drum. The diameter of the shaft wheel is 18 inches while the motor diameter is 4.5 inches hence speed ratio of the machine is 4. The tub utilizes blades in the form of paddles which aid on the mixing of the materials. The frame of the mixer is made up of steel. A 2 Hp motor was used in the prototype. The grinder used has a rotor and a stator. The rotor is the rotating part that serves as a blade when it passes the stator which is offset and leaves a small space to shear the grinding materials. A funnel is attached at the inlet of the grinder to make the materials easier to be fed to the grinder.

![Figure 1. Dual grinding and mixing machine](image)

2.2. Animal Manure and Feed Materials
The researchers gathered livestock manures from pigs and cows. This would speed up the decomposition process when consumed by the worms [6]. Different feed materials as seen in Figure 2 such as dried leaves, small branches, banana peels, and other vegetable and fruit pods underwent grinding process to further reduce their particle sizes.

![Figure 2. Feed materials used.](image)

2.3. African Night Crawlers
This study chose earthworms specie *Eudrillus Eugeniaeas* or commonly called African Night Crawlers shown in Figure 3. They are very easy to maintain in terms of feeding since they eat almost all kind of
biodegradable materials [7]. During the decomposition stage of the vermicomposting process, worm biomass increases in number.

![Figure 3. African Night Crawlers](image)

2.4. Vermicompost Bed
After grinding the feed materials to tiny bits and mixing them to animal manure, the mixture is ready to be placed in vermicompost beds as shown in Figure 4. The beds have width of 1 meter and length of 5 meter with at least 2 feet of pile height. The beds are frequently watered to maintain moisture content of at least 50%. Canopies are covering the beds from sunlight and heavy rains. The beds were patterned with those seen at TRP Vermi Farms located at Brgy. Masaya, Bay, Laguna.

![Figure 4. Vermicompost Bed](image)

2.5. Design Formulas for Dual grinding and mixing machine
The following design formulas are used in designing the mixer tub. The speed ratio is defined by the equation in (1)

$$\frac{D_2}{D_1} = \frac{N_1}{N_2}$$  \hspace{1cm} (1)

D1 and D2 are the diameters in inches of the motor and shaft wheel, respectively corresponding to their angular speed N1 and N2 both in rpm.

The mass of the paddle mixer m as seen in (2) is calculated using density of the material $\rho$ in kg/m$^3$ while V is the volume of the mixer in m$^3$. The volume of the paddle mixer is the sum of the volumes of the paddle, main and secondary shafts

$$m = \rho V$$  \hspace{1cm} (2)
This is the required torque of the machine, \( m \) is the mass of the load in kg, \( a \) is the linear acceleration in \( \text{m/s}^2 \) and \( L \) is the lever arm in meters. The formula is illustrated in (3)

\[
T = mal
\]  

(3)

The total power \( P \) as shown in (4) required to run the machine in Hp where in it is the sum of \( P_g \) and \( P_m \) power to run the grinder and motor, respectively.

\[
P = P_g + P_m
\]  

(4)

2.6. Testing Procedure

The mixture of the animal manure and feed materials were fed to the earthworms into the vermicompost beds. Thirteen beds were utilized corresponding the capacity of the machine. The amount of vermicompost and earthworms produced were recorded and compared to the output of TRP Vermi farms.

3. Results and Discussion

From the experiment conducted by the researchers, using the machine, the production of vermicompost as well as worm has increased. From the thirteen small beds, the beneficiary can produce 400 kilograms of vermicompost per month; while with the use of the prototype, it can accumulate an amount of 487.5 kilograms of vermicompost per month. The worm production also increased from 4 kilograms of worm per month to 7.5 kilograms of worm per month as shown in Table 1.

| Table 1. Monthly Vermicompost and Worm biomass produced in 13 beds |
|---------------------------------------------------------------|
| Vermicompost (kg)  | Worm (kg) |
|---------------------|-----------|
| TRP Vermi Farm     | 400       | 4        |
| Using Dual Grinding and Mixing Machine | 487.5   | 7.5      |

The preparation time for the mixture of animal manure and feed materials was also observed to decreased from 30-minute manual mixing to 10-minute dual grind and mixing.

4. Conclusion

The result of the testing of the prototype shows that the combined grinding and mixing process for the feed materials can help the production of the vermicompost. The prototype increases the production of the vermicompost in a shorter period. Compared to the manual mixing of the water and livestock manure, the use of the prototype may also decrease the preparation time from 30 minutes down to 10 minutes.

Grinded feed materials were more effective than the ungrounded agricultural waste when it comes to the feeding of the African Night Crawlers. The African Night Crawlers consume the grinded feed materials easier than the ungrounded agricultural waste. With this, the grinded feed materials can easily produce vermicompost in a shorter period.

In a monthly basis and utilizing thirteen beds, there is an estimate of 7 ½ times of harvest there is observed increase of 87.5 kg of vermicompost and 3.5 kg of worm production compared to the output of TRP Vermi Farms. The preparation time of the mixture was also lessened to 1/3 of its original cycle time of manual mixing. The productivity has been increased and the cycle time is reduced when using the dual grinding and mixing machine.

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