The Development of The Food Material Grinding Machine to Facilitate The Processing of BSF Maggot Feed

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Abstract. The Beringin Business Group in Selat Baru Village, Bengkalis Regency, manages the Black Soldier Fly (BSF) to produce maggots, which are then used as livestock feed for other businesses. The conversion of organic waste into BSF maggots is an effective and environmentally friendly method in organic waste processing. Therefore, a food material grinding machine is needed to process banana stems into feed material The reason for using banana stems is to make it easier for the maggots to consume their food, facilitating the decomposition process to produce BSF maggot feed. The machine is powered by a gasoline engine to efficiently grind banana stems and other organic waste. The grinding device employs a 6.5 HP gasoline engine operating at 3000 rpm. The engine's power is transmitted from the cutting blade to the device through a belt and a pulley. The machine operates by feeding banana stems into an initial funnel, which then guides them to the cutting blade for shredding, resulting in a paste-like or finely ground output. Three tests were conducted using varying diameters of banana stems: 2.5mm, 3.5mm, and 4.5mm. The test results indicated that processing banana stems with a diameter of 4.5mm yielded the recommended outcome, the average output of the machine is approximately 6.11 kilograms per hour.

Keywords: BSF maggots, grinding machine, cutting blade, shaft rotation.

1. Introduction

The rapid development of technology to process solid organic waste has become a significant concern, as improper handling can lead to prolonged social issues. Processing organic waste using biological agents such as maggots or larvae from the Black Soldier Fly (BSF), scientifically known as Hermetia illucens [1], has gained attention. The Maggot Business Group of Selat Baru Village in Bengkalis Regency is one such community group that cultivates BSF maggots to enhance the livelihoods of its members. Presently, the Maggot Business Group possesses a machine for grinding maggot feed material. However, the efficiency is limited, and the output for maggot feed is too substantial. Therefore, there is a need to develop a food material grinding machine to facilitate the finer processing of BSF maggot feed. This machine

ABEC 2023, September 21, Bengkalis, Indonesia

DOI 10.4108/eai.21-9-2023.2342917

is designed to process feed material into a smooth form that can be easily digested by BSF maggots.

From the aforementioned issues, there is a need for a device to grind organic waste, especially banana stems, utilizing existing technology such as the food material grinding machine. Previous research titled "The Design and Development of the 50 kg/hour Capacity Animal Feed Grinding Machine" successfully produced animal feed in paste form, albeit still coarse due to its intended use for fish feed. The machine utilized a 5 HP Robin engine with a rotation speed of 1000 rpm as the driving source [2]. Another study, "The Design and Development of the Animal Feed Grinding Machine for Improved Feed Consumption Effectiveness in Sukoharjo," employed a 6 HP gasoline engine with a rotating speed of 1500 rpm [3]. However, prior research results showed that the grinding machine designs were still inefficient, as evidenced by the motor power used and the resulting shredding capacity, which were inadequate for achieving a fine grind that could be thoroughly consumed by BSF maggots.

Therefore, this study is conducted to develop an efficient animal feed grinding machine, specifically for banana tree stems. This study focuses on creating a food material grinding machine aimed at facilitating the decomposition process of BSF maggot feed. The machine's design involves the use of a 6.5 HP gasoline engine as the power source, generating rotation that is then transmitted through the use of pulleys and V-belt. The machine incorporates a reel-shaped cutting blade with six cutting edges, along with a pulling shaft used to draw the banana stems for shredding. To simplify the process of collecting and grinding banana tree stems into a paste, the machine is equipped with a table. The inclusion of this table increases efficiency and enables continuous grinding operations for farmers.

2. Research Methods

The method used in this study involves the design and fabrication of the machine, as well as the testing of the performance of the created tool. This research consists of two phases: the machine design/fabrication phase and the machine testing phase. The equipment design process is carried out using Autodesk Inventor software. Subsequently, the fabrication and testing of the equipment are conducted at the Production Process Workshop and Welding Workshop of the Bengkalis State Polytechnic, located on Sungai Alam Street, Bengkalis. The following is Figure 1, which illustrates the flowchart of the design and development process of the BSF Maggot feed grinding machine.

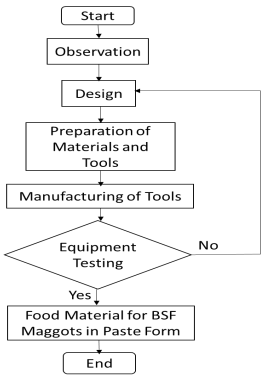
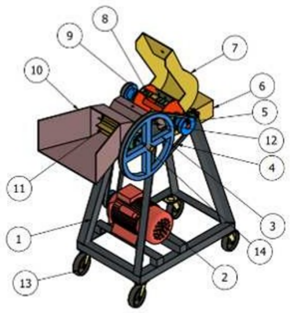


Fig. 1. The Design process of the BSF maggot feed grinding machine

3. Result and Discussion

In order to design this machine, a diagram is needed to illustrate the initial steps taken as well as the requirements, limitations, and advantages of constructing the machine. The machine fabrication refers to the technical drawings that have been meticulously designed and calculated. These technical drawings are presented in three-dimensional form. Figure 2 outlines the components of the machine design as follows:



Explanation		
NO	Quantity	Name
1	1	Frame
2	1	Dynamo
3	1	Pulley 12 Inch
4	2	V belt
5	3	Grinding eye
6	1	Chopper Blade Shaft
7	1	Bearing
8	4	Output plate
9	1	Bearing housing
10	1	Blade housing
11	1	Shaft pushing
12	2	Input shaft
13	4	Wheel
14	4	Bearing shaft

Fig. 2. The Design of the BSF maggot feed grinding machine

3.1 The Operation Principle

The BSF Maggot Feed Grinding Machine operates based on the motion principle of the driving motor. The motor utilized is a 6.5 HP gasoline engine with a rotation speed of 3000 rpm. The usage of this machine begins by connecting the gasoline motor cable to the power source. Subsequently, the gasoline engine will rotate, and its rotation will be directed to the blade shaft. This rotation is then transmitted to the pulling roll shaft. To grind the banana stems, the stems are fed through the input funnel, which is pulled by the pulling roll and finely ground into a paste by the cutting blade. The finely shredded paste-shaped output will exit through the output hopper.

This grinding machine features a body constructed from plates supported by an angle iron frame. Components are joined using welding, bolts, and nuts. To transmit power from the gasoline motor to the grinding machine's blade, a V-belt and pulley are employed.

3.2 The Design System Calculation

The machine is powered by a 6.5 HP gasoline engine. The drive system employs an electric motor with a rotation speed of 3000 rpm, and a pulley with a diameter of 3 inches is mounted on the motor. The calculation used in designing the machine components involves determining the rotation speed of pulley 2 using the formula:

$$n2 = \frac{n_1 d_1}{d_2} \quad (1)$$

n1: Motor rotation speed (in rpm)
d1: Diameter of the motor pulley (in mm)
n2: Second pulley rotation speed (in rpm)
d2: Diameter of the second pulley (in mm)
n3: Third pulley rotation speed (in rpm)
d3: Diameter of the third pulley (in mm)
n4: Fourth pulley rotation speed (in rpm)
d4: Diameter of the fourth pulley (in mm)

Furthermore, it is given that:

$$n_1 = 3000\ rpm;\ d_1 = 3\ inci = 76{,}2\ mm;\ d_2 = 3\ inci = 76{,}2\ mm$$

Therefore:

$$n_2 = \frac{3000\ rpm\ x\ 76{,}2\ mm}{76{,}2\ mm} = 3000\ rpm$$

At the shaft rotation, the cutting blade is transmitted to the pulling shaft. Next, the pulley that has been positioned in alignment with a diameter of 3 inches is connected using a V belt to a larger pulley with a diameter of 12 inches. The pulley is mounted on the pulling shaft, therefore the calculation of the rotation speed at the pulling shaft is:

$$n_2 = n_3 = 3000\ rpm;\ d_3 = 3\ inci = 76{,}2\ mm;\ d_4 = 12\ inci = 304{,}6\ mm$$

Therefore:

$$n_4 = \frac{3000\ rpm\ x\ 3\ inci}{12\ inci} = 750\ rpm$$

d1: Diameter size of the gasoline motor pulley (in mm)
d2: Diameter size of the pulley on the cutting blade shaft (in mm)
d3: Diameter size of the pulley on the cutting blade-pulling roll shaft (in mm)
d4: Diameter size of the pulley on the pulling roll shaft (in mm)

3.3 The Rotational Power Calculation

To determine the magnitude of the cutting force (F) obtained from the weight of the banana stem, which will be weighed and placed into the feed hopper of the grinding machine, measurements need to be taken to ensure proper engagement with the driving pulley without slipping. Once the mass of the banana stem is known to be 5 kg and the length of the blade arm is 0.075 m, the torque can be calculated using the formula: Torque = Force × Arm. In this case, the force in action is the weight of the banana stem, which can be calculated using the formula: Force = Mass × Gravity.

In this scenario, the value of Gravity can be approximated as 9.8 m/s² (the estimated value of Earth's gravity). Utilizing the mass value of 5 kg, we can calculate the force: Force = 5 kg × 9.8 m/s² = 49 N. Subsequently, we can calculate the torque: Torque = 49 N × 0.075 m = 3.675 Nm. Therefore, the magnitude of the torque is 3.675 Nm.

$$T = F \ x \ r \qquad (2)$$

Where r is the length of the blade arm.

$$T = 49 \ N \times 0{,}075 = 3{,}675 \ Nm$$

The result of the cutting blade shaft torque (T2) is 3.675 Nm.
Meanwhile, the result of the Motor Torque (T1) is as follows:

$$T_1 = \frac{T_2 \ x \ n_2}{n_1} \qquad (3)$$

The torque calculation will be derived to find the gasoline motor power as follows:

$$P = \frac{T_2 \ x \ 2\pi n}{60} = 5{,}3851 \ Hp$$

Based on the calculation, the minimum required motor power is approximately 1.55 HP. Since gasoline motors commonly available in the market are generally of larger sizes, such as 6.5 HP, a gasoline motor with that power will closely approach the minimum required power value for the BSF Maggot Feed Grinding Machine.

3.4 The Shaft Rotation Planning

The BSF Maggot Feed Grinding Machine utilizes S3OC Steel with the following planning:

Pd = P x fc (4)

Pd = 745,7 Watt x 1,2 = 894,84 Watt

3.5 The Torque Planning

$$T = \frac{\sigma}{sf1 \ x \ sf2}$$

(5)

$$\sigma = the \ steel \ shaft \ used \ is \ 48 \ Kg/mm2$$

Sf1 = 6,0
Sf 2 = 2,0

The obtained allowable stress is within the tolerance of

$$T = \frac{48 \ kg}{6{,}0 \ x \ 2{,}0} = 4kg/mm2$$

3.6 The Designed Machine Testing

In this testing process, banana stems that are preferred by BSF maggots are used. There are 3 tests conducted in this study, with diameters of 2.5cm, 3.5cm, and 4.5cm for a single shredding process to determine the most suitable stem size for this feed grinding machine. Each banana stem has a length of 6cm. The testing is performed for a continuous duration of 10 seconds, shredding the banana stems continuously. Data collection and testing are carried out three times to ensure more valid results. The outcomes are then weighed to determine the quantity obtained from a single banana stem.

Fig. 3. The results of banana stem Shredding

As seen in Table 1 below, the results of the conducted machine testing indicate that the recommended banana stem shredding size for BSF maggots in a single operation is 3.5cm, with a shredding capacity of 558 kg/hour, resulting in an average weight of 6.11 kg.

Table 1. The Machine Testing

	2,5 cm Stem		3,5 cm Stem		4,5 cm Stem	
No	Capacity (kg/hour)	Average Weight (kg)	Capacity (kg/hour)	Average Weight (kg)	Capacity (kg/hour)	Average Weight (kg)
1	410	3,5	465	4	539	5,44
2	427	3,53	498	4,51	554	6,2
3	454	3,97	502	5,31	581	6,7
Ave-rage	430	3,6	488	4,6	558	6,11

4. Conclusion

After conducting testing and research on the BSF Maggot Feed Grinding Machine, which features a frame length of 60 cm and a width of 26 cm, a cutting blade with a length of 15.5 cm, and a pulling mechanism with a length of 17 cm, it was observed that the used shaft has a diameter of 25.4 mm. The BSF Maggot Feed Grinding Machine employs a reel-type blade design consisting of 6 cutting blades. The power source utilized is a 6.5 HP gasoline engine with a rotation speed of approximately 3000 rpm.

The rotation of the gasoline engine is transmitted through the cutting blade shaft at 3000 rpm, subsequently resulting in a rotation speed of 350 rpm for the pulling roll shaft. The outcomes of the shredding process from the BSF Maggot Feed Grinding Machine with a cutting blade rotation speed of 3000 rpm and a pulling roll shaft rotation speed of 350 rpm Show satisfactory performance -200 rpm low. The machine is capable of shredding with a capacity of 558 kg per hour. The average output of the machine is approximately 6.11 kilograms per hour. This machine is capable of increasing production efficiency by up to 4 kg and reducing the harvesting time for maggot larvae from the previous 1 week to 5 days. This will have a positive impact on overall BSF larva production, allowing for increased production capacity and improved quality of the output.

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