The Design and Performance of Maggot Harvester

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Abstract. Organic waste from porang flour production in the form of calcium oxalate dust from Pilot Plant Faculty of Agricultural Technology, University of Brawijaya reaches 400-600 kg per ton porang chips milling. Combined with household and restaurant waste in Malang, which can reach 689 tons per day in organic matter, can be decomposed by using Black Soldier Flies (BSF) maggot. Maggot is a source of protein that can be used as fish, poultry, and animal feed which can be processed into dry maggot or maggot flour. The high cost of imported maggot flour processing machines with a large capacity is inappropriate for the small-scale industry, the absence of maggot harvesting tools also makes the work done manually and takes time. Thus, to facilitate the process of harvesting, drying, and making maggot flour, it is necessary to design a machine to support these activities so that the results can produce added value for high-protein maggot flour. This study aims to design a maggot harvester machine and test its performance for the small to middle-scale industry. The maggot harvester machine was successfully designed and built. The performance of the maggot harvester machine can successfully harvest the maggot and also differentiate between maggot, organic fine compost, and organic coarse compost. The results show that the best slope and sieve speed combination is a slope of 25.7% with a rotational speed of 10 rpm producing 650 grams of maggot. Meanwhile, the 150-watt halogen lamp effect on the maggot harvest time resulted in the fastest maggot harvest time, which was 370.2 seconds.

Keywords: Maggot BSF, Harvester, Performance.

1 Introduction

Maggot harvester is a mechanical sieving device used in the maggot harvesting process. This maggot harvester can separate maggots from coarse and fine compost materials from the decomposition of organic waste by maggots. The maggot harvester is equipped with a sieve speed regulator and a tilt angle that can be adjusted as needed. In addition, the addition of lamps is also carried out in the performance test of this tool to speed up the maggot down process, so that the maggot harvesting capacity can

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be increased through time efficiency and harvesting methods. The separation of maggots with coarse and fine compost can facilitate the subsequent processing of maggots.

BSF maggots are the larval phase of the black soldier fly, one of the insects that has an area of distribution almost all over the world [1]. BSF maggots have several characteristics, including the ability to decompose organic waste, have a fairly high pH tolerance, do not carry or spread disease genes, and are easy to cultivate [2]. Maggots can decompose organic waste and reduce up to 80% of the wet weight of waste and have been shown to reduce the spread of disease-causing bacteria such as *Salmonella* sp. The main advantage of maggots is their nutritional content, especially the content of high-quality protein and crude fat of ±35% and ±30%, respectively, so it is very potential as a source of feed for livestock and fish [3]. In addition to the high protein content, BSF maggots have another advantage in the form of the ability to produce natural enzymes that have a positive effect on increasing the digestibility of fish on feed [4].

Maggot harvesting can be done naturally, that is when the maggot begins to blacken and enters the prepupa period. In this phase, the maggot will move towards a drier place or gutter in the bio pond specifically designed for maggot cultivation [5]. However, this method is less efficient because maggot harvesting cannot be done all at once. In addition, this method can only be used to harvest maggots that have entered the prepupa period so they cannot be used to harvest maggots with a certain age. Other maggot harvesting methods are generally done manually with a sieve driven by human labor, which is less efficient in terms of time and energy. In addition, manual sifting is usually unable to effectively separate maggots from coarse and fine materials so it is necessary to do repeated sifting to obtain a maggot that is completely clean from coarse and fine compost.

The purpose of this study is to design and develop a maggot harvester that works on the principle of a sieve, with the addition of lights and a sieve speed regulator as well as adjustable tilt angles. In addition, it aims to facilitate the separation of maggots from coarse and fine compost during the harvesting process so that production capacity can be increased and save harvesting time compared to manual harvesting.

2 Materials and Method

2.1 Material and Equipments

The tool frame is made of 3x3 cm hollow iron with a thickness of 1.2 mm and 6.5 UNP iron. Other materials are an SS 201 doff plate, wire mesh filter, 2 pillow block bearings, gearbox, 2 HP electric motors, and other constituent components. The types of lamps carried out for testing include LED lamps, halogen lamps, and incandescent lamps. The maggot used in this maggot harvester performance test is 22 days old.

2.2 Research Preparation

The maggots used in this study were obtained through a cultivation process. The process of cultivating BSF maggots begins with the preparation of hatching eggs. The hatching media used is porang flour waste which is added with water to a mushy texture. This medium is then poured into a 40x30x13 cm plastic container. The BSF eggs to be hatched are obtained through online purchases. A total of 20 grams of eggs were weighed ±1 gram each using analytical scales. After that, the eggs are laid on aluminum foil and placed on the hatching medium that has been made, where each plastic container contains 1 gram of BSF eggs. After hatching, maggot enlargement and feeding will be carried out in the plastic container until the maggot is one week old. After one week, BSF maggots begin to be transferred to bio ponds measuring 3x3 meters. The purpose of this transfer is so that BSF maggots can grow more optimally and the fine and coarse compost resulting from the decomposition of waste by maggots dry out quickly. BSF maggot feeding is carried out according to the conditions and needs of BSF maggots. In the first week after hatching, the feeding activity of BSF maggots is not yet so active that feeding is carried out once every 2 days. After the BSF maggots increase in size and the feeding activity becomes more active, feeding is carried out daily.

The design of the maggot harvester has a stacking type with 2 sieve stages. The first stage sieve is designed to be able to move in a swinging manner and the slope can be adjusted as needed. The first stage sieve is made from wire mesh with a size of 10 mesh so that the fine organic compost and maggot will descend towards the second stage sieve. The second stage sieve is intended for the maggot to descend to the final output, with a 5-mesh wire mesh. Then to accelerate the lowering of the maggot to the collecting drawer, three types of lamps with different power were added. It aims to determine the effect of light on the speed of maggot descent on the harvesting machine. The design of the maggot harvesting machine can be seen in Fig. 1.

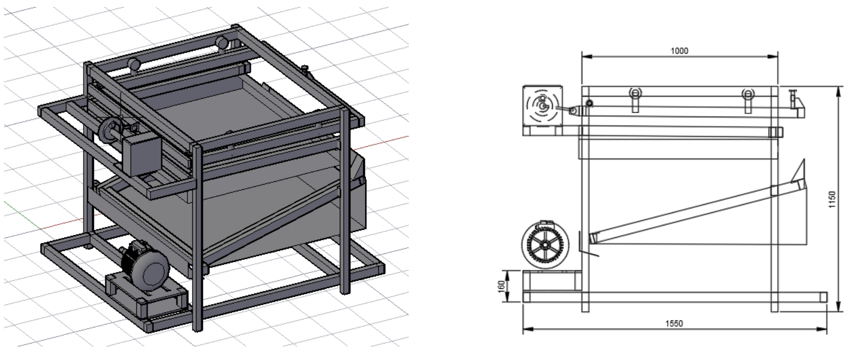


Fig. 1. Design of Maggot Harvester.

2.3 Research Design

The research was conducted in the Laboratory of Mechatronics, Department of Agricultural Engineering, Faculty of Agricultural Technology, University of Brawijaya. There are three treatments carried out to test the performance of this maggot harvester, including the sieve slope test, the sieve speed test, and the effect of the lamp on the maggot descent time. The sieve speed is tested with two different speed levels, while the sieve slope is tested with three levels of slope. The test of the effect of the lamp on the maggot descent time was carried out using three types of lamps with different powers.

2.4 Testing the Effect of Slope and Speen on Sieving Results

This test was carried out using two different speeds, namely 7.1 rpm and 10.0 rpm. The slope angle treatment used is 9.5%, 12.85%, and 25.7%. A total of 1 kg of samples consisting of a mixture of maggots and fine and coarse compost was used in this test. The test was carried out for 1 minute to determine the number of maggots that can be sifted at different variations in speed and slope of the sieve.

2.5 Testing the Effect of Power and Lamp Type on Maggot Harvesting Time

This test was carried out using three types of lamps that have different power. The first type is a halogen lamp that has a power of 150 Watt, the second type is an LED lamp with a power of 100 Watt, and the third type uses two incandescent lamps, each of which has a power of 55 Watt so that the total power for this incandescent lamp is 110 Watt. These three lights will be installed on the maggot harvester in turn, which is above the second stage sieve. Then observation and recording of the maggots harvesting time from the sieve to the collecting drawer will be carried out based on the use of each type of lamp.

3 Results and Discussion

3.1 Maggot Harvester Design Result

Based on the process of making the frame to the assembly of components, a maggot harvester is produced as in Fig. 2. The swinging motion on the first stage sieve is produced by a shaft connected with an electric motor by adding a pulley and a v-belt as a link. While the setting and adjustment of slope can be adjusted by moving the sieve-tightening bolt upwards by hitting with a rubber hammer, or by loosening the bolt then the slope of the sieve can be set.

Fig. 2. Maggot Harvester.

3.2 Effect of Slope and Speed on Sieving Result

To test the maggot harvester, two tests are carried out periodically to determine the capacity and capability of the machine in maggot harvesting. This machine has two sieves with different mesh sizes. The first sieve has a mesh with a size of 10 mesh. From this size, it is hoped that later it will be able to separate between maggots and fine media. To help speed up sifting, as well as the maggot going down to the second stage of sifting, a tilt regulator is added to the sieve of stage one.

The existence of a slope adjuster in a device will affect the mechanism of motion due to friction that occurs. In addition, it can also affect the movement of maggots, so it will facilitate the separation of maggots from fine and coarse compost. Slope and sieve speed testing yield data in Table 1.

Table 1. Test Results on Various Slopes and Speeds.

Slope (%)	Speed (7.1 rpm)	Speed (10.0 rpm)
9.5%	600 gr	550 gr
12.85%	550 gr	650 gr
25.7%	450 gr	650 gr

From the results of these experiments, it is still not optimal and still needs some evaluation. Rotation speed and slope influence the amount of maggot that drops. The greater the rotational speed used, the greater the number of maggots that fall, and vice versa. In addition, the greater the slope value used, the faster the maggot will drop. Several things cause the results of this experiment not to be maximized. First, the sieve board is uneven, some areas are a bit high or wavy. Second, some maggots cannot go down because they are stuck or trapped in a sieve. Third, the technique or method of sowing maggot, so that it can be evenly distributed on the sieving tool. Lastly, the scales used are less precise.

3.3 Effect of Power and Lamp Type on Maggot Harvesting

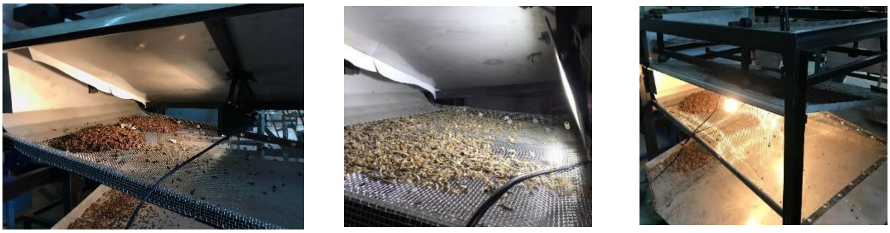
Table 2. Experiment Result Lamp Type on Maggot Harvesting

	Halogen	LED	Incandescent
Input	4.5 kg	4.5 kg	4.5 kg
Maggot	45.25 ± 0.85 %	35.785 ± 0.74 %	49.12 ± 0.20 %
Fine	46.4 ± 0.12 %	53.08 ± 0.06 %	47.445 ± 0.18 %
Coarse	5.855 ± 0.08 %	2.91 ± 0.02 %	1.63 ± 5 %
Material Loss	2.5 %	8.225 %	1.8 ± 0.004 %
Harvesting Time	370.2 s	446.7 s	648.4 s

Halogen Test. Based on the results of experiments using halogen lamps in the M1 sample, a maggot harvesting time of 370.2 s was obtained, as in Table 2. The characteristic of halogen lamps is that they are hot so that maggots that are in the harvest period will avoid light faster. Because light greatly affects the growth of maggots. This is by the theory that the living habitat of maggots is in humid areas, with minimal light, and moderate temperatures [6]. Therefore, hot light will be avoided faster by maggots, and maggot descent time in theory by using halogen lamps will be faster. The experiment with halogen lamps can be seen in Fig. 3.

LED Test. Based on maggot experiments using LEDs, the results in Table 2 were obtained. The characteristic of LED lamps is a type of energy-saving lamp, since it tends to be energy released in the form of light instead of heat [7]. Because it is a lamp with low heat, it will affect the maggot-down process in the collecting drawer. In this experiment, a maggot harvesting time of 446.7 s was obtained. When compared to the halogen lamp test results, the halogen lamp test results have a faster harvest time even though the number of maggots is more than the LED lamp test.

Incandescent Lamp Test. The results of the test using incandescent lamps can be seen in Table 2. It is known that the time of harvesting with the addition of incandescent lamps is quite different from the use of two other types of lamps. With a slightly larger number of maggots than the number of maggots in the halogen lamps test, there was a significant harvesting time difference. This can occur due to the characteristics of the incandescent lamp itself. The light from incandescent lamps is produced from the heating of electrons in the wolfram filament, which causes most of the incoming electrical energy to be converted into thermal energy rather than light energy [8]. Therefore, the light produced by incandescent lamps is dimmer, but the heat generated is higher than other types of lamps. In addition, incandescent lamps are very rarely used because they have very wasteful energy[9].



a b c

Fig. 3. Halogen Lamps Test (a), LED Lamps Test (b), Incandescent Lamps Test (c).

Maggot Yield Comparison. A comparison of the yields of each sample can be seen in Fig. 4. In the halogen lamps test, it can be seen that the maggot harvest results show that the maggot and fine media levels are almost the same. That is, the feeding capacity almost corresponds to the number of maggots farmed. Due to its optimum, in every 1 gr of maggot eggs are given feed as much as 4-5 kg [10]. It also has the same results as incandescent samples. Unlike the LED sample, the fine media in the LED sample is more than the number of maggots.

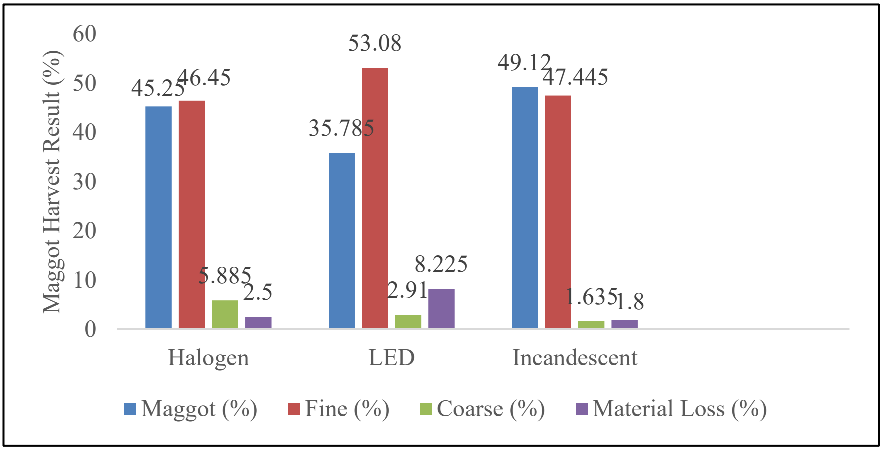


Fig. 4. Maggot Yield Graph.

Whereas in the coarse media produced, halogen samples have a larger percentage compared to other samples. Coarse samples are feed residues that cannot be decomposed by maggots. In Led and incandescent samples, it has less coarse media. However, there are some material losses in this study. Material loss has a high probability of being a rough medium. Because, at the time of the study, some rough media were still stuck in the mess. So, this will greatly affect the results of the study. Halogen and incandescent samples had material loss that was still normal in the study. However, in LED samples, the material loss produced is quite large. One of the things that causes is a leak during sifting so that some large enough material will easily fall off and affect the results of the research.

Maggot Harvesting Time Comparison. The graph of the results of the comparison of the three types of lights as well as the time of descent can be seen in Fig.5. In the graph, it can be concluded that halogen lamps have more samples than the other two lamps. However, the maggot descent time is faster when compared to other lights. Likewise with the comparison of LED lamps with incandescent lamps. Since the incandescent lamps used are only two pieces, the probability will change if the incandescent lamps used are 3. Thus, errors during the experiment, result in differences in research results. Tests of all three types of lamps showed that the addition of a lamp can accelerate the down process of the maggot to the collector. This is the literature that mentions that the photophobic nature of maggots causes maggots to move faster to find darker places, in which case maggots go down to the collecting drawer [11].

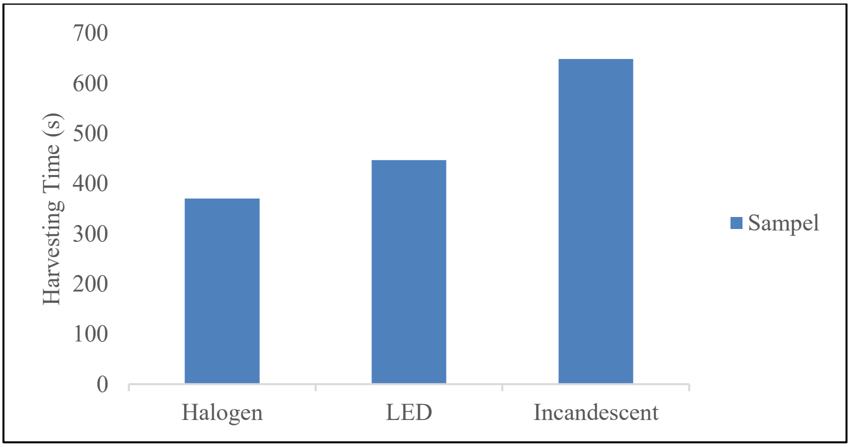


Fig. 5. Comparison chart of sample weight and maggot harvesting

There were several obstacles when the research was carried out, one of which was that in the results of fine media, several maggots were still found mixed in it. This is due to the presence of a loose space on the driving bulkhead of the harvester. So that when the sifting takes place, there are maggots that come down to the container of the fine media. In addition, in testing incandescent lamps, it only used two lamps because one lamp suffered electrical damage, so it could not turn on. In addition, uneven feeding of maggots will cause differences in size and different phase changes of maggots. As is the case at the time of harvest, there are still some maggots that are small in size. This also happens similarly when the maggot enters the pupa phase.

4 Conclusion

The use of maggot harvester in the process of harvesting maggots is better and more efficient than the manual harvesting method. The maggot harvester can separate maggots with coarse and fine compost in a time. From several tests that have been carried out, it can be concluded that the maggot harvester works well at a slope of 25.7% at a speed of 10 rpm. The use of lamps can speed up the harvest time, where the lamps that produce the shortest harvest time are halogen lamps. However, there are still some things that must be improved so that this maggot harvester can work more optimally. The mechanism of sifting and separation of maggots needs to be revisited so that no re-sifting is needed to separate maggots from compost, and there needs to be a repair of the uneven sieve field which causes the distribution of maggots to be less evenly distributed.

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