



## Designs of Maggot Rotary Dryer to Support Alternative Feed Production

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### Abstract

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The growth of maggot cultivation as an alternative feed source is increasing in response to the demand for sustainable organic waste management solutions. However, the drying process remains a major challenge, especially for small and medium-scale operations. This study aims to design and develop a 20-kg capacity rotary maggot dryer that is efficient, energy-saving, and suitable for community-scale production. The design method includes user needs analysis, material selection, CAD-based design simulation, and testing tool performance. The results indicated that the dryer can reduce maggot moisture content within an average drying time of 3 hours at 60–70°C with relatively low energy consumption. This innovation is expected to improve maggot production efficiency and promote appropriate technology for sustainable alternative feed development at the community level.

**Keywords:** *Maggot; Rotary Dryer; Appropriate Technology; Alternative Feed; Sustainability*

### Abstrak

Pertumbuhan budidaya maggot sebagai sumber pakan alternatif semakin meningkat seiring dengan kebutuhan akan solusi berkelanjutan dalam pengelolaan limbah organik. Namun, proses pengeringan maggot masih menjadi tantangan utama, terutama dalam skala kecil dan menengah. Penelitian ini bertujuan untuk merancang dan membangun alat pengering maggot tipe rotary berkapasitas 20 kg yang efisien, hemat energi, dan sesuai untuk kebutuhan produksi komunitas. Metode perancangan meliputi identifikasi kebutuhan pengguna, pemilihan material, simulasi desain menggunakan perangkat lunak CAD, serta uji performa alat. Hasil menunjukkan bahwa alat mampu mengeringkan maggot dengan waktu pengeringan rata-rata 3 jam pada suhu 60–70°C, dengan konsumsi energi yang relatif rendah. Inovasi ini diharapkan dapat meningkatkan efisiensi produksi maggot serta mendukung pengembangan teknologi tepat guna berbasis masyarakat untuk produksi pakan alternatif yang berkelanjutan.

**Kata-kata kunci:** *Maggot; Rotary Dryer; Teknologi Tepat Guna; Pakan Alternatif; Keberlanjutan*



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## 1. Introduction

The increasing demand for sustainable animal feed has driven global attention to alternative sources of protein that are environmentally friendly and efficient [1] [2]. One alternative that has received widespread attention is the Black Soldier Fly (BSF) larvae or maggots, which are able to convert organic waste into protein-rich biomass [3] [4]. The main problem that arises in the use of maggots as feed ingredients is the post-harvest process, especially drying [5] [6]. The high moisture content in fresh maggots causes a high level of damage and shortens the shelf life, so a fast and efficient drying method is needed [7] [8].

Various approaches have been taken to overcome this problem, ranging from natural drying (sun drying) to the use of static ovens [9]. Conventional methods such as sun drying are highly dependent on the weather and take a long time, while static electric dryers often show inefficiency in heat distribution and are wasteful of energy, especially on a medium scale [10] [11] [12]. Several studies have begun to examine rotary-type dryers which are known to be able to provide even heat distribution and speed up the drying process [13] [14]. However, most studies are still focused on drying other biomass such as agricultural products and industrial waste, not specifically for maggots.

The identified gap that emerged is the lack of technical studies and practical implementation of rotary dryers specifically designed for maggot characteristics, especially on a community or MSME scale [15] [16]. In fact, the potential for utilizing appropriate rotary dryer-based technology is quite large in supporting the efficiency of alternative feed production [17] [18]. In addition, there is not enough data available on optimal operational parameters, energy consumption, and performance efficiency of rotary dryers for maggots [19].

The Black Soldier Fly (BSF) larva possesses distinct physiological and thermal characteristics compared to conventional agricultural biomass [20] [21]. With a high moisture content of approximately 65–70% and a composition rich in proteins and lipids that are sensitive to elevated temperatures, the drying process for maggots requires precise thermal control to preserve nutritional quality [22] [23]. Exposure to excessive heat may lead to protein denaturation and lipid oxidation, both of which significantly reduce the nutritional value of the final product [24]. Additionally, due to their sticky texture when heated, maggots are prone to clumping, which can hinder the drying process and decrease operational efficiency. Consequently, the application of rotary dryer technology for maggot dehydration necessitates specific design adaptations that address these material-specific challenges.

This study proposes an engineering-based approach to developing a rotary dryer with a 20 kg capacity, specifically tailored to the thermal and physical properties of maggots, and optimized for use at the small-to-medium production scale. The novelty of the proposed design lies in several key innovations: a digital temperature control system to maintain drying temperatures below 70°C, a modified drum

structure equipped with spiral vanes and non-stick surfaces to prevent material agglomeration, and the potential integration of renewable energy sources such as biogas or solar power to enhance energy efficiency and sustainability. While previous studies have primarily focused on rotary dryers for agricultural or industrial biomass, research on dryers specifically engineered for maggots remains scarce. Therefore, this study aims to address this gap by contributing a practical, energy-efficient, and context-appropriate drying solution for the sustainable production of alternative animal feed.

This study offers the design and construction of a rotary type maggot dryer with a capacity of 20 kg which focuses on drying efficiency, even temperature distribution, and low energy consumption. The engineering design approach is used to overcome the limitations of existing tools, by considering the needs of small to medium-scale users. This innovation is expected to be able to fill the gap in the literature and practice of effective and applicable maggot drying technology.

The purpose of this study was to design and test the tool performance of a 20 kg capacity rotary dryer for the maggot drying process, measure the efficiency of reducing water content, energy consumption, and the quality of drying results. The methods used include CAD design, prototyping, and experimental testing of tool performance.

## 2. Method

This study uses an engineering experiment approach with the aim of designing, building, and testing the tool performance of a rotary dryer for the drying process of 20 kg of maggots. The process is carried out through several stages, starting from system design, selection of materials and tools, making prototypes, to testing tool performance.

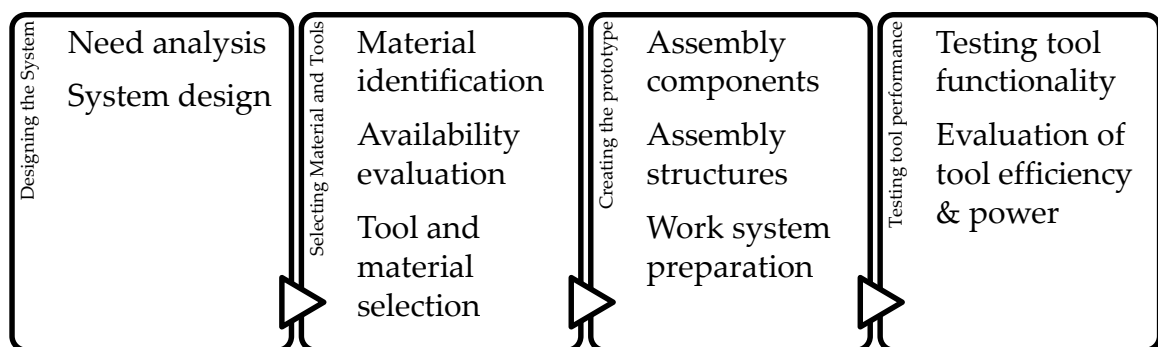


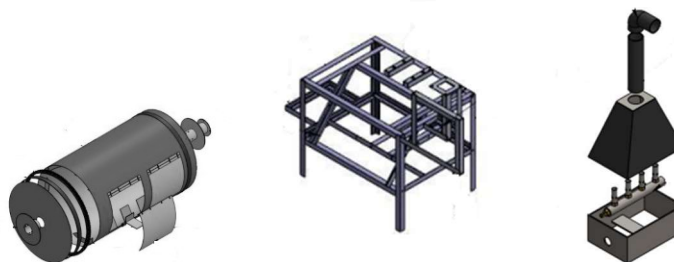
Figure 1. Research Flow

## 2.1. Materials and Tools

Test Material	: Fresh Black Soldier Fly Maggot with initial water content of $\pm 70\%$ , obtained from local farmers.
Rotary Drum Material	: Galvanized iron diameter 40 cm, length 70 cm.
Heating Element	: Nichrome coil with 1000-watt power, controlled by a digital thermostat.
Drive Motor	: 1/4 HP AC motor with gearbox for slow rotation of $\pm 10$ rpm.
Sensors and Measuring Instruments	: K type thermocouple (accuracy $\pm 1.5^\circ\text{C}$ ) Digital scale (capacity 30 kg, accuracy $\pm 1$ g) Digital hygrometer Digital wattmeter (accuracy $\pm 5\%$ ) for measuring power consumption

## 2.2. System Design

The design of the tool is made as shown in Figure 2, using SolidWorks software considering the ergonomics of use and thermal efficiency. The rotary drum is equipped with internal stirring fins to ensure that the maggots move evenly as the drum rotates. The heating system is installed in the combustion chamber below the drum, with hot air flowing through forced convection channels into the drum chamber.



**Figure 2.** System Design

## 2.3. Tool Making Process

The tool is made through a local fabrication process. The main frame uses 40×40 mm angle steel. The drum is installed horizontally with bearing mounts on both sides. The transmission system uses chains and sprockets from the motor to the drum shaft. Initial trials were conducted to ensure stable rotation and heat distribution.

## 2.4. Testing Procedure

The tool test was conducted to measure:

The drying time of 20 kg maggots from an initial water content of 70% to below 10%, the working temperature of the tool is maintained between 60–70°C, the temperature distribution along the drum using two thermocouples, total electrical energy consumption during the process. The quality of the results based on the final water content test using the oven method (referring to [SNI 01-2891-1992]). The drying process is carried out in a closed room to avoid the influence of ambient temperature. Every 30 minutes, maggot samples are taken from three different points (at the beginning, in the middle of processing, and at the end of the process) to analyze their water content.

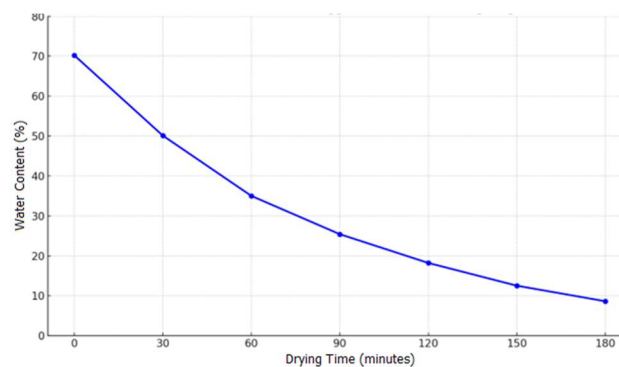
## 2.5. Data Analysis

The collected data were analyzed descriptively to determine the trend of decreasing water content, energy efficiency, and temperature stability. The test results were compared with the standard water content requirement of feed (<10%) to determine the success of drying.

## 3. Results and Discussion

### 3.1. Research Result

After the rotary dryer design and manufacturing process was completed, the device performance was tested with a fresh 20 kg maggot. The test was carried out for 3 hours at a temperature range of 60–70°C, using a 1000-watt heating element with automatic temperature control. Figure 3 shows the trend of decreasing maggot water content during the drying process. It can be seen that within 180 minutes, the water content dropped from 70.2% to 8.6%, indicating the effectiveness of the drying process using the designed rotary dryer.



**Figure 3.** Trend of Decreasing Maggot Water Content During the Drying Process.

**Table 1.** Changes in Maggot Water Content During Drying

Time (minutes)	Water Content (%)	Average Temperature (°C)
0	70.2	29.3
30	54.7	60.5
60	41.8	63.1
90	29.5	65.4
120	17.2	67.0
150	11.3	68.2
180	8.6	69.5

Energy consumption was recorded at 0.95 kWh/hour, with total energy usage for 3 hours reaching 2.85 kWh. The drying results met the standard of <10% water content for dry feed.

### 3.2. Discussion

The results of the study showed that the designed rotary dryer was able to reduce the water content of maggots efficiently within 180 minutes. This reduction in water content shows good thermal efficiency which is supported by the design of the rotating drum and controlled heating system. Compared with research which uses a static drying method, the time required reaches 6 hours to achieve the same water content, indicating that the rotary system provides more even heat distribution and stirring. The heating temperature maintained at 60–70°C shows the optimal range for maintaining the quality of maggot protein. Therefore, automatic temperature control in this tool is an important feature in maintaining the quality of the results. The use of a rotating drum also accelerates the water evaporation process by increasing the contact surface of hot air with maggots. Energy consumption of 2.85 kWh is considered efficient for a drying capacity of 20 kg. This efficiency is obtained due to a good thermal insulation system and optimization of the hot air flow design. However, the weakness of this system lies in its dependence on electricity, which is less than ideal for areas without stable energy access. This opens up opportunities for the development of a hybrid model based on solar power.

Overall, the design and performance of this rotary dryer show strong potential as an alternative small-medium scale dryer in maggot-based feed production. The novelty of this research lies in the integration of a 20 kg scale rotary system with automatic temperature control which has not been widely developed in the independent maggot-based feed processing sector.

#### 4. Conclusion

This study successfully designed and built a rotary maggot dryer with a capacity of 20 kg which is able to reduce water content from 70.2% to 8.6% in 180 minutes at an operating temperature of 60–70°C. These results indicate that the rotary system equipped with an automatic temperature controller and continuous stirring provides good drying efficiency and maintains the nutritional quality of maggots. The relatively low energy consumption also indicates that this tool can be used efficiently for the production scale of alternative feed based on maggot larvae. The main contribution of this research lies in the development of a drying tool with a simple yet functional design, which can be applied by small farmers and maggot farming business actors to support food security based on sustainable alternative protein sources.

For further development, it is recommended that this drying system can be integrated with renewable energy sources, such as solar panels, and further testing of the effect of temperature on the nutritional content of maggots is carried out in more depth. This research is expected to be a reference in the development of efficient, environmentally friendly, and applicable maggot processing technology in the field.

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