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Effect of Bran Media Variation on Maggot Growth in Waste Management

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Abstract

This study aims to evaluate the effect of bran variation on the growth of black soldier fly larvae (*Hermetia illucens*) under controlled initial conditions of 250 g larvae and 250 g organic waste. The experiment was conducted using different doses of bran supplementation (20–200 g), with daily observations of larval weight changes over 11 days. The results indicate that bran addition significantly influenced larval growth rate. Moderate doses (60–100 g) produced higher and more consistent weight gain compared to low doses (20–40 g) or excessive doses (160–200 g). The highest growth was observed in the 80 g treatment, reaching 890 g on day 10 before declining on day 11. In conclusion, moderate bran supplementation provides the most optimal medium conditions for larval growth, while insufficient or excessive amounts tend to be less efficient.

Keywords: Maggot, *Hermetia Illucens*, Bran, Growth, Organic Waste

1. Introduction

The management of organic waste presents a significant environmental challenge across various regions. The primary composition of organic waste, originating from food scraps and other biodegradable materials, can contribute to over 50% of the total waste generated on university campuses [1]. According to the National Waste Management Information System (SIPSN), the volume of national waste accumulation in 2022 reached 19.45 million tons (Febrian et al., 2024), consisting of 41.55% food waste and 18.55% plastic waste [2].

By 2025, Indonesia is projected to generate 56.63 million tons of waste, with only 39.01% being managed properly [3]. Meanwhile, 21.85% of waste is disposed of in landfills via open dumping, and another 39.14% is discarded into the environment through burning, illegal dumping, or into water bodies [3]. Ineffective management

systems have the potential to cause various negative impacts, including increased greenhouse gas emissions, environmental quality degradation, and public health issues for surrounding communities [4]. Data from 2022-2025 indicates that organic waste dominates the composition and is not managed optimally. This situation leads to adverse environmental effects, such as soil, water, and air pollution, as well as increased greenhouse gas emissions [5]. Therefore, the development of effective and sustainable management strategies is an imperative.

Conventionally, composting is a commonly applied method. However, this approach has several fundamental limitations, such as a relatively long process duration and the requirement for specific and consistent environmental conditions, including temperature, humidity, and carbon-to-nitrogen (C/N) ratio [6]. These limitations render conventional composting less feasible for large-scale application, such as in a university environment with high daily waste volumes [7]–[9].

As an innovative solution, the utilization of Black Soldier Fly (*Hermetia illucens*) larvae, or maggots, has demonstrated promising potential in recent years [10], [11]. These larvae possess the ability to degrade organic material rapidly and efficiently, while simultaneously producing a high-quality compost byproduct [12]. Maggots also hold economic value, as they can be processed into animal feed (containing 45%-50% protein) and fat (24%-30%) [13]. Consequently, maggots not only contribute to waste reduction but also provide economic benefits [14]. Numerous studies have proven that maggot-based technology not only accelerates the biodegradation process but is also capable of significantly reducing waste volume [15].

Based on this background, this research aims to evaluate the feasibility and sustainability of implementing maggot technology as part of an organic waste management system. Through this study, it is expected that a model for organic waste management can be obtained that is not only effective and sustainable but also holds educational value for the academic community and the public.

2. Methods

2.1 Problem Identification

This research was conducted at the University of PGRI Argopuro Jember. The research procedure, illustrated in [Figure 1](#), begins with the initiation or "Start" phase. In this stage, the researcher prepared a comprehensive research framework, including the general objectives, scope, and schedule. This initial phase also involved the preparation of supporting documents, such as observation sheets for each research step. Thus, the research could be carried out systematically and measurably from the outset.

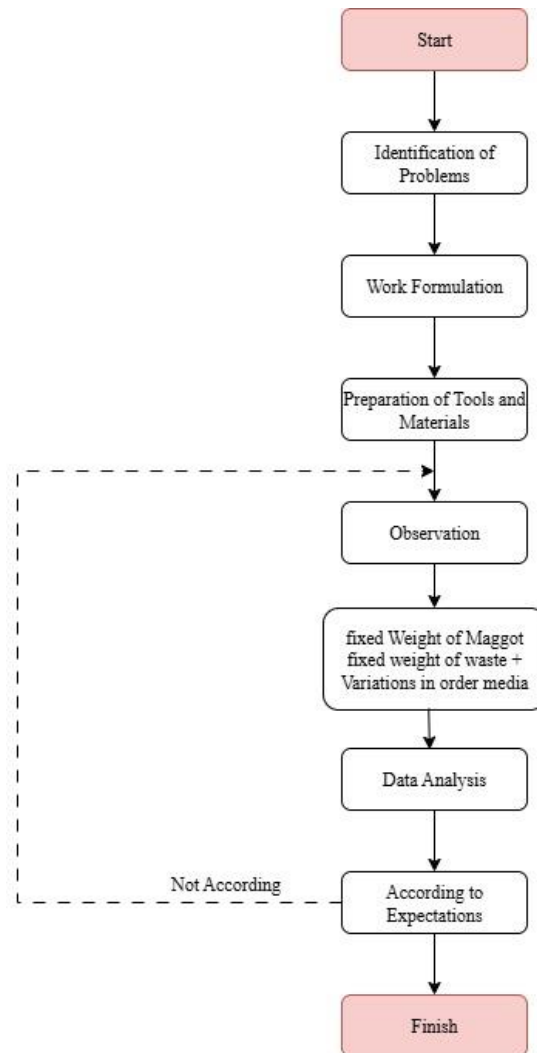


Figure 1. Research Procedures

The next step was problem identification, where the researcher delineated the main issue to be resolved. The problem addressed relates to the high volume of organic waste requiring a simple, inexpensive, and rapid processing technology. At this stage, the researcher reviewed field conditions, including the dominant types of organic waste, moisture content, and required processing capacity. This identification helped to pinpoint knowledge gaps, for instance, regarding the most efficient maggot-to-waste ratio or the type of supplementary media most conducive to maggot activity.

Following problem identification, the operational framework was formulated. In this phase, the researcher established research questions, hypotheses, and the experimental design. The independent variables were set according to the chart, namely variations in maggot weight with a constant waste media, and variations in other media with constant maggot weight and uniform waste media. The dependent variables were waste mass reduction and maggot weight.

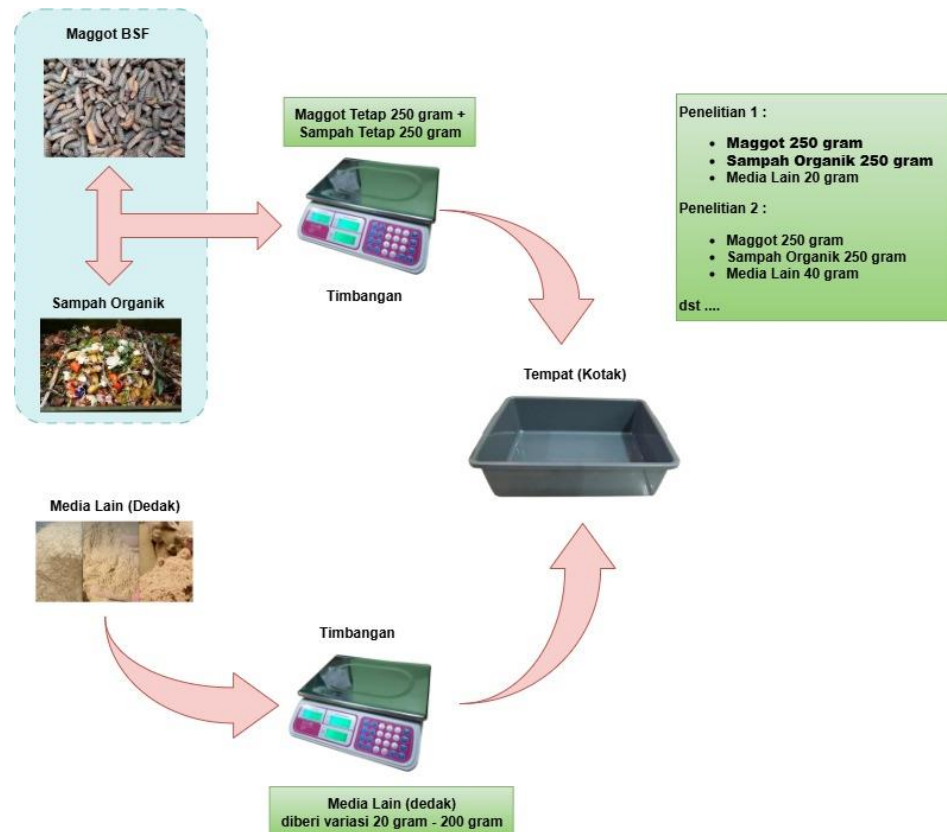


Figure 2. Maggot Treatment with Media

The subsequent stage was the preparation of tools and materials. The required equipment included a digital scale, maggot rearing containers with ventilation, gloves, and documentation devices. The materials used consisted of homogeneous organic waste, maggot larvae of a uniform age, and an additional medium, namely bran. All materials were weighed initially to serve as a basis for comparison. This preparation phase was crucial to ensure treatment uniformity.

The research then entered the observation phase. In this part, the arranged treatments were observed routinely every day. The parameters observed included the weight of residual waste, maggot survival rate (maggot weight), and media moisture. To ensure regularity, recordings were made at a consistent time. Furthermore, visual documentation in the form of photographs was taken periodically to allow for further evaluation of the substrate condition and larval development.

The observation in this research involved constant maggot weight and constant waste media with variations in other media. In this experiment, the quantity of maggots and the mass of waste were kept constant, while the type of additional medium (bran) was varied. This variation in media was intended to determine the effect of supplementary materials on aeration and moisture. The observed parameters were similar to the first observation.

The results from the observations then proceeded to the data analysis stage. The collected data were analyzed to examine differences between treatments. Post-

hoc tests could be applied to identify which treatment was the most effective. Visualizations in the form of graphs or diagrams were also created to clarify the analysis results.

After the analysis was performed, the researcher evaluated the conformity of the results. If the experimental results showed significant waste reduction with low maggot mortality, the research was deemed to meet the criteria. Conversely, if the results were not satisfactory, the researcher returned to the observation stage to make improvements, for instance, by adjusting the maggot ratio, changing the type of supplementary media, or improving the ventilation system. This process is iterative and repeats until optimal results are obtained.

The final stage was the research completion. In this phase, the researcher compiled a comprehensive report covering the objectives, methodology, results, analysis, and recommendations. The research findings can provide information on the optimal maggot-to-organic waste ratio and the best supplementary media to support decomposition, thereby not only reducing waste volume but also adding environmental value. Thus, this research procedure not only presents a practical solution for organic waste management but also provides a scientific basis for the broader development of bioconversion technology.

3.Results and Discussion

The process of collecting the organic waste material used in this research on *Hermetia illucens* maggots is shown in [Figure 3](#) depicts the collection of organic waste in the form of vegetables, specifically leftover cabbage and mustard greens, which were still in a fresh condition. Fresh organic waste was selected because its nutritional content remains preserved; it is not putrid and has not undergone excessive decomposition. This is important to ensure the bioconversion process by the maggots can proceed optimally, as maggots grow and develop more rapidly on a medium with appropriate moisture content, nutrients, and texture.



Figure 3. Organic Waste Collection Process

Figure 3. Organic Waste Collection Process: The organic waste used in this study consisted of vegetables, specifically leftover cabbage and mustard greens, which were still fresh. The selection of fresh organic material is essential to ensure that the bioconversion process by maggots occurs optimally, as maggots grow and develop more rapidly in media with the appropriate moisture, nutrients, and texture.

The use of this fresh organic material indicates that the research focuses on the initial stage of waste decomposition, rather than on long-accumulated waste. Thus, the observation results can represent the ideal conditions for maggot growth as well as their effectiveness in reducing fresh organic waste.

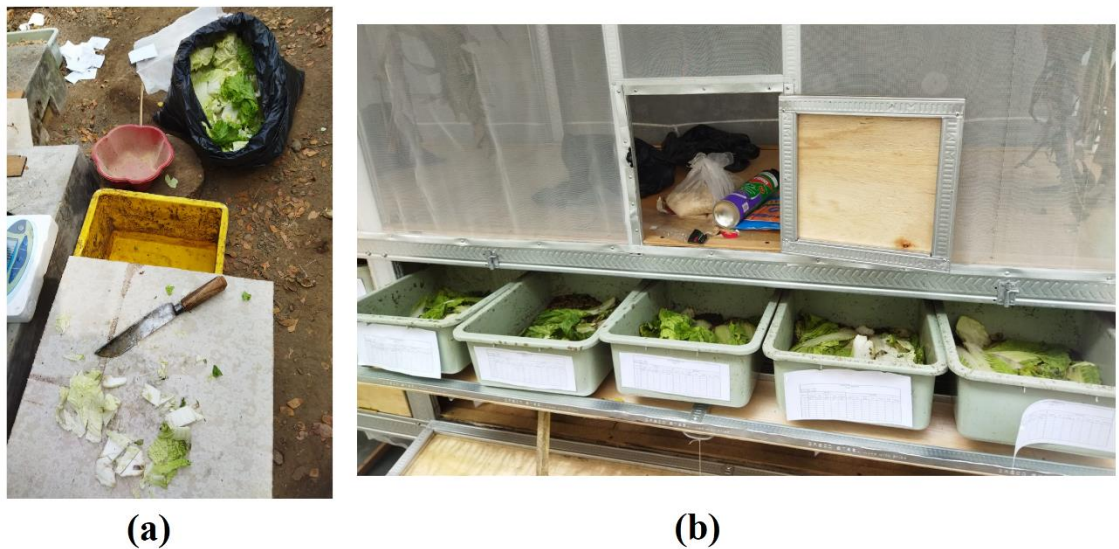


Figure 4. (a) Chopping of Organic Waste; (b) Placement in Maggot Rearing Container

The process of sorting and collecting fresh organic waste is a crucial stage in this research, as the initial quality of the medium significantly determines the success of maggot growth and the level of waste reduction achieved. Subsequently, the fresh vegetable waste, specifically cabbage, was chopped using a knife to achieve a smaller size, making it easier for the maggots to consume, as shown in **Figure 4(a)**. After chopping, the material was weighed using a digital scale to ensure the quantity used complied with the research specifications and was then placed in the maggot rearing container **Figure 4(b)**.

Figure 5(a) shows the process of separating maggots from the frass under conditions where the medium was too moist, making the residual organic matter difficult to decompose completely and causing it to adhere to the maggots' bodies. This condition can reduce maggot quality and slow down the separation process. Furthermore, **Figure 5(b)** illustrates the separation process under dry frass conditions. In this state, separation becomes easier as the frass does not clump, allowing for optimal maggot retrieval. **Figure 5(c)** shows the mixing of maggots with

organic waste and an additional medium in the form of bran. This process aims to provide supplemental nutrition and accelerate the decomposition of organic waste.

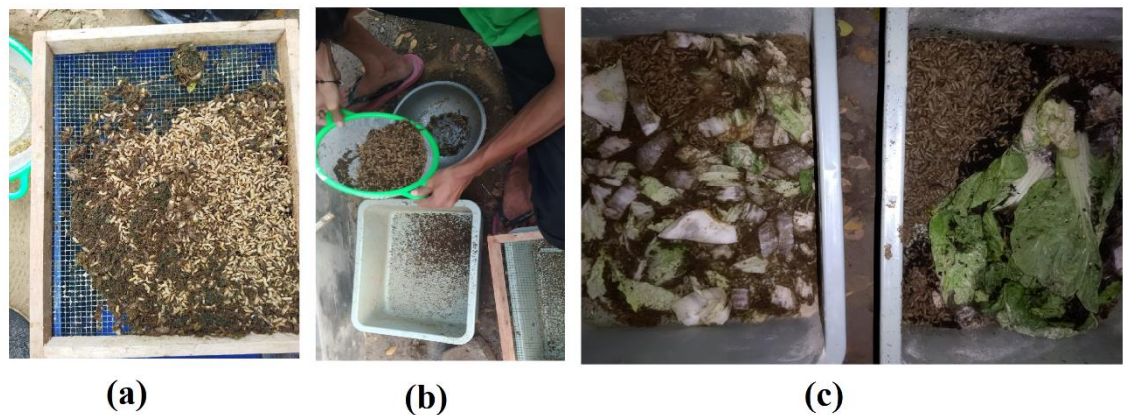


Figure 5. Separation of maggots and frass under: (a) moist conditions, (b) dry conditions; (c) Mixing of Maggots, Waste, and Bran Medium

This research aimed to evaluate the effect of varying quantities of bran on maggot growth under constant initial masses of 250 grams of maggots and 250 grams of organic waste. The bran quantities used included 20g, 40g, 60g, 80g, 100g, 120g, 140g, 160g, 180g, and 200g. The obtained data indicated differences in maggot growth patterns between treatments, evident from the weight dynamics from day 1 to day 11, as shown in **Figure 6**.

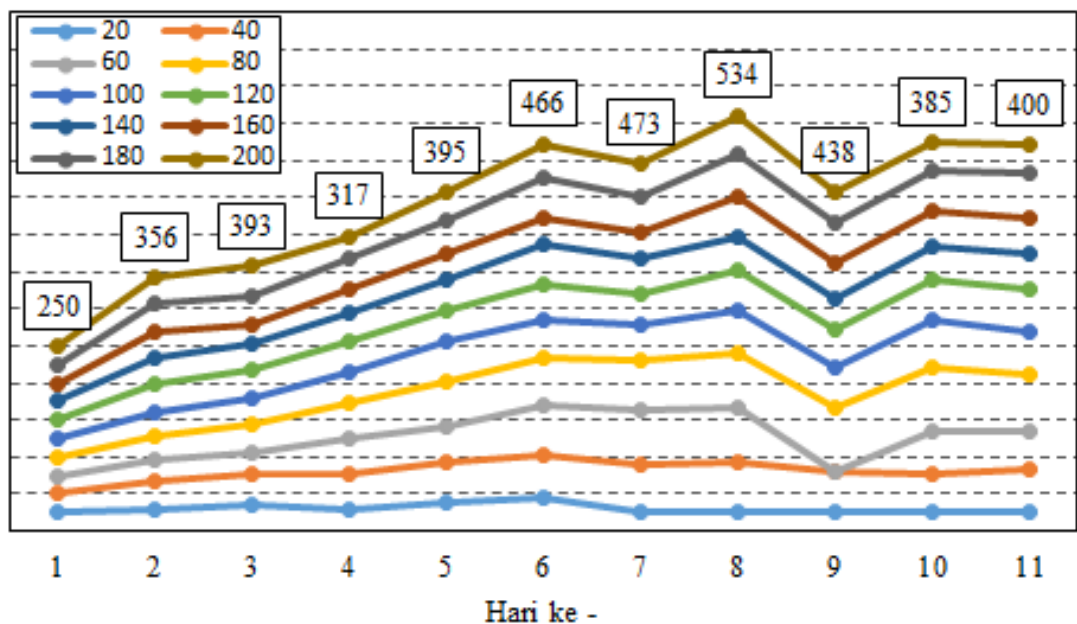


Figure 6. Maggot Development by Media Variation Based on Observation Day

Figure 6. Maggot Development Based on Media Variation: This chart shows the development of maggot weight influenced by varying amounts of bran provided

over 11 days. Treatments with 60–100 g of bran showed the most consistent and significant growth compared to lower or higher bran doses.

On the first day, all treatments showed a uniform maggot weight of 250 grams, indicating a constant and controlled initial experimental condition. By the second day, all treatments began to show weight gain, with relatively varied increases. For instance, the treatment with 40g of bran experienced a sharp rise to 400g, while the 20g treatment increased to 278g, and the 200g treatment increased to 356g. This suggests that the amount of bran potentially influences the initial growth rate.

The increase in maggot weight became more evident from the third to the fifth day. Treatments with 60–100g of bran tended to show consistent growth; for example, the 60g bran treatment reached 491g on the fourth day and 473g on the fifth day. The treatment with 80g of bran even increased to 620g on the fifth day. Interestingly, some treatments with higher bran quantities, such as 160g or 180g, did not exhibit growth as rapid as the medium-quantity groups but were rather fluctuative, reaching only 361g (160g bran) and 441g (180g bran) on the fifth day.

On the sixth day, a peak in growth was observed in some groups, particularly the 60g bran (664.9g) and 80g bran (662g) groups, which were significantly higher than other groups. The 20g bran treatment also showed significant growth (443.3g), although its value remained lower than the 60g and 80g treatments. Groups with higher bran quantities (160–200g) showed varied results: some were reasonably high (554g for 180g bran), but others were lower, indicating that excessive bran supplementation does not always benefit maggot growth.

From the seventh to the eighth day, the growth patterns showed fluctuations. Some groups experienced a decrease compared to the previous day; for example, the 20g bran treatment dropped drastically to 269g on the seventh day. Conversely, the 60g and 80g bran groups maintained high figures of 726g and 700g, respectively. On the eighth day, the 80g bran treatment even increased to 740g, while the 180g bran treatment also showed relatively good growth at 579g. This confirms that bran quantities in the range of 60–100g tend to be optimal for supporting maggot growth.

From the ninth to the tenth day, variations in results became more distinct. The treatment with 80g of bran showed a significant increase to 855g on the ninth day and 890g on the tenth day, the highest figure among all groups. In contrast, the treatment with 20g of bran remained relatively stagnant around 250g, indicating limited supplemental feed to support growth. Meanwhile, groups with excessively high bran quantities, such as 200g, showed lower results, only reaching 385g on the tenth day. This phenomenon is likely due to an overly dense or imbalanced medium, reducing the efficiency of feed consumption by the maggots.

On the eleventh day, most treatments experienced a decrease in weight. The 80g bran group, previously the highest, decreased to 775g, while the 60g bran group

decreased to 524g. Several other groups, such as the 200g bran group, remained at a low level (400g). This trend aligns with the physiological cycle of maggots approaching the final growth stage (prepupa), where body weight tends to decrease due to energy transition to the subsequent stage.

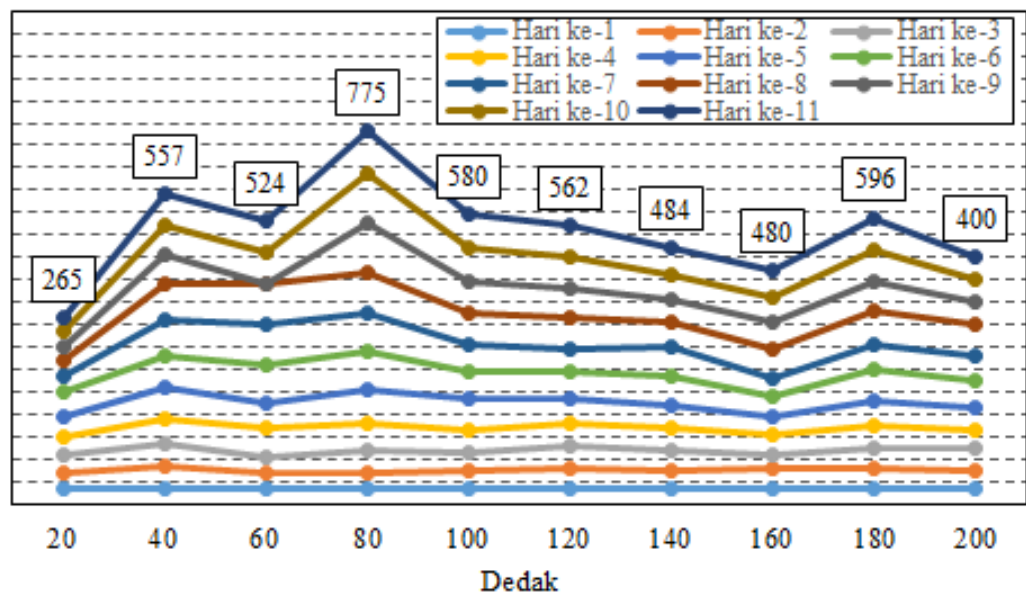


Figure 7. Maggot Development by Media Variation Based on Quantity of Bran Provided

Overall, the maggot growth patterns indicate that the addition of a moderate quantity of bran (approximately 60–100g) yields the most optimal growth. Quantities that are too small (20–40g) result in limited growth, while quantities that are too large (160–200g) tend to be inefficient and even yield lower final weights. Therefore, it can be concluded that there is an optimal range of bran that balances nutritional requirements and medium conditions, thereby maximally supporting maggot growth. The chart based on daily bran provision is presented in [Figure 7](#).

4. Conclusion

This study demonstrates that bran supplementation significantly influences the growth performance of *Hermetia illucens* larvae under controlled conditions with fixed initial masses of 250 g larvae and 250 g organic waste. The administration of moderate bran quantities, particularly within the 60–100 g range, resulted in superior and more consistent larval biomass accumulation compared to both deficient and excessive supplementation regimes. The optimal treatment using 80 g of bran yielded peak larval biomass of 890 g on day 10, prior to the characteristic prepupal weight decline observed on day 11. These findings suggest that bran serves dual functions as both a nutritional supplement and a physical media modifier.

Suboptimal quantities fail to support maximal growth, while excessive amounts impair feed conversion efficiency. These results contribute to the development of a more efficient organic waste bioconversion system by optimizing bran supplementation. The findings could potentially be applied to large-scale waste management practices, such as in universities or environments dealing with high volumes of organic waste.

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Authors' Declaration

Authors' contributions and responsibilities - The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

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Availability of data and materials - All data is available from the authors.

Competing interests - The authors declare no competing interest.

Additional information - No additional information from the authors.

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