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The Effect of The Combination of Fermented Coconut Dregs Media with Fermented Chicken Manure on the Size of Prepupae, Pupae, BSF Flies and the Size of the Abdomen

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Abstract. *Black Soldier Fly (Hermetia illucens) is an insect with considerable potential for organic waste bioconversion and sustainable protein production. This study aimed to evaluate the effect of fermented coconut dregs combined with fermented chicken manure on the size of prepupae, pupae, adult BSF, and abdominal development. The research was conducted using a laboratory experimental method with a Completely Randomized Design (CRD) consisting of five substrate formulations. Parameters observed included body length, width, and weight of prepupae, pupae, adult BSF, and abdominal dimensions. Data were analyzed using Analysis of Variance (ANOVA) at a 95% confidence level. The results showed that the different combinations of fermented coconut dregs and fermented chicken manure did not significantly affect (P > 0.05) the length, width, or weight of prepupae, pupae, adult BSF, or abdominal size. Although numerical differences were observed among treatments, the variation was not statistically significant. The treatment containing 90% fermented coconut dregs and 10% fermented chicken manure tended to produce higher values for several prepupal and pupal growth parameters, while the treatment containing 80% fermented coconut dregs and 20% fermented chicken manure tended to produce larger abdominal dimensions. These findings indicate that the tested substrate combinations were able to support BSF development, but none provided a statistically superior effect on morphometric characteristics. Further studies with broader nutritional variations and larger sample sizes are recommended to better understand the influence of substrate composition on BSF growth and development.*

Keyword: *BSF, Nutrition, Prepupaee, Pupae*

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INTRODUCTION

Black Soldier Fly (*Hermetia illucens*) has gained significant attention as a biological agent for organic waste bioconversion and sustainable protein production (Barragan-Fonseca et al., 2017; Lalander et al., 2019a). The larvae are capable of converting various organic substrates into high-value biomass rich in protein and lipids, making them suitable for animal feed, waste management, and circular bioeconomy applications. The success of BSF cultivation is strongly influenced by the quality of rearing substrates, which affect larval growth, prepupal and pupal development, adult emergence, and reproductive performance.

Numerous studies have reported that substrate composition plays a crucial role in determining the growth and developmental performance of BSF(Lalander et al., 2019). Substrates with balanced protein, carbohydrate, and mineral contents generally produce larger larvae and pupae with higher survival rates and improved reproductive potential. Previous research has evaluated various organic wastes, including food waste, vegetable residues, fruit waste, tofu by products, slaughterhouse waste, and palm kernel meal. However, information regarding the utilization of fermented coconut dregs and fermented chicken manure as combined substrates for BSF development remains limited.

Fermented coconut dregs are an abundant agro industrial by product generated from coconut milk processing. Although often considered low value waste, coconut dregs contain residual carbohydrates, lipids, crude fiber, and moderate protein levels that can potentially support insect growth. Fermentation has been reported to improve nutrient availability, reduce anti-nutritional compounds, and enhance substrate digestibility through microbial activity. Consequently, fermented coconut dregs may serve as a promising alternative feed substrate for BSF cultivation while simultaneously reducing agricultural waste accumulation.

Chicken manure is another organic material widely available from poultry farming activities. It contains considerable amounts of nitrogen, minerals, and organic matter that may contribute to microbial proliferation and nutrient enrichment of the substrate. Nevertheless, direct utilization of fresh chicken manure is often constrained by high ammonia concentrations, unpleasant odor, and potential pathogenic microorganisms. Fermentation can improve manure quality by stabilizing nutrients, reducing pathogen loads, and increasing substrate suitability for biological conversion processes. Therefore, combining fermented chicken manure with fermented coconut dregs may provide a more balanced nutritional composition for BSF development.

Despite the increasing interest in BSF based bioconversion systems, studies investigating the combined use of fermented coconut dregs and fermented chicken manure are still scarce. Most previous studies have focused on evaluating single substrates or conventional organic waste streams, leaving limited information regarding the effects of these locally abundant fermented materials on prepupal, pupal, adult, and abdominal development of BSF (Bellezza Oddon et al., 2024; Yandigeri et al., 2022). Furthermore, the morphometric responses of BSF to different proportions of these substrates have not been comprehensively evaluated.

Therefore, this study was conducted to evaluate the effects of different combinations of fermented coconut dregs and fermented chicken manure on the morphometric characteristics of Black Soldier Fly (*Hermetia illucens*), including prepupal size, pupal size, adult body size, and abdominal dimensions. The findings are expected to contribute to the development of alternative substrate formulations utilizing locally available agricultural and livestock wastes for sustainable BSF production systems.

LITERATURE REVIEW

Previous studies have consistently demonstrated that the growth and developmental performance of Black Soldier Fly (*Hermetia illucens*) are influenced by a complex interaction among environmental conditions, substrate quality, and colony management practices. Temperature and humidity are considered key environmental factors because they regulate metabolic activity, nutrient conversion efficiency, and developmental rate. Rearing systems that maintain stable environmental conditions through adequate shading and ventilation generally promote greater prepupal biomass and improve developmental performance (Toar et al., 2023). Similarly, Opare et al. (2022) reported that temperatures within the optimal range of 27–30 °C accelerate larval development and increase body size, whereas temperatures outside this range may reduce growth efficiency and survival. However, environmental factors do not act independently, as their effects are often influenced by substrate characteristics and larval density.

Nutritional composition of the rearing substrate has also been identified as a major determinant of BSF growth and metamorphosis. Substrates containing balanced levels of protein, carbohydrates, and organic matter generally produce larger prepupae and pupae with improved bioconversion efficiency (Lalander et al., 2019; Ha et al., 2025). High-protein diets support tissue formation and nutrient storage required during metamorphosis, whereas carbohydrate rich substrates contribute to energy reserves and lipid accumulation (Tinder et al., 2017; Suryati et al., 2023). Nevertheless, previous studies have reported variable responses depending on the type of organic waste used. For example, Pamintuan et al. (2019) observed superior growth performance in larvae reared on fish processing waste, whereas Belperio et al. (2024) found lower growth responses when vegetable based substrates were used. These findings suggest that BSF performance depends not only on nutrient quantity but also on nutrient availability and substrate characteristics.

In addition to substrate quality, larval density and microbial interactions have been reported to influence developmental outcomes. High larval density may increase competition for nutrients and elevate metabolic heat production, resulting in slower development and reduced body size (Dzepe et al., 2020; Opare et al., 2022). Furthermore, beneficial microorganisms associated with the substrate and larval gut contribute to nutrient degradation and assimilation, thereby enhancing growth performance and bioconversion efficiency (Li et al., 2023; Li et al., 2025). Although these studies have improved understanding of BSF biology, most investigations have focused on conventional substrates such as food waste, vegetable residues, brewer’s spent grain, slaughterhouse waste, or palm kernel by products (Lalander et al., 2019; Bellezza Oddon et al., 2024; Yandigeri et al., 2022). Information regarding the use of fermented coconut dregs combined with fermented chicken manure remains limited, particularly concerning their effects on prepupal, pupal, adult, and abdominal morphometric characteristics. Therefore, further investigation is required to evaluate the suitability of these locally available fermented substrates as alternative media for sustainable BSF production.

RESEARCH METHODS

This study was conducted using a laboratory experimental method to evaluate the effect of different combinations of fermented coconut dregs and fermented chicken manure on the morphometric characteristics of Black Soldier Fly (Hermetia illucens). The experiment employed a Completely Randomized Design (CRD) consisting of five treatments with forty replications per treatment. Therefore, a total of 200 experimental units were used in this study.

Each experimental unit consisted of a plastic rearing container containing 2 kg of treatment substrate and 1,000 BSF larvae of the same age. Larvae were maintained for 15 days until the prepupal stage was reached. At the end of the rearing period, one individual was randomly selected from each experimental unit for morphometric measurements. Consequently, 40 individual samples were obtained from each treatment, resulting in a total of 200 observed samples.

Preparation and Fermentation of Substrates

Coconut dregs were collected from local coconut-processing industries, while chicken manure was obtained from a poultry farm. Both materials were fermented separately using *Effective Microorganisms* 4 (EM4) as a fermentation starter. The substrates were mixed thoroughly with EM4 solution and maintained under anaerobic conditions in closed containers for seven days. Following fermentation, the substrates were homogenized and prepared according to the treatment formulations.

Experimental Treatments

Five substrate combinations were evaluated:

a) P0 = 100% fermented coconut dregs
b) P1 = 95% fermented coconut dregs + 5% fermented chicken manure
c) P2 = 90% fermented coconut dregs + 10% fermented chicken manure
d) P3 = 85% fermented coconut dregs + 15% fermented chicken manure
e) P4 = 80% fermented coconut dregs + 20% fermented chicken manure

Each treatment substrate was thoroughly mixed before being placed into the rearing containers. Subsequently, 1,000 BSF larvae were introduced into each experimental unit and reared under identical environmental conditions.

Rearing Conditions and Data Collection

Larvae were maintained under controlled environmental conditions with temperatures ranging from 27–30°C and relative humidity ranging from 60–70%. The development of prepupae, pupae, and adult BSF was monitored throughout the experimental period.

The observed parameters included:

1. Prepupal length, width, and weight.
2. Pupal length, width, and weight.
3. Adult BSF length, width, and weight.
4. Adult abdominal length and width.

Body length and width measurements were obtained using a digital caliper, whereas body weight was measured using a digital analytical balance. Environmental variables, including temperature, humidity, and substrate pH, were monitored regularly using a thermometer, hygrometer, and pH meter.

Statistical Analysis

Data were analyzed using Analysis of Variance (ANOVA) based on a Completely Randomized Design (CRD) at a 95% confidence level ($\alpha = 0.05$). The statistical model used was:

$$Yij = \mu + \tau i + \varepsilon ij$$

where:

a) Yij = observation value of the j-th replication under the i treatment;
b) μ = overall mean;
c) τi = effect of the i-th treatment;
d) εij = random experimental error.

When significant treatment effects were detected ($P < 0.05$), Duncan's Multiple Range Test (DMRT) was applied to compare treatment means. All statistical analyses were performed using appropriate statistical software.

RESULTS AND DISCUSSION

1. Prepupae

Data on the length, width and weight of prepupae with fermented coconut dregs and fermented chicken manure media can be observed in table 1

Table 1. The size of the prepupaee from the fermented coconut with fermented chicken manure

Treatment	Length (mm)	Width (mm)	Weigth (Gram)
P0	13.32±1.64	2.87±0.53	0.11±0.015
P1	12.93±1.35	2.94±0.54	0.10±0.028
P2	13.75±1.37	3.14±0.56	0.12±0.025
P3	12.62±1.56	2.72±0.56	0.09±0.022
P4	10.72±1.61	2.36±0.48	0.09±0.017

Note : P0 = 100% Ampas Kelapa Fermentasi ; P1 = 95% Ampas Kelapa Fermentasi + 5% Kotoran Ayam Fermentasi ; P2 = 90% Ampas Kelapa Fermentasi + 10% Kotoran Ayam Fermentasi ; P3 = 85% Ampas Kelapa Fermentasi + 15% Kotoran Ayam Fermentasi ; P4 = 80% Ampas Kelapa Fermentasi + 20% Kotoran Ayam Fermentasi

The mean prepupal length ranged from 10.72 to 13.75 mm, width ranged from 2.36 to 3.14 mm, and weight ranged from 0.09 to 0.12 g. Numerically, treatment P2 (90% fermented coconut dregs + 10% fermented chicken manure) produced the highest values for prepupal length, width, and weight. However, analysis of variance (ANOVA) indicated that the different substrate combinations did not significantly affect prepupal length, width, or weight ($P > 0.05$).

Although no statistically significant differences were detected among treatments, the numerical tendency observed in P2 suggests that the addition of a moderate proportion of fermented chicken manure may have improved substrate quality and nutrient availability. Fermented coconut dregs contain residual carbohydrates, lipids, and fiber that can serve as energy sources for larval growth, whereas fermented chicken manure contributes additional nitrogen and minerals that may support metabolic activity. The combination of these substrates may have created a more balanced nutrient profile, allowing larvae to accumulate slightly greater biomass before entering the prepupal stage.

The absence of significant differences among treatments indicates that all substrate formulations were generally capable of supporting prepupal development. This finding suggests that fermented coconut dregs alone already provided sufficient nutritional resources for larval growth, and the addition of fermented chicken manure up to 20% did not substantially alter prepupal morphometric characteristics. Similar observations have been reported by Lalander et al. (2019), who demonstrated that BSF larvae can successfully develop on a wide range of organic substrates despite differences in nutrient composition. Likewise, Ha et al. (2025) reported that substrate type influences larval performance primarily when substantial differences in nutrient availability occur, whereas substrates with relatively comparable nutritional quality often produce similar growth responses.

The tendency for higher prepupal measurements in P2 may also indicate that a moderate inclusion level of fermented chicken manure provided a more favorable balance between energy rich components from coconut dregs and protein containing organic matter from manure. Tinder et al. (2017) explained that adequate protein availability supports tissue development and nutrient storage during the transition from larval to prepupal stages. However, increasing the proportion of fermented chicken manure beyond 10% did not further improve prepupal size. This may suggest that additional manure inclusion did not provide sufficient nutritional advantages to generate measurable differences in growth performance.

Overall, the results indicate that the combination of fermented coconut dregs and fermented chicken manure supported normal prepupal development of BSF. Nevertheless, the relatively similar morphometric values observed across treatments suggest that the tested substrate formulations provided comparable nutritional conditions, resulting in statistically similar prepupal growth responses.

2. Pupae

Data on the length, width and weight of pupae with fermented coconut dregs and fermented chicken manure media can be observed in table 2.

Table 2. The size of the pupae from the fermented coconut with fermented chicken manure

Treatment	Parameter		
	Length (mm)	Width (mm)	Weigth (g)
P0	11.91±2.34	3.25±0.62	0.07±0.019
P1	13.01±1.55	3.52±3.83	0.06±0.021
P2	13.69±1.76	3.06±0.59	0.08±0.017
P3	12.07±1.82	2.82±0.56	0.06±0.023
P4	9.11±2.17	2.72±0.58	0.05±0.018

Note : P0 = 100% Ampas Kelapa Fermentasi ; P1 = 95% Ampas Kelapa Fermentasi + 5% Kotoran Ayam Fermentasi ; P2 = 90% Ampas Kelapa Fermentasi + 10% Kotoran Ayam Fermentasi ; P3 = 85% Ampas Kelapa Fermentasi + 15% Kotoran Ayam Fermentasi ; P4 = 80% Ampas Kelapa Fermentasi + 20% Kotoran Ayam Fermentasi

The average pupal length ranged from 9.11 to 13.69 mm, width ranged from 2.72 to 3.52 mm, and weight ranged from 0.05 to 0.08 g. Numerically, treatment P2 (90% fermented coconut dregs + 10% fermented chicken manure) produced the greatest pupal length and weight, whereas the highest pupal width was observed in P1. However, analysis of variance (ANOVA) showed that the different substrate combinations did not significantly affect pupal length, width, or weight ($P > 0.05$).

Although the statistical analysis indicated no significant treatment effect, numerical differences among treatments suggest that substrate composition may have influenced nutrient utilization during the transition from prepupa to pupa. The superior pupal length and weight observed in P2 indicate that the inclusion of 10% fermented chicken manure may have provided a more favorable balance of nutrients compared with the other formulations. Fermented coconut dregs contain residual carbohydrates and lipids that serve as energy sources, while fermented chicken manure contributes additional organic nitrogen and minerals that may support tissue development during metamorphosis. As a result, larvae reared on P2 tended to accumulate slightly greater biomass before entering the pupal stage.

The relatively similar pupal measurements across treatments indicate that all substrate formulations were capable of supporting normal pupal development. This finding suggests that the nutritional quality of fermented coconut dregs remained adequate even when used as the sole substrate component in P0. According to Lalander et al. (2019), BSF larvae possess a high capacity to utilize a wide range of organic materials, allowing successful development even under varying substrate compositions. Consequently, moderate differences in substrate formulation do not always translate into statistically significant differences in growth performance.

The decline in pupal length and weight observed in P4 may indicate that increasing the proportion of fermented chicken manure beyond a certain level did not provide additional developmental benefits. Although chicken manure can contribute nutrients, excessive inclusion may alter the physical characteristics of the substrate, including texture, moisture retention, and nutrient balance. Such changes may influence feed utilization efficiency and reduce the accumulation of body reserves required during metamorphosis. Similar observations were reported by Bellezza Oddon et al. (2024), who demonstrated that BSF growth responses depend not only on nutrient availability but also on the overall suitability and balance of the substrate composition.

The tendency for larger pupae in P2 is also consistent with the concept that balanced nutrient availability contributes to more efficient biomass accumulation during larval development. Binsin et al. (2023) reported that substrates with adequate nutritional composition generally support better growth performance and survival throughout the BSF life cycle. Likewise, Ha et al. (2025) emphasized that substrate quality plays an important role in determining developmental performance, particularly when nutrient composition influences the efficiency of nutrient conversion into biomass.

Overall, the results indicate that the combination of fermented coconut dregs and fermented chicken manure supported successful pupal development in all treatments. Although no significant differences were detected statistically, the numerical trend observed in P2 suggests that the inclusion of 10% fermented chicken manure may provide a more favorable substrate composition for pupal growth compared with higher manure inclusion levels.

3. BSF

Data on the length, width and weight of BSF with fermented coconut dregs and fermented chicken manure media can be observed in table 3.

Table 3. The size of the BSF body from the fermented coconut with fermented chicken manure

Treatment	Parameter		
	Length (mm)	Width (mm)	Weigth (g)
P0	12.09±1.06	2.81±0.39	0.03±0.02
P1	10.91±1.07	2.65±0.62	0.02±0.01
P2	11.04±2.22	2.99±0.26	0.01±0.008
P3	10.52±1.9	2.7±0.32	0.001±0.008
P4	12.44±2.01	99±0.43	0003±0.022

Note : P0 = 100% Ampas Kelapa Fermentasi ; P1 = 95% Ampas Kelapa Fermentasi + 5% Kotoran Ayam Fermentasi ; P2 = 90% Ampas Kelapa Fermentasi + 10% Kotoran Ayam Fermentasi ; P3 = 85% Ampas Kelapa Fermentasi + 15% Kotoran Ayam Fermentasi ; P4 = 80% Ampas Kelapa Fermentasi + 20% Kotoran Ayam Fermentasi

The average body length ranged from 10.52 to 12.44 mm, body width ranged from 2.65 to 2.99 mm, and body weight ranged from 0.001 to 0.03 g. Numerically, treatment P4 (80% fermented coconut dregs + 20% fermented chicken manure) produced the highest body length and width, whereas treatment P0 (100% fermented coconut dregs) resulted in the highest body weight. However, analysis of variance (ANOVA) indicated that the observed differences among treatments were not statistically significant ($P > 0.05$).

Although the differences were not significant, the numerical variation among treatments provides useful insight into the influence of substrate composition on adult morphology. The greater body length and width observed in P4 suggest that the inclusion of a higher proportion of fermented chicken manure may have contributed additional nutrients required for structural growth during larval development. Chicken manure contains organic nitrogen and minerals that can support tissue formation and physiological development. As reported by Ha et al. (2025), variations in substrate composition may influence nutrient conversion efficiency and consequently affect the morphometric characteristics of BSF throughout its life cycle.

Interestingly, the highest adult body weight was recorded in P0, despite this treatment not producing the greatest body dimensions. This finding suggests that body size and body mass do not always increase simultaneously. A possible explanation is that larvae reared exclusively on fermented coconut dregs accumulated greater energy reserves in the form of lipids before metamorphosis. Fermented coconut dregs are known to contain residual lipids and carbohydrates that can be converted into energy stores during larval growth. According to Tinder et al. (2017), nutrient composition influences how assimilated resources are allocated between structural development and energy storage. Similarly, Suryati et al. (2023) reported that substrates rich in energy sources can promote the accumulation of lipid reserves, particularly lauric acid, which constitutes an important component of BSF biomass.

The contrasting pattern observed between body dimensions and body weight may therefore indicate differences in nutrient partitioning among treatments. In P4, nutrients may have been preferentially utilized for skeletal and structural development, resulting in longer and wider adult flies. In contrast, the coconut dregs-based substrate in P0 may have favored the accumulation of internal energy reserves, contributing to greater body mass despite relatively smaller body dimensions. This observation highlights the importance of considering multiple morphometric parameters simultaneously when evaluating BSF growth performance.

The absence of statistically significant differences among treatments further suggests that all substrate formulations were capable of supporting normal adult development. BSF larvae are known to exhibit considerable adaptability to different organic substrates, provided that basic nutritional requirements are met. Lalander et al.

(2019b) demonstrated that BSF can successfully develop on a broad range of organic waste materials, while Bellezza Oddon et al. (2024) reported that growth responses are often influenced by the balance and availability of nutrients rather than by a single substrate component alone. Therefore, the relatively similar morphometric values observed across treatments indicate that both fermented coconut dregs and fermented chicken manure can serve as suitable substrates for BSF production.

Overall, the results demonstrate that increasing the proportion of fermented chicken manure tended to enhance adult body length and width, whereas fermented coconut dregs alone tended to produce heavier adults. Nevertheless, these numerical differences were insufficient to generate statistically significant treatment effects, indicating that all substrate combinations provided comparable conditions for adult BSF development.

4. Abdominal Development and Reproductive Quality

The body size of the Black Soldier Fly (BSF), especially the development of the abdomen in the adult phase, is a morphological parameter that has a close relationship with reproductive performance and the quality of the offspring produced. The abdomen functions as a storage center for energy reserves and the location for the development of reproductive organs, especially the ovaries in females. Therefore, abdominal size not only reflects nutritional status during the larval phase, but also determines reproductive capacity, egg size, hatchability, and the genetic quality of the resulting BSF population. Factors such as substrate quality, broodstock body size, environmental conditions, population density, and genetic management play an important role in determining abdominal development and reproductive efficiency of BSF. Table 4 shows the length and width of the abdomen

Table 4. The size of the abdomen from the fermented coconut with fermented chicken manure

Treatment	Parameter	
	Length (mm)	Width (mm)
P0	6.73±0.69	2.77±0.37
P1	6±1.14	2.77±0.43
P2	6.38±0.78	2.80±0.31
P3	5.96±0.63	2.66±0.80
P4	7.01±1.05	2.9±0.42

Note : P0 = 100% Ampas Kelapa Fermentasi ; P1 = 95% Ampas Kelapa Fermentasi + 5% Kotoran Ayam Fermentasi ; P2 = 90% Ampas Kelapa Fermentasi + 10% Kotoran Ayam Fermentasi ; P3 = 85% Ampas Kelapa Fermentasi + 15% Kotoran Ayam Fermentasi ; P4 = 80% Ampas Kelapa Fermentasi + 20% Kotoran Ayam Fermentasi

The average abdominal length ranged from 5.96 to 7.01 mm, while abdominal width ranged from 2.66 to 2.9 mm. Numerically, treatment P4 (80% fermented coconut dregs + 20% fermented chicken manure) produced the highest abdominal dimensions compared with the other treatments. However, analysis of variance (ANOVA) indicated that the observed differences were not statistically significant ($P > 0.05$).

Although no significant treatment effect was detected, the numerical variation among treatments suggests that substrate composition may have influenced nutrient accumulation during larval development, which subsequently affected abdominal growth in the adult stage. The larger abdominal dimensions observed in P4 may indicate that the inclusion of fermented chicken manure provided additional nutrients required for tissue formation during metamorphosis. Fermented chicken manure contributes organic nitrogen and mineral components that may complement the energy-rich characteristics of fermented coconut dregs, resulting in a more balanced nutrient supply throughout development.

The tendency for larger abdominal size in treatments containing fermented chicken manure is consistent with the observation that body development in BSF depends on nutrient availability during the larval stage. Since adult BSF do not actively accumulate substantial nutrients after emergence, the morphological characteristics observed in adults largely reflect nutrient reserves acquired during immature developmental stages. Therefore, differences in abdominal dimensions among treatments may represent variations in the efficiency of nutrient utilization and biomass accumulation prior to pupation.

In the present study, however, the relatively similar abdominal measurements across all treatments indicate that each substrate formulation was capable of supporting normal adult development. This finding suggests that fermented coconut dregs alone already provided sufficient nutrients to sustain growth, while the addition of fermented chicken manure produced only modest improvements in abdominal size. A similar pattern was reported by Lalander et al. (2019), who observed that BSF can efficiently utilize various organic substrates when basic nutritional requirements are fulfilled, often resulting in comparable growth performance despite differences in substrate composition.

The numerical superiority observed in P4 may also indicate that increasing the proportion of fermented chicken manure enhanced nutrient balance within the substrate.

Ha et al. (2025) reported that substrate quality can influence nutrient conversion efficiency and body development throughout the BSF life cycle. Likewise, Bellezza Oddon et al. (2024) emphasized that the suitability of a substrate depends not only on nutrient concentration but also on the interaction among substrate components, which may affect nutrient accessibility and utilization. In the present study, the combination of fermented coconut dregs and fermented chicken manure appeared to provide adequate nutritional conditions for abdominal development, although the differences were insufficient to produce statistically significant responses.

It is important to note that abdominal size alone cannot be used to directly infer reproductive performance. While larger abdominal dimensions may indicate greater biomass accumulation during development, parameters related to reproduction such as fecundity, egg production, mating success, or ovarian development were not evaluated in this study. Therefore, interpretations should be limited to morphometric development rather than reproductive capacity.

Overall, the results demonstrate that all substrate formulations supported normal abdominal development of adult BSF. Although treatment P4 tended to produce larger abdominal dimensions, the absence of significant statistical differences indicates that the tested substrate combinations provided relatively similar conditions for adult morphometric development.

CONCLUSION

The results of this study demonstrated that different combinations of fermented coconut dregs and fermented chicken manure did not significantly affect ($P > 0.05$) the morphometric characteristics of Black Soldier Fly (*Hermetia illucens*), including prepupal, pupal, adult, and abdominal dimensions. Although numerical differences were observed among treatments, these variations were not statistically significant. The substrate formulation containing 90% fermented coconut dregs and 10% fermented chicken manure tended to produce higher values for several prepupal and pupal parameters, whereas the formulation containing 80% fermented coconut dregs and 20% fermented chicken manure tended to result in larger adult body and abdominal dimensions. Overall, all tested substrate formulations were able to support normal growth and development of BSF throughout its life cycle, indicating that fermented coconut dregs, either alone or combined with fermented chicken manure, have potential as alternative substrates for BSF rearing. Further studies involving substrate nutritional analysis, biomass conversion efficiency, survival rate, and reproductive parameters are recommended to provide a more comprehensive understanding of BSF responses to different substrate compositions.

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