Comparison of The Nutritional Composition of Black Soldier Fly Bred on Organic Waste and Bred on Commercial Pellet mixed with Rice Bran

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ABSTRAK

Ningrum SG, Ilham MZ, Yulianto AB, Nussa ORPA, Purnamasari K. 2024. Perbandingan komposisi nutrisi Lalat Tentara Hitam yang dikembangbiakkan pada sampah organik dengan yang dikembangkanbiakan pada pakan campuran pelet komersial dengan dedak padi. JITV 29(1):29-35. DOI:http://dx.doi.org/10.14334/jitv.v29.i1.3357.

Lalat tentara hitam (BSF, *Hermetia illucens*) merupakan serangga yang sering digunakan sebagai pakan ternak yang mudah, murah, dan cepat berkembang biak. Namun, lalat ini belum pernah digunakan untuk makanan unggas. Penelitian ini bertujuan untuk membandingkan kandungan nutrisi lalat tentara hitam, larva-instar ketiga, dan pupa yang diberi pakan limbah organik dan yang diberi pakan campuran pelet ayam komersial dengan dedak padi. Metode yang digunakan dalam penelitian ini menggunakan analisis proksimat kandungan nutrisi lalat prajurit hitam untuk bahan kering, abu, protein kasar, lemak kasar, serat kasar, kalsium, ekstrak bebas nitrogen, dan energi bruto. Hasil penelitian ini dapat digunakan sebagai pakan alternatif unggas di Indonesia di masa mendatang.

Kata Kunci: Nutrisi Ternak, Lalat Tentara Hitam, Diptera, Walet

ABSTRACT

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The black soldier fly (BSF, *Hermetia illucens*) is an insect often used as animal feed that is easy, inexpensive, and fast to breed. However, these flies have never been used for the poultry diet. This study compares the nutritional content of black soldier flies, third-instar larvae, and pupae fed with organic waste and a mixture of commercial chicken pellets with rice bran. The method used in this study uses proximate analysis of the nutritional content of black soldier flies for dry matter, ash, crude protein, crude fat, crude fiber, calcium, nitrogen-free extract, and gross energy.

Key Words: Animal Nutrition, Black Soldier Fly, Dipterans, Swiftlet

INTRODUCTION

The escalating demand for sustainable and nutritionally balanced animal feed has led to exploring unconventional protein sources (Hawkey et al. 2021; Sajid et al. 2023). Among these, the Black Soldier Fly (BSF), renowned for its efficient conversion of organic waste into nutrient-rich biomass (Raksasat et al. 2020; Rehman et al. 2022; Surendra et al. 2020), emerges as a promising candidate. This research explores the innovative process of creating nutrients obtained from BSF-derived ingredients. It focuses on optimizing poultry nutrition and investigating their potential inclusion in the formulation for breeding swiftlets, particularly those intended for edible nest production.

As global populations burgeon, the poultry industry faces the challenge of meeting the escalating demand for high-quality, protein-rich animal products (Guiné et al. 2021; Scanes 2018). Simultaneously, the swiftlet breeding industry strives for innovative solutions to enhance the nutritional content of their birds (Looi & Omar 2016), ultimately influencing the quality of edible nests. The study delves into the meticulous preparation of BSF-derived ingredients, aiming to unlock their full potential as a sustainable protein source for poultry and a supplementary component in the breeding of swiftlets.

We are facing a problem: swiftlets can not be cultivated because of their wild nature, so commercial feed production often fails to be applied (Ammartsena & Ditthapan 2023). Edible-nest swiftlet is an insectivore that eats flying insects from its environments, such as bees, beetles, mosquitoes and flies (Mursidah et al. 2020). Although swiftlets do not need to choose high-nutrition feeds, some ingredients such as carbohydrates, fats, and proteins are necessary for their body's metabolism (Ahmad et al. 2019). In addition, the nutritional content of EBN, namely protein and minerals, can also be affected by the feed consumed by edible-nest swiftlet (Benjakul & Chantakun 2022). Black soldier fly (BSF; *H. illucens*) is a fly (Diptera) generally used as animal feed. These flies originate from the American continent but are now widely bred in countries with tropical and temperate climates worldwide. BSF is an alternative protein with many benefits compared to other farmed insect species (Wang & Shelomi 2017). Using environmentally friendly natural biodiversity wealth such as BSF (Cattaneo et al. 2023; Rifai & Permata 2023), this research is expected to help swiftlet farmers avoid economic losses. Also, this research can enhance the future edible-nest swiftlets population by providing alternative feed for swiftlets.

This research addresses the need for novel, sustainable protein sources in poultry diets and explores the uncharted territory of utilizing BSF-derived ingredients to enhance the nutritional profile of swiftlets. By unraveling the intricacies of preparation methods, we aspire to contribute valuable insights that may revolutionize how we formulate animal feeds, promoting ecological sustainability and improving avian breeding practices.

MATERIALS AND METHODS

Preparation of BSF (*H. Illucens)* samples

This research method refers to previous studies with modifications. The life stages of BSF used in this study included third-instar larvae and pupae. BSF collected from the Magot Breeding Center in Surabaya, East Java, Indonesia. BSF colonies were maintained in polypropylene containers (10 L, with a capacity for 100 individuals) covered with muslin cloth at 25°C.

Preparation of feeding

The breeding materials were obtained from organic (mixed vegetable) waste and a mixture of commercial chicken feed and rice bran (G-11, Comfeed, Japfa, Jakarta, Indonesia). The materials were mixed with water (ratio 1:2) in a container. BSF adults were allowed to mate and fed each 25 g of the proposed diet. After breeding and hatching, half of the population of the third-instar larvae was collected for analysis. The other larvae were allowed to grow until pupation. Pupae were collected for further analysis.

Nutrient analysis of BSF

About 100 g of each of the third-instar larvae and pupae of BSF were collected, washed first, and stored in the freezer at -20 °C for 24 hours before being analyzed. A slightly modified SNI 01-2891-1992 (Badan Standardisasi Nasional 1992) was applied to the samples with three replicates. Nutritional levels were examined on dry matter, ash, crude protein, crude fat, crude fiber, calcium, nitrogen-free extract (NFE), and gross energy.

Dry matter content (DM) was measured by sampling 2 g of each sample, aliquoted and dried in a forced-f convection drying oven at 105°C for 3 h, and then cooled in an exicator. Moisture content was calculated using the formula (original weight of the sample: the dried weight of the sample) x 100%. DM was the difference between 100% (sample) and moisture content.

Total ash was determined by burning 3 g of sample to be perfect ash in an electric furnace at a maximum temperature of 550°C, and then samples were cooled in an exicator. Ash content was calculated using the formula: (weight of the sample and cup after burned – empty cup weight/original weight of the sample) x 100%. The difference between DM and total ash was the amount of organic matter.

Crude protein was estimated using the Kjeldahl method (18-8-31/MU/SMM-SIG, Kjeltec). Approximately 0.51 g of sample was first digested with 2 g of selen mix (2.5 g of SeO_2, 100g of K_2SO_4, and 20 g of $CuSO_45H_2O$) and 25 mL of concentrated H_2SO_4. After the mixture was cooled at room temperature, 5 mL of NaOH 30% was added to the flask. The flask was then placed in a distillation connection unit, and the distillate was mixed with 2% boric acid and a few drops of methyl red. The distillate mixture was titrated with 0.01 N HCl, and protein concentration was calculated using the formula: ((V1-V1) x N x 0.014 x f.k x fp): w. The difference between organic matter and crude protein was the amount of nitrogen-free organic.

Crude fat was measured using the Weibull method in petroleum ether by calculating the formula: ((w1 - w2): w) x 100%. About 2 g of sample was added with 30 mL HCl 25% and 20 mL water. The mixture was boiled for 15 min and filtered with filter paper. The filter paper and the content were dried at 105°C and extracted in petroleum ether for 3 h at 80°C. The ether part was removed and dried in an oven at 105°C. The lipid content was calculated as the difference between fat flask weight after extraction (g) and fat flask weight before extraction (g) divided by the original weight of the sample (g) x 100%. Total sugar was determined by calculating nitrogen-free organic and lipid (Marrubini et al., 2017).

The extracted sample with H_2SO_4 and NaOH determined the crude fiber. A total of 4 g of sample was added by 50 mL of 1.25% H_2SO_4 and boiled for 30 min. After that, the boiled sample was added 50 mL of 3.25% NaOH and boiled again for 30 min. The mixture was filtered and rinsed with 1.25% H_2SO_4, hot water, and 96% ethanol. The residue weight was dried at 105°C. The dried residue (w2) was weighed and heated in an electric furnace at 550°C to form ash (w1). The fiber was the difference between w2 and w1 divided by the original weight of the sample x 100%. NFE was determined by calculating the total sugar and crude fiber (Ningrum 2021). Gross energy was calculated using the formula: (9.11 kcal/g x % fat + 5.86 kcal/g x % crude protein + 3.95 kcal/g x % total sugar): 100 (Garcia et al. 2016). ICP-OES 18-13-1/MU/SMM-SIG method (Chasanah et al. 2020) was used to determine the calcium content.

Statistical analysis

The nutritional composition among the life stages and the breeding materials were compared by one-way analysis of variance (ANOVA) followed by Duncan's post hoc test in SPSS 25.0 ($P<0.05$). Boxplots expressed a comparison of the nutritional value of third-instar larvae and pupae of BSF for different breeding materials.

RESULTS AND DISCUSSION

Significant differences in nutritional content were found based on comparing the nutritional value of each BSF stage (third-instar larvae and pupae) with different breeding materials (Table 1). The dry matter of third-instar larvae and pupae bred on chicken pellet with bran was significantly higher (97%) than that of the third-instar larvae (96%) and pupae (85%) bred on organic waste ($F=1604.306$, $df=1$, $P<0.05$). For ash content, pupae bred on chicken pellets with bran showed the highest quantity (26%) compared with the others ($F=3241.252$, $df=1$, $P<0.05$).

The third-instar larvae bred on mixed chicken pellet with bran has the highest crude protein (32%) ($F=415.944$, $df=1$, $P<0.05$), crude fat (14%) ($F=496.382$, $df=1$, $P<0.05$), and gross energy contents (2703 KJ/g) ($F=392.192$, $df=1$, $P<0.05$). At the same time, pupae showed the highest content for crude fiber (28%) ($F=140.803$, $df=1$, $P<0.05$) and calcium (5%) ($F=3241.252$, $df=1$, $P<0.05$). The third-instar larvae bred on organic waste showed the highest NFE content ($F=25.957$, $df=1$, $P<0.05$).

Based on the results of this study, the two growth stages of this species provide different information on nutrient content; this is due to the different nutrient requirements at each stage of the life of this species. For example, larvae need much energy to make the pupation process successful (Dzepe et al. 2020; Kim et al. 2021; Stadler & Takáč 2022). In this study, the larvae were shown to have a high crude protein and crude fat content, so the energy produced was also more significant than the pupae. However, pupae have a higher mineral content than larvae. It is normal because the pupae have undergone chitinization. In the results of a comparative analysis of the BSF stages developed in each breeding material, the results show that the third-instar larvae developed using a mixture of commercial chicken pellets and bran provide a higher nutritional content compared to the larval or pupal stages bred with organic waste; this is due to the nutritional content of commercial chicken pellet mixtures with bran containing more fat, protein, and minerals.

On the other hand, organic waste provides a higher crude fiber content in the pupae but a high NFE in the larval stage. This result shows that the pupae grown on organic waste have lower nutrient content than the larvae and pupae produced on commercial chicken pellet mixture material with bran. Despite their low digestibility, our results show that pupae grown on commercial chicken pellets mixed with bran have a very

Table 1. Nutritional value (means±SD) of black soldier fly (BSF, *H. Illucens)* for different breeding diets materials and different growth stages

Breeding Diets Materials	Growth Stage	Dry matter (%)	Ash (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	NFE[1)] (%)	Gross energy (KJ/g)	Calcium (g/100g)
Organic waste	Larvae	96.89±0.08[b2)]	10.56±0.06[d]	27.53±0.33[d]	5.37±0.32[d]	26.21±0.06[b]	27.20±0.70[a]	2367.79±8.20[b]	2.85±0.12[d]
	Pupae	85.36±0.38[c]	11.51±0.28[c]	30.49±0.10[b]	13.95±0.29[b]	28.64±0.21[a]	0.74±0.69[c]	2166.99±6.26[c]	3.35±0.15[c]
Chicken pellet + rice bran	Larvae	97.44±0.26[a]	15.11±0.12[b]	32.42±0.32[a]	14.85±0.63[a]	21.40±0.01[c]	13.65±0.74[b]	2703.39±25.82[a]	3.72±0.10[b]
	Pupae	97.13±0.09[ab]	26.42±0.00[a]	29.67±0.10[c]	12.39±0.36[c]	28.09±0.58[a]	0.55 ± 0.31[c]	1968.58±31.91[d]	5.22±0.24[a]

NFE= Nitrogen-free extract. Different superscripts in each row in the same column indicate that they significantly differ for the nutritional value at $P<0.05$. All testing was performed with three replicates

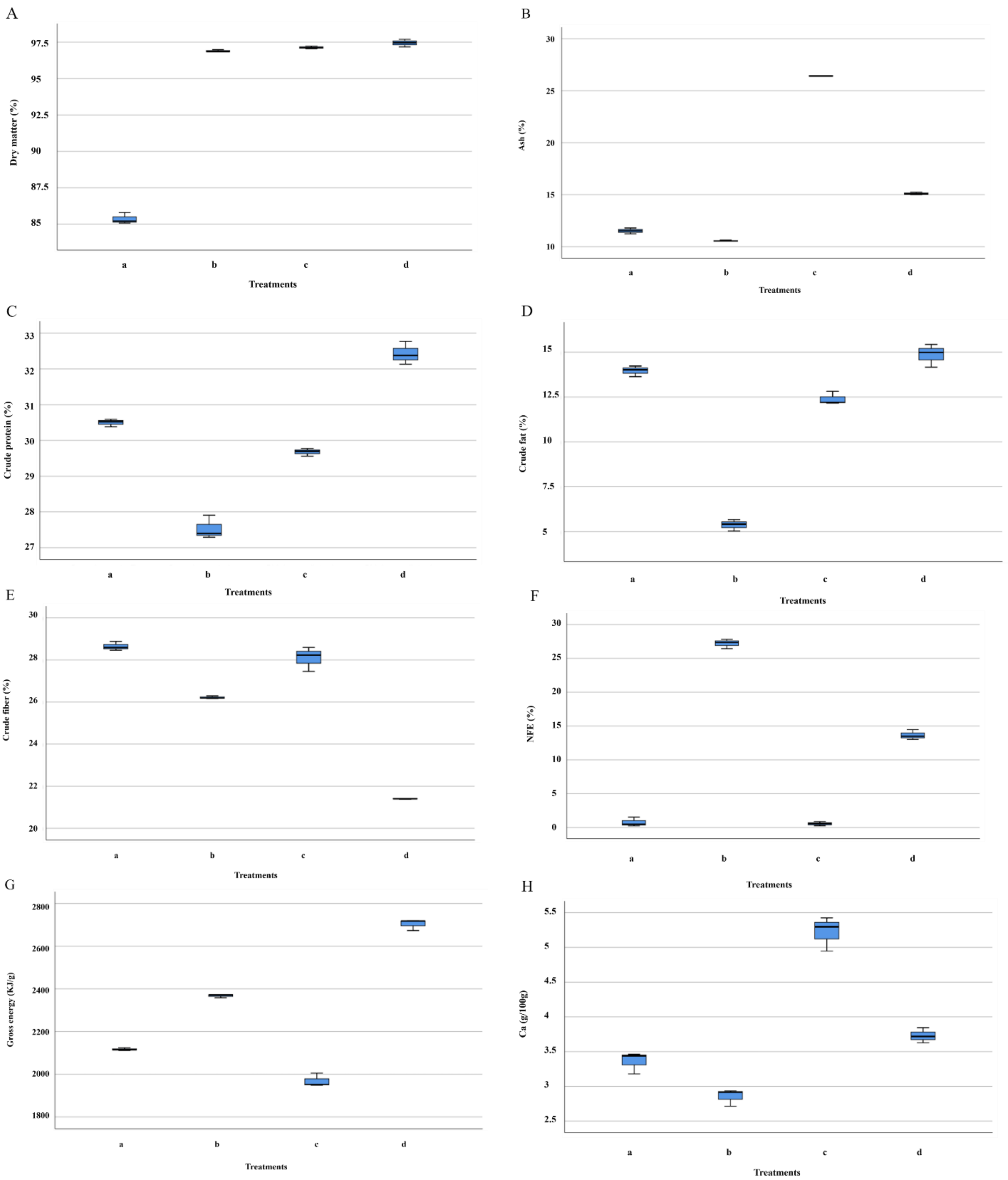

Figure 1. Nine groups of boxplots correspond to each of the treatments. A: Dry Matter, B: Ash, C: Crude protein, D: Crude fat, E: Crude fiber, F: Nitrogen-free extract (NFE), G: Gross energy, H: Calcium. a: organic waste-pupae, b: organic waste-third-instar larvae, c: chicken pellet with rice bran-pupae, d: chicken pellet with rice bran-third instar larvae

high content. This result indicates that pupae grown on commercial chicken pellet mixtures with bran suit the swiftlet egg production process. Even so, providing immobile feed such as pupae as swallow feed is a challenge for swallow breeders. To the best of our knowledge, this study is the first to report a comparison of the nutritional content of BSF (*H. Illucens)* third-instar larval stages and pupae grown in a mixture of commercial chicken pellets with bran and organic waste. There were significant differences between the types of BSF breeding diet materials used.

Since the scarcity of food sources for edible-nest swiftlet can threaten the swiftlet population in Indonesia, commercial feed for edible-nest swiftlet is highly desirable, and providing swiftlet feed is a challenge for edible-nest swiftlet breeders in the future. Edible nest swiftlet feed is expected to provide complete nutrition for the growth of this bird species. Even though it is given manually, edible nest swiftlet feed should have the property of "moving" because these birds eat insects that fly or move. These birds commonly consume insects from the orders Hymenoptera, such as ants, wasps, and bees (Tong et al. 2021). Also, edible-nest swiftlets consume aphids, plant lice, mayflies, beetles, booklice, butterflies, grasshoppers, caddisflies, thrips, mites, ticks, true bugs, termites, and spiders. However, ants and wasps consume edible nest swiftlets most (Fujita & Leh 2020). These birds prefer to prey while flying (Yaacob et al. 2021) and can still stick to a vertical surface when preying (Duerr & Gage 2020). In addition to this bird feed, which must live, edible nest swiftlet feed should be economical and easy to produce. BSF maggot is often used as an alternative feed for poultry (Ahmed et al. 2023; Edea et al. 2022; Khan 2018) and fish (Sari et al. 2021; Shah et al. 2022; Sinansari & Fahmi 2020), but has never been used for feeding edible nest swiftlets. This study compared and determined the difference in nutritional content between the pupae and the third instar BSF larvae bred on organic waste with those bred using a mixture of chicken pellets and bran. From this study, we aim to make it easier for swiftlet breeders to develop an edible nest of swiftlet live food. The results suggest combining commercial chicken pellets with bran is more nutritious than organic waste for BSF third-instar larvae and pupae stages. Thus, the third-instar larval of BSF could be challenged as an edible nest swiftlet's diet.

The utilization of specific diet materials in swiftlet breeding, mainly focusing on comparing organic waste and a combination of commercial chicken pellets with bran, presents a crucial consideration for swiftlet breeders. Analyzing the cost-benefit aspects of these diet materials becomes imperative to guide breeders in making informed decisions. Utilizing organic waste for breeding BSF larvae may be cost-effective due to its availability. However, the nutritional content may vary, and the long-term sustainability of this approach needs assessment. While the mixture of commercial chicken pellets with bran might incur additional costs, the potential increase in nutritional value could justify the investment. The improved nutritional profile may contribute to swiftlet health and overall breeding success. Although organic waste is a natural and sustainable resource, the present study suggests that the nutritional content of BSF third-instar larvae and pupae bred on this substrate is inferior to those bred on a combination of chicken pellets and bran. The results indicate that combining chicken pellets with bran enhances the nutritional content of BSF larvae and pupae; this implies potential benefits in improved swiftlet health, reproductive success, and the quality of edible nests. While organic waste may provide a low-cost option, its sustainability and consistent nutritional quality need scrutiny. Fluctuations in nutrient availability may impact the long-term success of swiftlet breeding operations. Investing in a more nutritious diet may contribute to the long-term viability of swiftlet breeding programs. The potential improvement in swiftlet health and reproductive outcomes could outweigh the initial cost considerations.

This study hints at the possibility of using third-instar larvae of BSF bred on a diet of chicken pellets and bran as an edible nest swiftlet's diet. This potential shift in dietary practice could offer additional benefits, such as enhanced nest quality and increased swiftlet population. In conclusion, while the initial costs of utilizing a mixture of chicken pellets with bran may be higher, the potential long-term benefits of enhanced nutritional content and breeding success outweigh the expenses. Swiftlet breeders should carefully evaluate the cost-effectiveness and sustainability of their chosen diet materials, considering both short-term and long-term implications for the health and productivity of their swiftlets and the quality of the edible nests produced.

CONCLUSION

Black soldier fly (BSF, *H. Illucens)* third-instar larval stage fed with a mixture of commercial chicken pellets and rice bran had the highest crude protein, fat, and energy content. Pupae fed with a mixture of commercial chicken pellets and bran had the highest mineral and calcium content. As consideration for breeding material, commercial chicken pellet mixtures can increase the nutritional content of BSF in the third-instar larvae and pupae stages.

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