Performance and Nutritional Composition of Black Soldier Fly Larvae on Cattle Rumen Content Wastes in Ilorin, Nigeria

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Abstract

This study evaluated the performance and nutritional composition of black soldier fly larvae (BSFL) reared on cattle rumen content (CRC) wastes in Ilorin, Nigeria. Fresh CRC was collected, processed, and used either alone (CRC_{100}) or mixed 1:1 with fruit wastes (CRC_{50}). A commercial broiler starter feed (CF) served as a control. Six-day-old larvae were reared under a completely randomized design with three treatments, each replicated ten times. Survival rates exceeded 85% across all treatments, with no significant differences ($p>0.05$). However, larval weights were highest on CF, followed by CRC_{50}, and lowest on CRC_{100} ($p<0.05$), indicating enhanced growth when CRC was combined with fruit wastes. Proximate analysis revealed that 15-day-old larvae reared on CRC-based substrates had crude protein contents (44.68 - 44.91%) comparable to conventional protein sources, but moderate nitrogen-free extract levels, suggesting moderate energy supply. The results show that CRC, especially when blended with fruit wastes, can yield protein-rich BSFL suitable as livestock feed, while also promoting sustainable waste valorization.

Keywords: *Black Soldier Fly, Rumen content, Micro-livestock, Sustainable Food Systems*

Description of Problem

In the quest for sustainable food and feed production, various insect species are being farmed as micro-livestock because of their potential to close critical resource gaps. Among these, the black soldier fly (BSF), *Hermetia illucens* L. has garnered significant attention due to its remarkable ability to thrive on livestock manure, food scraps and diverse other organic wastes, including (1). Black soldier fly larvae (BSFL) meal is rich in high-quality protein with a well-balanced amino acid profile, making it an excellent supplement for animal feed (2). However, studies have demonstrated that its nutritional composition is strongly influenced by type of rearing substrate (3). Also, not all organic wastes support optimal larval development (4). In Nigeria, local abattoirs generate large quantities of rumen content daily (5) that are often disposed improperly, leading to environmental pollution. Information on the suitability of rumen content wastes for rearing high-quality BSFL for livestock feed is scant in Nigeria. This study, therefore, assessed the performance and nutritional composition of BSFL reared on cattle rumen waste in Ilorin, Nigeria.

Materials and Methods

The study was conducted in the Faculty of Agriculture, University of Ilorin, Ilorin, Nigeria. Fresh cattle rumen content (CRC) was collected from a local abattoir. The waste was dewatered, air-dried for two weeks and then stored until needed. Two types of CRC-based substrate treatments were produced for rearing BSFL in the study. The first, tagged CRC_{100}, comprised only cattle rumen content while the second, tagged CRC_{50}, consisted of a mix of CRC and fruit wastes in the ratio 1:1. The fruit waste (mainly peels of watermelon, pineapple and orange) used was collected from local markets in Ilorin, washed, milled and airdried to constant weight and then stored until needed. A commercial broiler starter feed (CF) was

included as a high-quality reference treatment (6) for comparison.

BSF eggs were obtained from a commercial farm and reared on a broiler starter feed slurry for six days. The six-day-old larvae (6-DOL) were used to initiate the experiment. The study followed a completely randomized design with three treatments (CRC_{100}, CRC_{50} and CF), each replicated ten times. Each experimental unit comprised a 10L plastic bowl (33 cm top diameter, 26 cm base diameter, 12 cm height) containing 200 g of the assigned substrate and hundred 6-DOL. Substrates were replenished on days 5 and 10 after setup, when larvae were 11-DOL and 15-DOL, respectively. Before each replenishment, larval survival was recorded, and average larval weight was measured. Additionally, five larvae were randomly sampled per unit for proximate analysis (7).

Larval survival data were expressed as percentages per treatment replicate at each growth stage. Percentage survival, average weight, and proximate composition were analyzed using one-way ANOVA at a 5% significance level. When assumptions of homogeneity of variance were met, Tukey's Honestly Significant Difference (HSD) test was used for mean separation. All statistical analyses were conducted using relevant packages in R version 4.3.1 (8).

Results and Discussion

Percentage survival of BSFL on CRC_{100} and CRC_{50} rearing substrate treatments was generally above 85% and was comparable (p>0.05) to the control treatment at both the 11-DOL and 15-DOL stage of development (Table 1) indicating that the wastes contain nutrients useful for BSFL growth. This aligns with (9) who reported percent survival range of 85 – 92% on fruit and vegetable wastes in India. Nevertheless, the mean weight of 11-DOL (0.15 g) and 15-DOL (0.27 g) reared on the control substrate was significantly more (p<0.05) than those of larvae reared on either CRC-based substrate at the same time point (Table 2). Similarly, 15-DOL reared on CRC_{50} gained significantly more (p<0.05) weight (0.18 g) than those reared on CRC_{100} (0.13 g). This observation suggests that the nutritional composition of cattle rumen content was enhanced by mixing it with fruit wastes. Unlike single substrates, blends of two or more substrates help balance nutrients thus improving BSFL growth and development (10).

Table 1. Survival of black soldier fly larvae reared on cattle rumen content waste-based substrates in Ilorin, Nigeria

Substrates	Mean larval survival (%)	
	11-day old larvae	15-day old larvae
CRC_{100}	100.00^{a}±0.00	86.00^{a}±4.95
CRC_{50}	100.00^{a}±0.00	87.40^{a}±4.22
CF	100.00^{a}±0.00	86.80^{a}±7.16

Values (mean ± standard deviation) in a column following by the same letter(s) are not significantly different at α = 0.05 according to Tukey's Honestly Significant Difference test; CF: Chicken feed (control); CRC: Cattle rumen content waste; CRC_{50}: Cattle rumen content waste and fruits waste at ratio 1:1

Table 2. Mean weight of Black Soldier Fly Larvae reared on cattle rumen content waste-based substrates in Ilorin, Nigeria

Substrates	Weight per larva (g)	
	11-day old larvae	15-day old larvae
CRC_{100}	0.08^{b}±0.08	0.13^{c}±0.00
CRC_{50}	0.10^{b}±0.02	0.18^{b}±0.02
CF	0.15^{a}±0.02	0.27^{a}±0.01

Values (mean ± standard deviation) in a column following by the same letter(s) are not significantly different at α = 0.05 according to Tukey's Honestly Significant Difference test; CF: Chicken feed (control); CRC: Cattle rumen content waste; CRC_{50}: Cattle rumen content waste and fruits waste at ratio 1:1

The proximate composition of 11-DOL and 15-DOL BSFL reared on the three substrate treatments (Table 3) also shows significant variations in nutrient composition. For 11-DOL, percentage crude protein value in the control (43.01%) was significantly higher ((p<0.05) than for BSF reared on CRC_{50} (41.50%) and CRC_{100} (37.45%). For 15-DOL, percentage crude protein in larvae reared on CRC_{100} (44.91%) and CRC_{50} (44.68%) was significantly higher (p<0.05) than on the control (38.88%). These values are comparable to the CP of BSFL reared on Brewer's Grains, yeast and fish trimmings (11) or on food wastes (6); (12). In

contrast, 11-DOL reared on CRC_{100} had the highest (p<0.05) nitrogen free extract value (33.02%) while the lowest (17.89%) was recorded in larvae reared on CRC_{50}. Conversely, 15-DOL reared on the control substrate had significantly higher (p<0.05) nitrogen free extracts value (31.18%) compared to larvae reared on CRC-based substrates.

Table 3: Proximate composition of black soldier fly larvae reared on cattle rumen content in Ilorin, Nigeria

BSF larvae	Proximate Composition (%)					
	Moisture	Crude Protein	Crude Fat	Crude Fibre	Ash	Nitrogen Free Extract
11-DOL on CRC_{100}	$9.09^{b} \pm 0.02$	$37.45^{c} \pm 0.01$	$6.11^{c} \pm 0.01$	$7.63^{c} \pm 0.01$	$6.72^{b} \pm 0.03$	$33.02^{a} \pm 0.04$
11-DOL on CRC_{50}	$14.24^{a} \pm 0.01$	$41.50^{b} \pm 0.07$	$9.62^{a} \pm 0.01$	$9.88^{b} \pm 0.03$	$6.88^{c} \pm 0.01$	$17.89^{c} \pm 0.09$
11-DOL on CF	$7.12^{c} \pm 0.02$	$43.01^{a} \pm 0.02$	$9.42^{b} \pm 0.03$	$10.52^{a} \pm 0.01$	$7.62^{a} \pm 0.01$	$22.32^{b} \pm 0.01$
15-DOL on CRC_{100}	$8.89^{a} \pm 0.04$	$44.91^{a} \pm 0.03$	$9.09^{b} \pm 0.01$	$10.15^{b} \pm 0.00$	$7.54^{b} \pm 0.02$	$19.43^{b} \pm 0.04$
15-DOL on CRC_{50}	$8.02^{b} \pm 0.07$	$44.68^{b} \pm 0.04$	$10.43^{a} \pm 0.01$	$10.23^{a} \pm 0.02$	$7.26^{c} \pm 0.00$	$19.37^{b} \pm 0.01$
15-DOL on CF	$6.84^{c} \pm 0.02$	$38.88^{c} \pm 0.03$	$5.97^{c} \pm 0.01$	$7.96^{c} \pm 0.01$	$9.19^{a} \pm 0.01$	$31.18^{a} \pm 0.04$

Values (mean ± standard deviation) in a column followed by the same letter(s) are not significantly different at α=0.05 according to Tukey's Honestly Significant Difference test. DOL: Day old larvae; CF: Chicken feed (control); CRC: Cattle rumen content waste; CRC_{50}: Cattle rumen content waste and fruits waste at ratio 1:1

These results show that rearing BSFL only rumen content wastes or a blend of rumen content and fruit wastes, yield larvae with high protein content comparable with some traditional protein-based feed ingredient including soybean meal and groundnut cake with 44 – 48% CP and 38 – 48% CP, respectively (NIAS, 2024). Nevertheless, the generally low crude fibre but moderate nitrogen free extract composition of larvae reared on the different rumen content-based substrates indicate that they have high digestibility but would supply moderate energy. Consequently, their use must be paired with higher-energy ingredients for optimal animal performance (13); (14).

Conclusion and Application

Black soldier fly demonstrates how micro-livestock can convert waste into valuable resources, tackling the interconnected issues of food security, feed shortages, and environmental sustainability. Using cattle rumen content provides a sustainable method for rearing black soldier fly larvae as livestock feed in Nigeria, but its full potential is best realized when combined with other low-cost, readily available organic wastes, such as fruit wastes, to produce nutritionally optimal larval biomass.

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