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Management of Kitchen Waste Material Through the Use of Black Soldier Fly Larvae (*Hermetia illucens*) for Sustainable Waste Management and Availability of Feed for Livestock

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Abstract

Using black soldier fly larvae (BSFL) to manage and treat biodegradable waste, such as kitchen waste, is a promising and sustainable method for handling organic waste generated from homes, schools, farms, and industries. While feeding on this waste, the black soldier fly larvae grow and increase in biomass, which can then serve as feed for livestock, including poultry and fish. A total of 50 larvae, each weighing 0.10 g and 10 days old, were inoculated into a plastic container of specified dimensions and fed with 50 g of kitchen waste (substrate). The number of black soldier fly larvae decreased from 50 to 37, with a total weight of 1.3 g, while the substrate (50 g) reduced to 18.32 g (frass). The proximate and chemical composition analysis yielded the following results: moisture content at 71%, ash content at 2.32%, crude protein at 18.40%, crude fiber at 1.34%, crude fat at 2.28%, and carbohydrates at 4.2%. Among the minerals, calcium was recorded at 476.30 mg/100 g, phosphorus at 126.30 mg/100 g, potassium at 545.80 mg/100 g, sodium at 65.40 mg/100 g, magnesium at 124.60 mg/100 g, iron at 5.75 mg/100 g, zinc at 4.60 mg/100 g, copper at 0.16 mg/100 g, and manganese at 0.12 mg/100 g. For vitamins, vitamin B1 was measured at 0.19 mg/100 g, vitamin B2 at 1.60 mg/100 g, and vitamin E at 1.10 mg/100 g. The results obtained during the feeding of the larvae indicate that BSFL has the potential to reduce organic waste to frass, which can serve as a biofertilizer. Most of the proximate and chemical composition values are consistent with those found in BSFL fed with other substrates, and they meet the nutrient requirements of most livestock feeds. The proximate, mineral, and vitamin composition of BSFL under investigation suggests that BSFL fed with kitchen waste could be a valuable and promising feed source for the livestock industry.

Keywords

Black Soldier Fly Larvae; Biodegradable; Kitchen Waste; Proximate; Chemical Composition

1. Introduction

The black soldier fly (BSF), *Hermetia illucens*, is a valuable insect species whose larvae have many potentials for converting organic waste into compost, and the larvae biomass generated could also be harvested for its protein and fatty acid content [1].

The larva-feeding behavior also discourages the clustering of pest flies (Pest control). The waste generated becomes

useful as fertilizer (biofertilizer). The residue from black soldier fly larvae (BSFL) decomposition is similar to compost, contains nutrients and organic matter, and, when used in agriculture, helps to reduce soil depletion.

Solutions for waste disposal are being sought, and some of those proposed (already in practice) are to use the waste palm kernel shells and palm press as biofuel to create steam used in the oil palm mill processes or the creation of mulch from empty fruit bunches and ash to be reused as fertilizer, both of which lead to self-sufficiency, sustainability and improved net energy balance of the oil palm mills [2, 3].

According to [4] Nigeria generates 542.5 million tons of organic waste per annum, and waste is fast becoming a menace in many urban centres. Black soldier fly larvae (BSFL) have large and powerful chewing mouthparts allowing them to shred and devour waste.

Kitchen waste is any kind of rubbish produced during your commercial kitchen activities—such as preparing food, cleaning plates and equipment, and dealing with customers' leftovers. Food waste is the main type of kitchen waste, but other products and materials also make up such waste, including packaging, equipment, and more. The study is chosen considering the fact that management of kitchen waste is of great importance from the point of view of a healthy quality of environment.

The main objective of the study is to evaluate the feasibility of black soldier fly larvae to digest and degrade waste in a laboratory experiment in the Entomology division, NIFOR that will result in the utilization of waste material into useful products and explore the benefits and limitations of this technology.

2. Materials and Methods

2.1 Collection of Materials

Kitchen waste material was collected from houses, then sun-dried and ground into powder form. This grinded waste material was subjected to aerobic composting to initiate microbial activity. Moisture content was maintained at 60% to 70% and the mixture was kept in a plastic container covered with paper having holes to facilitate aeration in order to get the final composted material. The mixture was hand manipulated at regular time intervals and remoistened for sufficient microbial activity [5].

2.2 Collection and Introduction of BSFL

When the temperature became constant and the color of the kitchen waste turned brown to black, it was used as a substrate for feeding BSFL. BSFL was obtained from the Entomology division NIFOR. 50 larvae of 10 days old were introduced in a small plastic container containing about 50 g of substrate.

During the course of the investigation, samples were examined every 48 hours for 21 days of composting

2.3 Data Collection

Data was collected on the initial weight of substrate (g), the initial number of BSFL, the number of BSFL after, the initial weight of BSFL (g), the weight of BSFL after (g), and the weight of substrate after.

2.4 Proximate and Chemical Composition Analysis

The BSFL that was reared to prepupae with the substrate (kitchen waste) was collected at the end of the experiment and was analyzed for its proximate and chemical composition following the method [6].

3. Results and Discussion

3.1 Larvae Management and Composting on BSFL

As shown in Table 1, the substrate weighing 50g was degraded or reduced to 18.32g by the BSFL. The number of BSFLs introduced during the experiment reduced to 37 from 50, while the weight of the BSFL increased to 1.30g from an initial weight of 0.10g within 21 days of the experiment.

The experiment affirmed that black soldier fly larvae have the potential to convert organic waste into high-value products (biofertilizer) and in return the organic waste such as kitchen waste will increase the biomass of the black soldier fly larvae. The larvae possessed the ability to valorized organic waste (kitchen waste) which is a potential benefit for developing countries like Nigeria. This conforms to the work of [7].

The results of the proximate and chemical composition of BSFL in this study is a confirmation of its utilization as an

ingredient for animal feeds which has gained considerable interest recently. This observation is similar to the reports of [8], who reported the crude protein, crude fibre, ash content, and fats of wild black soldier fly larvae. He further stated the mineral and vitamin content of wild black soldier fly larvae, which is similar to the findings of this study.

Figure 1. 0-1 hour of introduction of BSFL.

Figure 2. 24 hours of introducing BSFL

Figure 3. 240 hours of introduction of BSFL.

Figure 4. S400 hours of introduction of BSF.

Table 1. Impact of composting on BSFL

Initial weight of substrate (g)	Initial weight of larvae (g)	Initial number of larvae	Final weight of substrate (g)	Final weight of larvae (g)	Final number of larvae
50.00	0.10	50	18.32	1.30	37

Table 2. Proximate analysis of BSFL fed with kitchen waste for 21 days

S/N	Parameters	BSFL	Units
1	Moisture content	71.30	g/100g
2	Ash content	2.32	g/100g
3	Crude fibre	1.34	g/100g
4	Crude fat	2.28	g/100g
5	Crude Protein	18.40	g/100g
6	Carbohydrate	4.20	g/100g

Table 3. Mineral contents of BSFL fed with Kitchen waste for 21 days

S/N	Minerals	BSFL	Units
1	Potassium (K)	545.80	Mg/100g
2	Sodium (Na)	65.40	Mg/100g
3	Calcium (Ca)	476.30	Mg/100g
4	Magnesium (Mg)	124.60	Mg/100g
5	Phosphorus (P)	126.30	Mg/100g
6	Nitrogen (N)	2.94	Mg/100g
7	Manganese (Mn)	0.12	Mg/100g
8	Iron (Fe)	5.75	Mg/100g
9	Zinc (Zn)	4.60	Mg/100g
9	Copper (Cu)	0.16	Mg/100g

Table 4. The vitamin content of BSFL fed with kitchen waste for 21 days

S/N	Vitamins	BSFL	Units
1	Vit. B1	0.19	Mg/100g
2	Vit. B2	0.60	Mg/100g
3	Vit. E	1.01	Mg/100g

4. Conclusion

The work indicated the possibilities of recycling organic waste such as kitchen materials by using this waste to feed the BSFL. By doing so the BSFL builds its body composition of protein, fat, minerals, and other vital nutrients required for feed production. This system could be a sustainable method of organic waste management and a way to provide the livestock industry with nutrients for livestock farming especially now that the cost of grains and soybeans are on the very high side.

However, there is a need to always examine the nutrient content or composition of these waste materials as the quality of substrates may probably influence or determine the growth, nutrients, and biomass of the black soldier fly larvae.

Currently, more work is ongoing on BSFL in the Entomology division, NIFOR, to determine its use in palm oil mill effluent (POME) management, as well as feeding poultry birds with BSFL raised with different substrates and a lot more.

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