Advanced and Sustainable Technologies (ASET) eISSN 2976-2294
*Volume 3 (Special Issue), March 2024 [57-62]*

# Bioconversion of Agro-Wastes by Black Soldier Fly Larvae

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Received 25 September 2023, Revised 5 October 2023, Accepted 15 October 2023

**ABSTRACT**

*The utilization of Black Soldier Fly larvae (BSFL) in agro-waste bioconversion is becoming popular due to its potential to reduce waste volume and produce protein and lipids from the larvae. This research was carried out to evaluate the capacity of BSFL to biologically convert different types of selected plant and animal-based agro-wastes. The assessment of the BSFL growth (diameter, length, and weight) was recorded. Results indicated that BSFL were capable of digesting goat manure, banana, and cabbage, though the respective digestion rates differed. The waste reduction capacity ranged from 21.82 % - 36.74 %, with the highest achieved with banana and the lowest was goat manure. The highest growth rates of BSFL in terms of weight, diameter, and length were achieved by digesting cabbage waste, followed by banana and goat manure. There is a high potential to utilize BSFL in agro-waste management due to its eco-friendly and sustainable method.*

**Keywords:** Black Soldier Fly larvae, bioconversion, agro-waste, biosolids.

## 1. INTRODUCTION

The rapid population growth of the world has accelerated waste production of over 30 million dry tonnes of biowastes annually [1]. Most of these wastes are being conventionally treated by landfilling, incineration, and composting [2]. These methods may lead to health threats and environmental issues such as methane gas emissions [3] and leachate problems [4]. Thus, there is a pressing need to develop alternative waste management methods that are more sustainable and environmentally friendly. Consequently, biological treatments were developed as potential alternatives to organic waste conversion, minimizing the amount sent to landfills. Among biological treatments, bioconversion is one of the most promising alternatives with prospects of nutrient recovery as well as turning organic wastes into useful by-products.

Bioconversion utilizes enzymes, microbes, or other biological agents to transform wastes into valuable products such as bioethanol, biodiesel, and feedstock. Besides, the biological process involved in bioconversion is naturally-occurred. With the aid of biocatalysts, the whole process is environmentally acceptable. Bioconversion also provides environmental and economic benefits by providing greater disposal capacity, reducing the hazardous gas emissions from landfills, reducing the fouling problem for recyclables, and remediating ecological disasters.

In this context, Black Soldier Fly (BSF) is the best candidate for biodegradation as it is not a pest and does not transmit pathogens. Black Soldier Fly larvae (BSFL) are currently being successfully used to convert agro-wastes into insect larval biomass and organic composts. BSFLs are capable of decaying a great variety of organic matter, including human feces, animal manure, and rotting plant material [5]. [6] have studied the ability of BSFL to reduce *Escherichia coli* in dairy manure. The result shows that the prepupae weight and the ability to reduce the *E. coli* population are

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significantly affected by the quantity of manure fed to the black soldier fly larvae. In a research conducted by [7], three different diets were included in a mixture of vegetable, fruit waste, and fish waste. The results show that the reduction of organic waste by BSFL for vegetable : fruit waste mixture, vegetable: fruit: fish mixture, and fish waste was 51.91% (33.29 mg/larva.day), 48.73% (27.32 mg/larva.day) and 39.91% (20.73 mg/larva.day) respectively. [2] presented an evaluation of the feasibility of bioconversion of food waste from a campus cafeteria with BSFL in terms of economic, social, and biological aspects. [8] have evaluated the capability of BSFL to consume and decompose mixed municipal solid waste. Thus, these prove that BSFL can reduce organic wastes efficiently both in terms of weight or volume. Moreover, the degradation of organic solid wastes by BFSL can also be an alternative to nutrient recovery. The BSF pupae can be harvested and processed to produce fat and protein [9]. The protein can be used as feeds for livestock or fish, while the fat can be used as raw material to produce biodiesel.

This research was conducted to evaluate the capacity of BSFL to perform bioconversion of different types of local agro-wastes comprising vegetables, fruits, and animal feces. The weight reduction of the waste, as well as the BSFL growth feeding on these wastes, were observed and analyzed.

## 2. MATERIAL AND METHODS

### 2.1 Source of Larvae and BSF Rearing

In this study, rotten banana was used as the attractant to attract the adult BSF. The adult BSF were attracted to the rotten banana inside the trapper, which was made of a transparent bottle. The insect trapper comprises entrance holes to allow the BSF to fly into the trapper. A stack of corrugated cardboard was hung in the middle of the trapper to provide a confined space for the female ovipositor [10]. Then, the insect trapper filled with rotten bananas was placed in an open area near the dump site.

The eggs of BSF were collected from the corrugated cardboard and transferred into larvarium, a cage for larvae to grow to full size [11]. The larvarium was built outside and covered to provide an optimum environment for the growing condition. Thus, the temperature and humidity were monitored to be in a range of 27 - 33°c and 65 - 75%. The medium for larval growth was kept in a moist condition for the larvae to grow [10].

(a) (b)

**Figure 1:** The (a) BSF trap and (b) larvarium area.

## 2.2 Feed Substrate Preparation

The collection of agro-waste is done before the feeding step. The goat manure was collected from the nearby barn and taken to the laboratory immediately. This is to prevent bacteria and fungus degradation in the manure [10]. Meanwhile, the rotten banana and cabbage were collected from a nearby wet market and shredded into small pieces to increase the surface area on which the BSFL can feed on [10].

100g of goat manure, processed rotten banana, and rotten cabbage were filled into three transparent containers. Each type of waste was replicated thrice, and they were fed by batch. Each of the containers was designed to have some holes for air circulation, facilitating gas exchange [10]. 100 BSFLs, which have been grown to medium size in larvarium, were placed into each container and allowed to grow until they reached the prepupal stage.

## 2.3 Analysis of Waste Reduction and Larvae Growth

### *2.3.1 Waste Reduction Capacity*

The capacity of BSFL was determined by waste reduction percentage. Thus, the initial weight of the wastes ($w_i$) was recorded at the start of the feeding. Then, on the final day, the larvae turned into prepupae (t), and the final weight of the waste ($w_f$) were also recorded. The waste reduction percentage was calculated using the following equation (1);

$$Percent\, Waste\ Reduction = \frac{w_i - w_f}{w_i}\ x\ 100\% \qquad (1)$$

### *2.3.2 Larvae Growth*

The life cycle of the BSF is presented in Figure 2. Since the life cycle of BSF is only around 40 days, daily observations and measurements were performed for weight, length, and diameter. On a random basis, 10 larvae were chosen for measurement for every container. Forceps were used for grasping or holding the BSFL, while the length and diameter of the middle part of the larvae were measured using a digital vernier caliper. The weight of individual larva was measured using an analytical balance of two decimals.


**Figure 2:** The life cycle of the black soldier fly (Source: Alvarez, 2012).

## 3. RESULTS AND DISCUSSION

### 3.1 Waste Reduction Capacity of the BSFL

Figure 3 illustrates the percentage of waste reduction of different types of waste. The result showed that the highest waste reduction was recorded with bananas at 36.74%, followed by cabbage at 33.28%. Whereas, the lowest waste reduction was achieved in goat manure with 21.82%. This finding is lower than the values given by [2], reporting more than 50%, [8] reporting 65-75%, and [11] reporting 78%, which was observed from various types of waste streams.

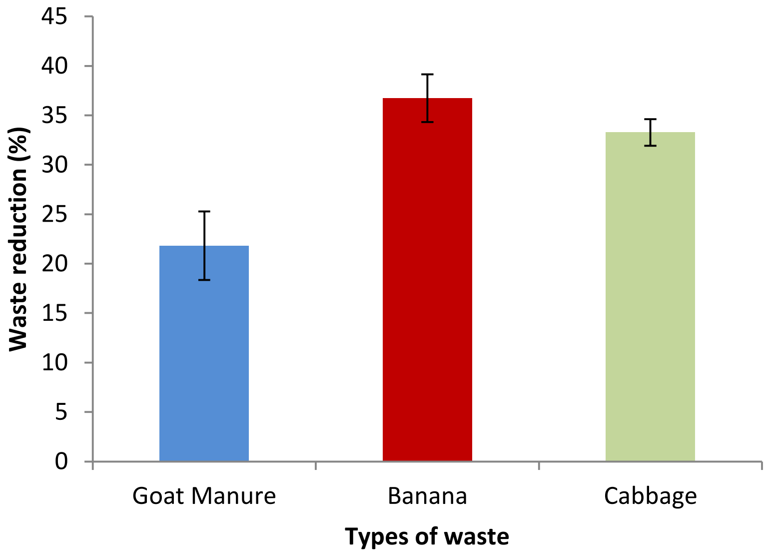
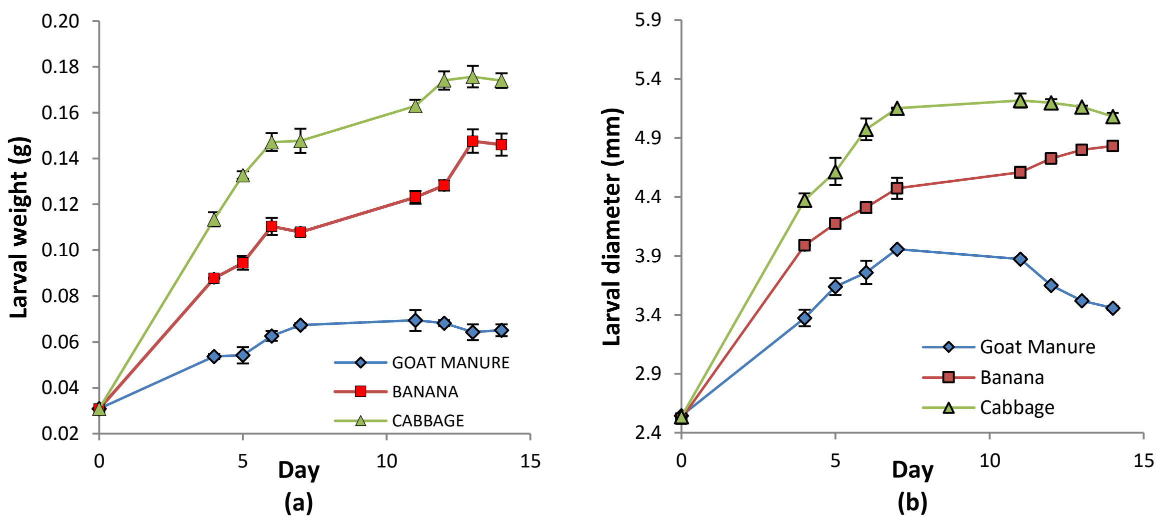



**Figure 3:** Percentage of waste reduction against types of waste.

### 3.2 The Larval Growth Rate

The growth performance of the BSFL feeding on different types of waste has been performed for two weeks. The growth of BSFL feeding on different types of waste is presented in Figure 4, which includes larval weight, diameter, and length.



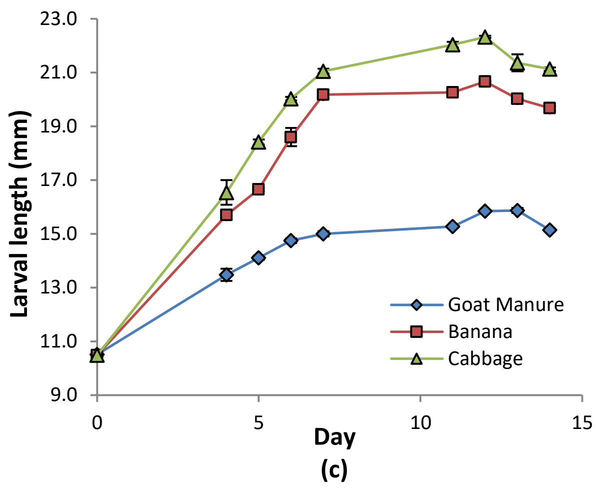



**Figure 4:** The growth of larvae over 14 days (a) larva weight (b) larva diameter (c) larva length.

From Figure 4(a), the highest final larval weight was registered by the cabbage (0.174 g) and then followed by the banana (0.146 g). The goat manure recorded the lowest final larval weight (0.065 g). Figure 4(b) shows the BSFL fed on cabbage recorded the highest final larval diameter, which is 5.081mm, followed by banana with 4.832 mm, while the lowest final larval weight was by the goat manure (3.458 mm). Figure 4(c) shows that the highest final larval length was achieved by the cabbage (21.13 mm), followed by the banana (419.68 mm), and the lowest final larval weight was recorded by the goat manure (15.14 mm).

The growth of BSFL in cabbage and banana is significantly higher than that of goat manure. According to [7], this might be due to the nutritional contents which were easily derived from vegetables and fruit waste. This condition was important to support the larvae's metabolism; thus, the larval growth accelerated. Moreover, the cabbage and banana have an optimal C/N ratio in performing waste decomposition. This is important for accelerating the larvae metabolism as the carbon acts as an energy source for growth.

The lower growth rate of BSFL fed on goat manure can be explained by the incompatibility of goat manure, which has lower nutritional value and fibrous material that is hard to digest [12]. The feeding efficiency is reduced due to the high cellulose, hemicellulose, and lignin ratio in goat manure. The cellulosic materials were largely bounded by lignin. Thus, the organic compound became highly resistant to biological breakdown. Even though goat manure is a good source of nitrogen, it is low in carbon content, which is important for supporting larval metabolism.

## 4. CONCLUSION

In conclusion, the BSFL can digest different types of agro-waste, including vegetables, fruits, and animal wastes. However, the waste degradation rate is varied by the kind of waste. This research showed that banana and cabbage degrade faster than goat manure. Furthermore, the BSFL had the highest growth by digesting cabbage, followed by banana and goat manure waste.

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