The Potency of BSF Maggot Culture for Green Economic Resilience

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Abstract. The Green Economy is a program created to establish a sustainable economy based on environmental protection through various measures. This green culture has developed in recent decades due to the increasing shared awareness of sustainable practices. This is done in order to be able to provide a decent standard of living for all people, by increasing rapid economic growth, and also meeting sustainable inclusive aspects. The use of black soldier fly maggot in organic waste treatment can be used as a solution for tropical countries with low and medium income to reduce the side effects of climate change caused by the low value of sustainable sanitation and infrastructure. In this paper, the authors used a systematic literature review methodology to identify and critically review relevant research findings to collect and analyse data according to the principles of the Cochrane Manual of Systematic Evaluation of Interventions and the Preferred Reporting Item Statement for Systematic Review and Meta-analysis (PRISMA). This research aims to identify all empirical evidence that fits the pre-specified inclusion criteria to explains the terminology of the green economy, the importance of black soldier fly maggot in the green economy program, and the potential of black soldier flies in sustainable economic improvement. A review of the literature indicates the effective potential of black soldier maggot in energy conversion and decarbonization for profitable economic activities.

Keywords: green economy · bsf · maggot

1 Introduction

Maggots have been used for centuries as a food source for animals and humans alike. In recent years, there has been a growing interest in using maggots as a sustainable and environmentally friendly way to recycle organic waste. Black soldier fly (BSF) maggot, *Hermetia illucens* (L., 1758) (Diptera: *Stratiomyidae*), offer a cost-effective potential alternative for recycling biological waste. The flies can be found tropical and subtropical as well as some temperature zones. Adult flies do not have mouthparts, stingers or digestive organs and are thus incapable of attacking and feeding [1, 2]. This in turn means that even if black soldier flies get in contact with food, they, unlike house flies, do not transmit pathogens from waste to humans [3–5].

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BSF maggot culture is a process that uses the larvae of the black soldier fly to break down organic waste. This method is more efficient than traditional composting methods, due to the speed at which BSF maggots can consume and breakdown organic matter. Not only does this process create nutrient-rich compost, but it also reduces greenhouse gas emissions associated with traditional methods of waste disposal such as landfill or incineration [6]. The use of BSF maggot culture offers many benefits for both individuals and businesses looking to reduce their environmental impact. For businesses, implementing a BSF system can help meet sustainability goals and improve public perception. For individuals, using BSF Maggot Culture helps reduce household waste while creating nutrient-rich compost for gardening purposes [7].

In many parts of the world, small-scale farmers struggle to make a living due to low crop yields and lack of access to markets. BSF maggot culture could provide a much-needed boost to rural economies by creating new opportunities for income generation. In addition, the use of BSF maggot as animal feed can help reduce pressure on natural resources, as they require less land and water than traditional livestock production systems [8].

In addition, the ability of black soldier fly maggot to consume organic waste can occur due to the presence of cellulosic bacteria in the digestion of BSF maggot. The presence of these cellulosic bacteria will produce cellulose enzymes that will convert lignocellulosic and nutrients in organic matter into protein and fat in the biomass produced by the maggot. This biomass can be used as fertilizer or animal feed which is very high in nutrients. The use of black soldier fly (BSF) maggot culture is an efficient method of breaking down organic matter, making it an ideal solution for green economic resilience [9].

According to Newton [10], BSF maggot also have a very high fertility rate and good tolerance to growth media which makes them able to be developed in various growth media with maximum results. A high fertility rate is essential to ensure that the developed BSF maggot will benefit from the costs incurred in treatment. Feeding cassava peel to black soldier maggot weighing 200mg/larva/day is the optimal treatment option because it produces a biomass product of 1.54mg/day and a residue of 67.1mg/day. This treatment resulted in a survival ratio that reached 100% and protein and fat content that had reached the SNI standard [11].

According to research conducted by Lalander and Nguyen [12, 13], BSF flies have the potential to convert solid waste, pig farm waste, household waste, organic waste and reduce the half-life of various substances such as nitrogen and phosphorus. The maggot of black soldier flies (BSF) are voracious eaters and can convert organic waste into valuable nutrients that can be used to support livestock production. Not only is BSF maggot culture environmentally friendly, but it also has the potential to generate income and create jobs in rural communities.

Nevertheless, the literature lacks insight into the perspectives of various stakeholders. At the same time, there is no information on stakeholder perspectives on what an enabling environment for BSFL-based animal feed production should look like. Enabling environments include practices, policies and attitudes that encourage people to act and help them succeed. For his BSFL production for use in animal feed to reach its potential to meet environmental sustainability goals, it is important to develop an enabling environment.

2 Literature Studies

Analysis was performed according to the principles of the Cochrane Manual of Systematic Evaluation of Interventions and the Preferred Reporting Item Statement for Systematic Review and Meta-analysis (PRISMA). A systematic literature search was performed using a combination of the following search terms: bugs; insect; Black soldier flies; *H. illucens*; Agriculture. The document search strategy is complemented by manual search. To avoid selection bias, the following predefined inclusion criteria were used: 1) Presence of a control group excluding BSF; 2) protein source(s) in the control diet replaced with BSF; 3) studies that investigated the effects of BSF on growth performance (SGR, FCR and/or feed intake) or nutrient utilization (ADC protein and PER) and energy utilization; 4) reported standard deviation or mean of standard error and 5) written in English. Duplicate reports, proceedings and conference proceedings were not included. If a study included more than one control diet, the relevant BSF diet was compared separately to each individual control regimen. When a study with more than two treatments provided more than one comparison with a meta-analysis, those comparisons were coded individually.

2.1 Definition of Green Economy

A green economy is an economy that aims to reduce environmental risks and ecological scarcities. This can be done through a variety of means such as investing in renewable energy, improving resource efficiency, and protecting natural capital. A green economy also has the potential to create new jobs and spur economic growth [14].

The term green economy was first coined by Nicholas Stern in a 2006 report for the UK government. In general, a green economy can be thought of as one that is low carbon, resource efficient and socially inclusive. A key feature of a green economy is that growth in one sector does not lead to negative impacts in another – it is what economists call 'decoupled' growth. Green economies are based on three pillars: environmental sustainability, social inclusiveness, and economic productivity [14].

Environmental sustainability means making sure that natural systems can continue to provide the services we rely on, such as clean water and air, food production, flood protection, and climate regulation. It also means protecting biodiversity so that future generations can enjoy the benefits of a rich variety of life on Earth. Social inclusiveness ensures that all people have equitable access to the benefits of a green economy—including good jobs; safe housing; clean energy; healthy food; transportation options; education opportunities; and affordable healthcare. Economic productivity means creating value—generating wealth while using fewer resources and causing less pollution [15].

Achieving a green economy requires shifts in how we produce goods and services, how we consume them, how we manage our natural resources (land, water, forests) and how we generate power (from renewable sources instead of fossil fuels). Such changes will create new businesses opportunities and jobs while reducing greenhouse gas emissions and other forms of pollution. A green economy also offers considerable health co-benefits by improving air quality, for example [16].

The green economy is an important aspect of agriculture. It refers to the use of environmentally friendly practices to produce food and other agricultural products. This includes using renewable resources, such as solar and wind power, to minimize the impact on the environment. The green economy also promotes sustainable practices, such as crop rotation and organic farming, which help protect natural resources. The benefits of the green economy are numerous. It can help reduce greenhouse gas emissions, improve air quality, conserve water resources, and promote biodiversity. The green economy is an important part of creating a sustainable future for agriculture [17].

A green economy can help farmers to save money on inputs such as energy and water. Additionally, it can help them to increase their yields by using more efficient production methods. Furthermore, a green economy can create new markets for environmentally friendly products produced by farmers and provides opportunities for farmers to receive payments for environmental services that they provide, such as carbon sequestration or biodiversity conservation [18].

2.2 Black Soldier Fly Maggot

Hermetia illucens, also known as the Black Soldier Fly (BSF) is an insect endemic to the tropics and subtropics region of the Americas. But over time BSF flies can be found almost all over the world, such as in Europe, Africa, Oceania (Australia and New Zealand) and Asia (Indonesia, the Philippines, Japan, and Sri Lanka) as well as other countries located between latitudes 40° south and 45° north of the earth. Human migration and trafficking are among many of the factors that contribute to the spread of BSF throughout the world. BSF fly is a type of fly that is considered non-pest and identified as a holometabolous insect with the ability to perform complete metamorphosis (complete metamorphosis) [19].

The BSF, *Hermetia illucens* (L.) (Diptera: *Stratiomyidae*) is one of the most promising insect species to be cultivated in massive numbers due to its ability to convert organic waste material into biomass that can be used as feed for aquaculture species and poultry. Through this recycling process, organic matter can be fermented efficiently and effectively to produce superior products such as protein for animal feed, fat for bioenergy, and compost that can be used as fertilizer [20] (Fig. 1).

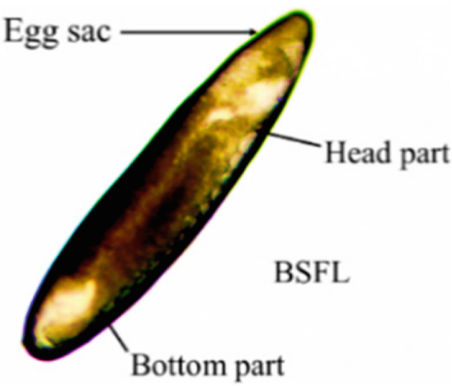

Fig. 1. Black Soldier Fly maggot encased in eggs under a 40x light microscope magnification [21].

According to Kim [22], BSF is a fly with saprophagous and polyphagous properties, which allows them to consume decaying materials and a wide variety of biomass. BSF which is in the family *Stratomyidae* grows in various colors from yellow, greenish black, and blue, and has a shape similar to that of bees and moths. Black Soldier Fly has a Larva life phase which consists of 6 stages called instars and develops for 14–22 days to accumulate bio mass. However, the formation of biomass is directly proportional to factors such as food media, and environmental factors. After experiencing the larval stage, the BSF will develop into the pre-pupa stage when the BSF stops consuming food and forms a pupa that has a hard surface. Pupation period will last for 14 days and young flies can live up to 10 days. The reproductive period will occur after 2 days of maggot reaching maturity and the female BSF fly will lay her eggs (oviposites) in small crevices or cracks on the surface that she can find.

The growth period of the BSF fly from birth to adulthood can take 40–43 days. Several studies showed that BSF maggot contained a fat fraction with components of lauric acid C12:0 as much as 38.43 wt%, palmitoleic acid C16:1 as much as 15.71 wt%, myristic acid as much as C14:0 12.33 wt%, oleic acid (trans fat) C18:1 as much as 8.81 wt% and C18:0 stearic acid as much as 2.95 wt% [23].

2.3 The Importance of Black Soldier Maggot in the Green Economy Program

BSF maggot as an alternative feed tends to be easy, economic, practical, and environmentally friendly. The use of maggot as an alternative feed is becoming more popular due to the many benefits it offers. Maggot is a high-protein food source that is easily digestible by animals. It is also a good source of essential amino acids and fatty acids. In addition, maggot contains high levels of chitin which can help improve gut health and immunity in animals [24].

The use of maggot culture for animal feed has been practiced for centuries in Europe and Asia. However, the use of black soldier fly maggot (BSFL) as animal feed is a relatively new practice that is gaining popularity due to its many benefits. BSFL are high in protein (45–50%) and fat (20–25%), making them an excellent source of nutrition for animals such as chickens, pigs, fish, cattle, and even humans. In addition, the exoskeletons left behind after the maggots have been harvested can be used as a valuable resource in the production of biochar [25].

The economic benefits of using maggot as an alternative feed are significant. BSF maggot production requires very little input in terms of water, land, or energy compared to other livestock feeds such as soybeans or corn. In fact, one study found that producing 1kg of dry maggots requires only 0.11 kWh of electricity compared to 3.6 kWh for soybeans and 5.4 kWh for corn. This makes maggot a very efficient and sustainable option for livestock farmers looking to reduce their costs while still providing their animals with a nutritious diet [26].

Maggot feed is also an important part of the waste management process and can be used as a renewable energy source. Maggots are feed on organic matter. They are commonly found in decomposing food waste. Maggot feed is created when maggots are allowed to feast on food waste, which breaks down the organic matter into a nutrient-rich slurry. This slurry can then be used as a fertilizer or soil amendment, or it can be converted into biogas through anaerobic digestion. Biogas is a renewable energy source that can be used to generate electricity or heat. This new system has many benefits over traditional methods of agriculture, including being more efficient in terms of land use and water use, as well as being more environmentally friendly [27].

BSF maggots have also been shown to be effective in breaking down plastic waste. A published study found that BSF maggot were able to degrade up to 80% of low-density polyethylene (LDPE) within 10 days. This finding could have important implications for reducing plastic pollution, as LDPE is one of the most common types of plastic used in packaging and other consumer products. Given the right conditions, a single pound of BSF maggot can eat up to half a ton of waste per day [28].

The use of maggots for bioremediation is a new and innovative approach with great potential for green economic resilience. BSF maggot culture is an effective way to clean up organic waste, including food waste, animal manure, and sewage sludge. This process can be used to recycle nutrients back into the soil, reducing the need for chemical fertilizers. Additionally, BSF maggot culture can be used to generate renewable energy through the production of methane gas. This technology has great potential to help communities become more self-sufficient and reduce their reliance on fossil fuels [29].

3 Results and Discussion

The Black Soldier Fly (BSF) is a species of fly that is known for its ability to decompose organic matter. BSF maggots are often used in the process of vermicomposting, which is the practice of using worms to break down organic waste. This process is considered to be more efficient than traditional methods of composting, and it produces a nutrient-rich soil amendment that can be used to improve plant growth. Maggot culture also has the added benefit of producing flies, which are an important food source for many birds and other animals.

In addition to their environmental benefits, BSF maggots also offer economic advantages. They can be raised on food waste, which would otherwise need to be disposed of at a cost. Additionally, the sale of vermicompost produced from BSF maggots can provide a source of income for farmers or others who engage in this type of agriculture. Given these multiple benefits, it seems clear that harnessing the power of BSF maggots could help promote green economic resilience.

There are several reasons why maggot culture is an effective tool for green economic resilience. It is a low-cost way to produce compost and improve soil health. It requires no fossil fuels or other inputs that contribute to climate change. Finally, maggot culture can help reduce waste by recycling organic materials that would otherwise end up in landfills or incinerators. When used properly, maggot culture can provide a number of benefits for both farmers and the environment.

Under the paradigm of insects as an alternative protein to mitigate the effects of climate change or rising populations, *H. illuscen*'s advantages might reasonably put it as the insect of choice, not only does it not compete with humans or livestock for food, or require significant environmental manipulation [30], but also it provides an economic and ecological service in processing the waste substrates that it feeds on. No other insect comes close to closing so many material flow loops and creating nearly self-sustaining food production cycles as BSFL, effectively making BSFL rearing on wastes a self-financing form of pollution reduction [31, 32]. BSFL thus show strong promise as part of a sustainable system with hydroponics or composting and aquaculture or poultry farming [33–35], particularly in situations where food choices would be extremely limited, such as space travel [34, 36] or the most pessimistic global food insecurity crises envisioned by population growth extrapolation [37].

BSF maggot culture is an important tool for green economic resilience. It is a form of waste management that can be used to recycle organic waste into valuable resources, has the potential to generate income from the sale of live animals, products derived from them, or by-products of the process. Additionally, BSF maggots are not susceptible to diseases that commonly affect other livestock, making them a safer option for recycling food waste. Finally, BSF maggots can be harvested and used as bait in fishing or as food for reptiles and amphibians; thus providing another source of income from this sustainable practice.

4 Conclusion

The potency of BSF maggot culture for green economic resilience is undeniable. Not only do they consume vast amounts of organic waste, but they also produce a high-quality protein that can be used as animal feed or fertilizer. BSF maggots are also an excellent source of green energy. Their bodies are composed of approximately 40% fat, making them an ideal candidate for biodiesel production.

The potential applications for BSF maggot culture are nearly endless and their impact on green economic resilience is significant. As we continue to face environmental challenges, it is important to explore and invest in sustainable solutions such as BSF maggot culture that offer both ecological and economic benefits.

While there are many advantages to using BSF maggot culture for green economic resilience, there are some challenges that must be considered before implementing this technology on a large scale. First, the initial investment in infrastructure and equipment may be prohibitive for some businesses or organizations. Second, proper training is necessary to ensure that the process is carried out safely and effectively. Finally, strict quality control measures must be put in place to prevent contamination of finished products with pathogenic bacteria.

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