PRODUCTION OF INSECT-BASED PROTEIN MEAL AS AN ALTERNATIVE TO CONVENTIONAL SOURCES IN LIVESTOCK ENTERPRISES

[*]Oladejo Opeyemi A., [+]Akintaro Olamide, [*]Ayoola Mathew O, [*]Kolawole Peace E., [*]Oguntunji Abel O, [*]Alabi Olufemi M.

[*]SAFE-BSF (Sustainable and environmentally safe agriculture - Black soldier fly) Research Group, Bowen University, Iwo, Nigeria

[+]Entrepreneurial Studies, First Technical University, Ibadan, Oyo State.

Corresponding author: *opeaoladejo@gmail.com*

ABSTRACT

Predictions suggest that by 2050, the global population will be more than 9 billion people, leading to a potential 70% surge in the demand for animal proteins. The production of poultry incurs a significant cost, with about 70–75% attributed to feed expenses. Producers in developing nations, such as Nigeria, grapple with challenges stemming from the high prices of protein and energy-rich feed ingredients, impacting the overall cost and pricing of poultry feeds. The high prices and limited availability of conventional feed ingredients especially fish meal (FM) and soybean meal (SBM) underscore the need for sustainable alternatives with comparable amino acid profile most especially lysine and methionine. In this context, exploring alternative and cost-effective sources of animal protein becomes crucial for mitigating production overheads. One promising avenue involves the integration of insects, particularly the black soldier fly (BSF), into poultry diets. The BSF is unlike other insect species that are lethal and pathogenic; and it is well-suited for large-scale industrial manufacturing of livestock feed. Livestock meals derived from BSF larvae (BSFL) present a reliable, economical, and highly nutritious alternative to traditional animal protein sources. The BSF larvae proteins is a prospective alternative to the conventional protein sources. Integrating BSFL into poultry production systems emerges as a promising strategy to enhance sustainability, waste management, circular bioeconomy (re-use, recycle), low-cost alternative to fish meal, mitigation of greenhouse gases (GHG) emission and positive impact on the health and welfare of poultry species.

Keywords: black soldier fly larvae, circular bioeconomy, fishmeal, poultry production, sustainable-agriculture, soybean meal,

INTRODUCTION

The global population is expected to reach approximately 8.5 billion by 2030, with a continual rise to around 9.7 billion by 2050 (UN, 2019). This annual increase of people comes with a potential of 70% surge in the demand for animal proteins (FAO, 2020; Hossain & Bhuiyan, 2023). Meeting this escalating demand for animal-derived proteins, particularly from poultry egg and meat production, will be crucial in the coming years. Consequently, the future is likely to witness an increased demand for poultry feed as the demand for poultry products grows. However, sustaining this growth in poultry production poses challenges as feed resources may become limited (Thirumalaisamy *et al*., 2016).

A significant hurdle is that 70–75 percent of the total cost of poultry production is allocated to feed. Producers, especially in developing nations like Nigeria, face difficulties due to the escalating prices of protein and energy-rich feed ingredients (Udo & Umanah, 2017). The global doubling of fish and soybean prices over the past decade further exacerbates the economic strain. Traditional protein-rich feed ingredients, such as soybean meal (SBM) and fish meal (FM), have become economically unviable for local resource-poor farmers, leaving them with narrow profit margins. Smallholder farmers, in particular, find it unsustainable to rely on FM and SBM as chicken feed ingredients. Therefore, there is a pressing need to explore sustainable, economically feasible, and environmentally safe alternatives, such as insect-based larval proteins.

In recent years, the utilization of insect meal as high-quality ingredients in the diets of chickens, pigs, and fish has experienced rapid growth (Onsongo *et al*., 2018). Insects offer high-quality protein content and can be mass-produced with a low environmental footprint, contributing to a reduction in greenhouse gas emissions (Van Huis *et al*., 2013). The economic sensibility of using insect meals in animal diets, particularly in poultry, surpasses that of traditional protein ingredients (Onsongo *et al*., 2018). The Black Soldier Fly (BSF), *Hermetia illucens L.*, emerges as a potentially low-cost, nutrient-rich alternative protein source, comparable in protein quality to fish meal and plant sources. Processed

BSF larvae boast a nutrient profile rich in crude protein content (38.5–62.7%), well-balanced amino acids, good-quality fatty acids (14.0–39.2%), and essential micronutrients like iron and zinc (Shumo *et al*., 2019a). However, it's crucial to note that the nutritional composition of these insects may vary depending on the species, developmental stage, and the rearing substrates.

Insect meal

Insect meal has been shown to be a rich source of protein, amino acids (lysine, methionine), and minerals (calcium, phosphorus, zinc), with a high digestibility rate, making it a valuable feed ingredient for poultry production (Rumpold & Schlüter, 2013). Additionally, using insect meal in poultry feed could reduce the cost of production (Sumbule *et al*., 2021) and the environmental impact on the industry. Furthermore, the use of insect meal has the potential to improve the growth performance and meat quality of broilers (Onsongo *et al*., 2018), pig (Chia et al., 2018) and fish (Muin et al., 2017). For instance, when insects and/or the larvae are incorporated in the poultry diet, it has no direct competition for food resources with the human population.

Among the different insect species, the black soldier fly (BSF) is the most suitable for extensive industrial manufacturing for livestock feed production (Makkar *et al*., 2014). BSFL (Hermetia illucens L.; Diptera: Stratiomyidae) are a saprophytic insect that primarily feeds on organic wastes such as plant residues, animal manure, and waste, food waste, agricultural by-products, or straw at the larvae stage (Nguyen *et al*., 2015). The BSFL utilization of organic waste can help to reduce pollution (Chala *et al*., 2022). In the process of degrading waste, BSFL converts organic waste into amino acids, peptides, proteins, oils, chitin, and vitamins, thereby controlling certain harmful bacteria (such as *Salmonella* and *Escherichia coli*) and pests. (Erickson *et al*., 2004; Liu *et al*., 2008).

Black soldier fly (BSF)

Hermetia illucens L. is the most widespread of all species (Singh & Kumari, 2019) of BSF which originated in the South American savannah and are widely distributed in temperate, subtropical, and tropical regions, with an optimum temperature range of 25◦C to 30 ◦C (Shumo *et al*., 2019b). It is a large, slender black species with three segments—head, thorax, and abdomen with brownish wings and tentacles projecting from the head (Üstüner *et al*., 2003). There are five segments on the abdomen with white spots. Their life cycle has five stages: egg, larvae, pre-pupa, pupa and adult. The larvae and pupa stages are the most nutrient-rich and largely depend on the quality of substrate consumed by the BSFL. Depending on the environment condition, the lifecycle of BSF varies from 30 - 36 days and can be raised all year round. It lays eggs and in 3 – 5 days after mating, the eggs are hatched into larvae and remain as larvae for about 2 weeks at 4 – 18 days of the life-cycle. After which it is changed to the black less active stage of pre-pupa and pupa stage (which is a bit hard and black in colour) (Singh & Kumari, 2019). Adult worms have no mouth, digestive system, or stinger; pose no threat to other organisms (Park, 2016) and have no affinity for the human body and fresh food. Therefore, they also do not serve as vectors for disease transmission (Sheppard *et al*, 2002).

The BSF is a non-lethal insect that could help with two significant issues in modern agriculture, including disposal of organic wastes, by-products, and side streams as well as providing a viable substitute protein source for the poultry industry (Hossain & Bhuiyan, 2023). Meals made from BSF larvae (BSFL) are a reliable, affordable, and incredibly nutritious alternative source of animal protein. The prices and availability of traditional feed ingredients like soybean meal (SBM) and fish meal (FM) are quite high. The addition of this insect meal to livestock diets may reduce feed costs without degrading the performance of the animals, while potentially increasing the profitability of the livestock industry (Chala *et al*., 2022). Incorporating BSFL into poultry diets reduces the reliance on traditional protein sources like SBM and FM, which can help mitigate overfishing and deforestation associated with these industries. Hence, using BSFL in poultry production can contribute to sustainable agriculture and a friendly environment excellent at converting organic waste, such as food scraps and manure, into valuable protein-rich larvae (Lu *et al*., 2022). The lysine and methionine concentration of BSF larvae proteins is comparable to that of SBM, but somewhat lower than that of FM, making the BSFL a comparable amino acid profile (Lu *et al*., 2022). The amount of ash in the BSFL varies depending on the age of the BSFL and is adequate in calcium and phosphorus. The BSFL maggot meal is served to the animal live, chopped, or dried and ground forms. By transforming them into a biomass rich in protein and fat that can be used for a variety of tasks, such as animal feeding, the generation of biodiesel, and the creation of chitin, the BSFL is successful at reducing animal manure and organic waste materials (Chala *et al*., 2022). BSF was able to quickly and creatively

ingest and digest raw organic waste materials (cattle, pig, or poultry dung, kitchen trash, slaughterhouse waste: blood and offal). Furthermore, BSFL can help with waste management by efficiently consuming organic waste, reducing the need for landfill disposal and potentially lowering greenhouse gas emissions (El-Sabrout *et al*., 2023; Khalifah *et al*., 2023).

CONCLUSION

The inclusion of BSF as an alternative and cheaper source of rich insect protein-based ingredient promoted in this research is indispensable in lowering the overhead cost of production with attendant increase in profit margins; thus, constituting a major or partial replacement of the high-cost conventional fishmeal, without degrading the performance of the animals. This will consequently increase the profitability of the livestock industry. Succinctly, the significance can be simply described as: waste management, circular bioeconomy (re-use, recycle), low-cost alternative to fish meal, mitigation of greenhouse gases (GHG) emission and positive impact on the health and welfare of poultry.

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