NexAvens Scientific Library

OPEN ACCESS

NL Journal of Veterinary and Animal Nutrition

Volume 1 Issue 1 April 2025

Review Article

Nutritional and Bioactive Benefits of Black Soldier Fly Larvae for Poultry

Ishaya Usman Gadzama

Corresponding Author: Ishaya Usman Gadzama, Scientist, National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Zaria, Nigeria.

Received Date: November 12- 2024 **Publication Date:** February 20- 2025

Abstract: This paper examines the nutritional and bioactive benefits of black soldier fly larvae (BSFL) for poultry. The review highlights the larvae's high protein (37-63% dry matter) and fat content (7-35%), rich essential amino acids, and presence of vitamins and minerals. It also discusses the antimicrobial and immunomodulatory properties of BSFL, such as lauric acid, chitin, and antimicrobial peptides, and their potential to improve gut health and reduce the incidence of diseases like necrotic enteritis. Additionally, the review shows that chitin and medium-chain fatty acids (MCFAs) in BSFL contribute to its prebiotic properties, promoting beneficial gut bacteria and enhancing immune function. Studies reveal mixed results on growth performance, with some indicating improvements while others report negative impacts depending on inclusion levels and rearing substrates. BSFL inclusion positively influences gut health by promoting beneficial bacteria like Roseburia and suppressing harmful bacteria like Clostridium and Corynebacterium. BSFL holds significant potential as a sustainable and nutritious ingredient in poultry diets. However, further research is necessary to optimize its inclusion rates for different poultry species and life stages, and to understand the long-term impacts of BSFL inclusion on health and productivity.

Keywords: Black Soldier Fly Larvae, Poultry Nutrition, Antimicrobial, Lauric Acid, Chitin, Gut Health

Introduction

The world's rapidly expanding population has caused a surge in demand for protein. This demand presents significant challenges to the animal feed industry [1]. First, there is a shortage of traditional protein sources for animal feed. Second, conventional protein sources come with their own set of sustainability and environmental challenges. This has led to a search for alternative protein sources [2,3]. The black soldier fly larvae (BSFL), scientifically known as Hermetia illucens (L.) (Diptera: Stratiomyidae), are a potential solution to the challenges of a growing population and a shortage of protein sources because they offer a sustainable and environmentally friendly alternative to traditional animal feed [4,5,6]. Several research articles highlight the potential of BSFL to efficiently convert organic waste into high-quality protein [3,6]. This ability makes them an ideal candidate for upcycling food waste and agricultural byproducts, diverting these materials from landfills and transforming them into valuable feed ingredients [7]. BSFL farming has a low environmental footprint compared to traditional protein sources [8]. Their production requires significantly less land, water, and energy [7,8]. BSFL have a high protein content, ranging from 37% to 63% dry matter, and is rich in essential amino acids necessary for muscle development, growth, and eggshell formation in poultry [9,10]. In addition, BSFL contains a significant amount of fat (7% to 35%), composed mainly of saturated fatty acids like lauric acid (C12:0) and palmitic acid (C16:0) [11,12]. Unsaturated fatty acids, like palmitoleic (C16:1) and linoleic (C18:2) acids, are also present in BSFL [13]. Furthermore, the larvae are rich in essential nutrients, including vitamins and minerals like iron, calcium, phosphorus, and zinc, vital for various physiological functions in poultry [14]. BSFL contain antimicrobial and immunomodulatory compounds like lauric acid, chitin, and antimicrobial peptides.

These compounds can kill both Gram-positive and Gram-negative bacteria, improving poultry health and productivity [15,16,17]. Lauric acid, a major component of BSFL fat, exhibits antimicrobial properties and inhibits the growth of Clostridium perfringens, a bacterium responsible for necrotic enteritis in poultry [16,17]. Other medium-chain fatty acids (MCFAs) in BSFL fat also possess significant antibacterial activity [18]. BSFL and their byproducts are believed to have prebiotic properties due to their chitin and MCFA content [18,19]. Feeding BSFL has been linked to improved non-specific immunity and a more favourable intestinal microbiota composition [20]. However, the nutritional composition of BSFL is influenced by the rearing substrate, which impacts the overall nutritional value of poultry [2,10,21].

Impact of BSFL Inclusion in Poultry Diets

Growth Performance

Studies show varying results on the impact of BSFL inclusion on broiler chickens' growth performance. Some studies show that replacing conventional protein sources with BSFL linearly increased daily feed intake and reduced live weight and average daily gain [22]. Other studies have demonstrated improved growth performance with increased body weight gain and better feed conversion ratio when diets contained BSFL at levels ranging from 10% to 20% [20,23,24]. However, inclusion levels above 25% often negatively impacted growth performance due to the high chitin content in BSFL meal, interfering with crude protein digestibility [20,25,26]. Complete substitution of fish meal with BSFL meal also reduced nutrient digestibility in broiler chickens [26].

Digestibility

The digestibility of BSFL varies depending on the rearing substrate and processing methods [21,27]. Defatted BSFL meals can be effectively utilized in broiler diets, providing a valuable source of energy and amino acids [28]. Partially defatted BSFL meals have shown higher digestibility and energy values than highly defatted meals [28]. In layer chickens, both mechanical pressing and chemical extraction defatting methods did not adversely affect metabolic energy and nutrient digestibility [29]. However, pressed BSFL demonstrated better digestibility of crude fat and total energy [29].

Gut Health

BSFL inclusion has shown positive impacts on gut health by promoting beneficial bacteria growth, such as Roseburia [23]. BSFL fat reduced potentially pathogenic bacteria, such as Clostridium and Corynebacterium [30]. Additionally, BSFL protein has been shown to suppress the growth of Clostridium perfringens in vitro [31]. The chitin and medium-chain fatty acids in BSFL are believed to enhance gut and immune health in broiler chickens through prebiotic and antimicrobial properties [32]. In layer chickens, replacing soybean meal with BSFL meal altered the cecal microbiota composition, increasing the production of short-chain fatty acids (SCFAs) like butyrate, acetate, and propionate [33]. These SCFAs provide numerous benefits to the host and exhibit antimicrobial activity [34]. It is important to note that the optimal inclusion rate of BSFL in poultry diets is still under investigation, with varying results across studies. Factors such as insect developmental stages, nutritive value, and bird species can influence the outcomes. Further research is necessary to determine the long-term impacts of BSFL inclusion on poultry health and productivity, as well as the ideal inclusion rates and effects of different rearing conditions.

Conclusion

While studies have shown promising results, the impact of BSFL inclusion on poultry growth performance can vary depending on factors such as inclusion levels, rearing substrate, and processing methods. High inclusion levels (above 25%) can negatively impact growth performance due to the high chitin content, which can interfere with protein digestibility. However, appropriate inclusion levels of BSFL, especially defatted meals, can enhance nutrient digestibility and provide valuable energy and amino acids. Furthermore, BSFL inclusion has been linked to improved gut health by promoting beneficial bacteria growth and reducing pathogenic bacteria. This positive impact on gut health can be attributed to the prebiotic properties of chitin and medium-chain fatty acids present in BSFL. Further research is needed to optimize BSFL inclusion rates and understand the long-term impacts on poultry health and productivity.

References

1.Yashim, S. M., Adekola, S. T., Abdu, S. B., Gadzama, I. U., & Hassan, M. R. (2016). Feed intake, growth performance and nutrient digestibility in growing Red Sokoto bucks fed diets containing graded levels of dried sweet orange peel meal. Animal Research International, 13(1), 2328-2337.

2. Gadzama, I. U., Yashim, S. M., & Ndudim, R. K. (2019). Nutritional composition of housefly larvae meal: a sustainable protein source for animal production–a review. Nigerian Journal of Animal Production, 127-130. https://www.njap.org.ng/index.php/njap/article/view/7324

3. Sankara, F., Sankara, F., Pousga, S., Coulibaly, K., Nacoulma, J. P., Ilboudo, Z., Ouédraogo, I., Somda, I., & Kenis, M. (2023). Optimization of production methods for black soldier fly larvae (Hermetia illucens L.) in Burkina Faso. Insects, 14(9), 776. https://doi.org/10.3390/insects14090776

4. Stamer, A. (2015). Insect proteins—a new source for animal feed: The use of insect larvae to recycle food waste in high-quality protein for livestock and aquaculture feeds is held back largely owing to regulatory hurdles. EMBO Reports, 16(6), 676–680. https://doi.org/10.15252/embr.201540519

5. Gadzama, I. U., & Amodu, J. T. (2018). House Fly (Musca domestica) Larvae as Protein Source for Livestock Production—A Review. J. Anim. Prod. Res, 30, 91-96.

6. Gadzama, I. U. (2024). Influence of rearing substrate on black soldier fly larvae nutritional value for animal feed. Wikifarmer. Retrieved from: https://www.researchgate.net/publication/383121796_Influence_of_Rearing_Substrate_on_Black_Soldier_Fly_Larvae_Nutritional_Value_for_Animal_Feed

7. Siddiqui, S. A., Süfer, Ö., Çalışkan Koç, G., Lutuf, H., Rahayu, T., Castro-Muñoz, R., & Fernando, I. (2024). Enhancing the bioconversion rate and end products of black soldier fly (BSF) treatment–A comprehensive review. Environment, Development and Sustainability, 1-69.

8. Salahuddin, M., Abdel-Wareth, A. A., Hiramatsu, K., Tomberlin, J. K., Luza, D., & Lohakare, J. (2024). Flight toward Sustainability in Poultry Nutrition with Black Soldier Fly Larvae. Animals, 14(3), 510.

9. Spranghers, T., Ottoboni, M., Klootwijk, C., Ovyn, A., Deboosere, S., De Meulenaer, B., ... & De Smet, S. (2017). Nutritional composition of black soldier fly (Hermetia illucens) prepupae reared on different organic waste substrates. Journal of the Science of Food and Agriculture, 97(8), 2594-2600.

10. Ravi, H. K., Degrou, A., Costil, J., Trespeuch, C., Chemat, F., & Vian, M. A. (2020). Larvae mediated valorization of industrial, agriculture and food wastes: Biorefinery concept through bioconversion, processes, procedures, and products. Processes, 8(7), 857.

11. Barragan-Fonseca, K. B., Dicke, M., & van Loon, J. J. (2017). Nutritional value of the black soldier fly (Hermetia illucens L.) and its suitability as animal feed–a review. Journal of Insects as Food and Feed, 3(2), 105-120.

12. Abd El-Hack, M. E., Shafi, M. E., Alghamdi, W. Y., Abdelnour, S. A., Shehata, A. M., Noreldin, A. E., ... & Ragni, M. (2020). Black soldier fly (Hermetia illucens) meal as a promising feed ingredient for poultry: A comprehensive review. Agriculture, 10(8), 339.

13. Kierończyk, B., Rawski, M., Stuper-Szablewska, K., & Józefiak, D. (2022). First report of the apparent metabolisable energy value of black soldier fly larvae fat used in broiler chicken diets. animal, 16(11), 100656.

14. Wang, Y. S., & Shelomi, M. (2017). Review of black soldier fly (Hermetia illucens) as animal feed and human food. Foods, 6(10), 91.

15. Moretta, A., Salvia, R., Scieuzo, C., Di Somma, A., Vogel, H., Pucci, P., ... & Falabella, P. (2020). A bioinformatic study of antimicrobial peptides identified in the Black Soldier Fly (BSF) Hermetia illucens (Diptera: Stratiomyidae). Scientific reports, 10(1), 16875.

16. Zhang, S., Xiong, P., Ma, Y., Jin, N., Sun, S., Dong, X., ... & Xu, W. (2022). Transformation of food waste to source of antimicrobial proteins by black soldier fly larvae for defense against marine Vibrio parahaemolyticus. Science of The Total Environment, 826, 154163.

17. Skřivanová, E., Marounek, M., Dlouha, G., & Kaňka, J. (2005). Susceptibility of Clostridium perfringens to C2–C18 fatty acids. Letters in applied microbiology, 41(1), 77-81.

18. Kim, B., Bang, H. T., Jeong, J. Y., Kim, M., Kim, K. H., Chun, J. L., & Ji, S. Y. (2021). Effects of Dietary Supplementation of Black Soldier Fly (Hermetia illucens) Larvae Oil on Broiler Health. The journal of poultry science, 58(4), 222–229. https://doi.org/10.2141/jpsa.0200070

19. Joosten, L., Lecocq, A., Jensen, A. B., Haenen, O., Schmitt, E., & Eilenberg, J. (2020). Review of insect pathogen risks for the black soldier fly (Hermetia illucens) and guidelines for reliable production. Entomologia Experimentalis et Applicata, 168(6-7), 432-447.

20. Dabbou, S., Gai, F., Biasato, I., Capucchio, M. T., Biasibetti, E., Dezzutto, D., ... & Schiavone, A. (2018). Black soldier fly defatted meal as a dietary protein source for broiler chickens: Effects on growth performance, blood traits, gut morphology and histological features. Journal of animal science and biotechnology, 9, 1-10.

21. Lu, S., Taethaisong, N., Meethip, W., Surakhunthod, J., Sinpru, B., Sroichak, T., ... & Paengkoum, P. (2022). Nutritional composition of black soldier fly larvae (Hermetia illucens L.) and its potential uses as alternative protein sources in animal diets: A review. Insects, 13(9), 831.

22. Nayohan, S., Susanto, I., Permata, D., Pangesti, R. T., Rahmadani, M., & Jayanegara, A. (2022). Effect of dietary inclusion of black soldier fly larvae (Hermetia illucens) on broiler performance: A meta-analysis. In E3S Web of Conferences (Vol. 335, p. 00013). EDP Sciences.

23. Fruci, M., Kithama, M., Kiarie, E. G., Shao, S., Liu, H., Topp, E., & Diarra, M. S. (2023). Effects of partial or complete replacement of soybean meal with commercial black soldier fly larvae (Hermetia illucens) meal on growth performance, cecal short chain fatty acids, and excreta metabolome of broiler chickens. Poultry Science, 102(4), 102463.

24. Nguyen, T. N., & Tran, H. N. (2024). Effects of Black Soldier Fly Larvae Supplementation in Ac Chickens' Feed: Impact on Meat Yield and Quality. Alexandria Journal of Agricultural Sciences, 69(2), 166-174.

25. Cutrignelli, M. I., Messina, M., Tulli, F., Randazzo, B., Olivotto, I., Gasco, L., ... & Bovera, F. (2018). Evaluation of an insect meal of the Black Soldier Fly (Hermetia illucens) as soybean substitute: Intestinal morphometry, enzymatic and microbial activity in laying hens. Research in veterinary science, 117, 209-215.

26. Nampijja, Z., Kiggundu, M., Kigozi, A., Lugya, A., Magala, H., Ssepuuya, G., ... & Mugerwa, S. (2023). Optimal substitution of black soldier fly larvae for fish in broiler chicken diets. Scientific African, 20, e01636.

27. Shumo, M., Osuga, I. M., Khamis, F. M., Tanga, C. M., Fiaboe, K. K., Subramanian, S., ... & Borgemeister, C. (2019). The nutritive value of black soldier fly larvae reared on common organic waste streams in Kenya. Scientific Reports, 9(1), 10110.

28. Schiavone, A., Cullere, M., De Marco, M., Meneguz, M., Biasato, I., Bergagna, S., ... & Dalle Zotte, A. (2017). Partial or total replacement of soybean oil by black soldier fly larvae (Hermetia illucens L.) fat in broiler diets: Effect on growth performances, feed-choice, blood traits, carcass characteristics and meat quality. Italian Journal of Animal Science, 16(1), 93-100. https://doi.org/10.1080/1828051X.2016.1249968

29. Xin, Y., Xu, M., Chen, L., Wang, G., Lu, W., Liu, Z., ... & Li, L. (2024). Effects of Different Defatting Methods of Black Soldier Fly (Hermetia illucens) Larvae Meal on the Metabolic Energy and Nutrient Digestibility in Young Laying Hens. Animals, 14(17), 2521.

30. Dabbou, S., Lauwaerts, A., Ferrocino, I., Biasato, I., Sirri, F., Zampiga, M., ... & Schiavone, A. (2021). Modified black soldier fly larva fat in broiler diet: Effects on performance, carcass traits, blood parameters, histomorphological features and gut microbiota. Animals, 11(6), 1837.

31. Dong, L., Ariëns, R. M., America, A. H., Paul, A., Veldkamp, T., Mes, J. J., ... & Govers, C. (2021). Clostridium perfringens suppressing activity in black soldier fly protein preparations. LWT, 149, 111806.

32. Dörper, A., Veldkamp, T., & Dicke, M. (2021). Use of black soldier fly and house fly in feed to promote sustainable poultry production. Journal of Insects as Food and Feed, 7(5), 761-780.

33. Borrelli, L., Coretti, L., Dipineto, L., Bovera, F., Menna, F., Chiariotti, L., ... & Fioretti, A. (2017). Insect-based diet, a promising nutritional source, modulates gut microbiota composition and SCFAs production in laying hens. Scientific reports, 7(1), 16269.

34. Namkung, H., Yu, H., Gong, J., & Leeson, S. (2011). Antimicrobial activity of butyrate glycerides toward Salmonella Typhimurium and Clostridium perfringens. Poultry Science, 90(10), 2217-2222.