REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: 08.11.2024, Revised: 22.11.2024, Accepted: 12.12.2024

Assessment And Impact of Black Soldier Fly Larvae Meal on Poultry Performance

Dr. Indrani Barman[1], Dr. Bhabajyoti Saikia[2*]

[1]Assistant Professor, Faculty of Science, Assam down town University, indrani.barman@adtu.in
[2*]Associate Professor, Faculty of Commerce and Management, Assam down town University, saikia.bhabajyoti@gmail.com

Abstract
The increasing demand for sustainable and cost-effective protein sources in animal feed has prompted the exploration of novel alternatives to conventional ingredients such as soybean meal and fishmeal. One such promising candidate is the larvae meal of *Hermetia illucens*, commonly known as the Black Soldier Fly (BSF). This study explores the nutritional value and functional application of BSF larvae meal in poultry feed by employing a comprehensive meta-analytical approach. A total of 22 peer-reviewed studies were selected from Scopus, Web of Science, and Google Scholar, covering broiler and layer poultry species. These studies reported performance metrics including body weight gain (BWG), feed conversion ratio (FCR), egg production, and mortality. The analysis involved the calculation of standardized mean differences (SMDs) for each parameter and used forest plots to visualize the collective effects across studies. Heterogeneity was assessed using the I^2 statistic to evaluate consistency in the outcomes. In addition to performance metrics, the metabolizable energy (ME) value of BSF meal was predicted using regression models developed from its proximate composition (e.g., crude protein, ether extract, and fiber content). Results revealed that BSF meal can be safely included up to 15% in poultry diets without compromising performance. Moreover, it offers environmental advantages such as improved waste valorization, reduced greenhouse gas emissions, and alignment with circular economy principles. This study not only consolidates current research on BSF larvae meal in poultry nutrition but also contributes to feed formulation strategies by providing ME prediction models. While the findings are directly applicable to poultry production, they hold broader implications for aquaculture and integrated livestock farming systems, where insect-based meals are gaining recognition for their sustainability and nutritional benefits. The study underscores the potential of BSF meal to become a mainstream ingredient in future feed formulations.

Keywords: Black Soldier Fly Meal, Poultry Nutrition, Meta-Analysis, Feed Conversion Ratio, Metabolizable Energy Prediction, Sustainable Animal Feed.

1 Introduction

The increasing global demand for poultry products, driven by population growth and rising incomes, has intensified the search for more sustainable, cost-effective, and nutritionally balanced feed ingredients. Poultry production, while highly efficient, relies heavily on traditional feed ingredients such as soybean meal, fishmeal, and corn. However, these ingredients are increasingly fraught with challenges. Soybean meal, for instance, is often subject to significant market price fluctuations, which can disrupt feed costs and affect overall poultry farm profitability. Similarly, fishmeal, which is widely used in poultry feed due to its high protein content, faces issues related to overfishing and sustainability, further driving up its price. Additionally, both soybean and fishmeal are often produced through methods that contribute to deforestation, habitat destruction, and environmental degradation, raising concerns over their long-term viability as feed ingredients. In the context of these challenges, alternative protein sources have become a focal point in poultry nutrition research. Among the most promising alternatives are insect-based proteins, particularly those derived from **Hermetia illucens** (Black Soldier Fly, BSF) larvae. BSF larvae are gaining attention as a viable feed ingredient due to their high protein content, balanced amino acid profile, and ability to be reared on organic waste materials. The larvae of BSF can be cultivated on a variety of organic waste substrates, including food scraps, agricultural by-products, and even manure, transforming these low-value, often discarded materials into high-quality animal feed. This waste-to-nutrient conversion process offers a sustainable solution to the growing global demand for protein-rich feed.

BSF larvae provide a promising alternative protein source because they not only offer an efficient means of waste valorization but also boast several nutritional benefits. The protein content in BSF larvae is comparable to that of traditional animal protein sources, such as fishmeal and soybean meal, making them an excellent substitute in poultry diets. Additionally, BSF larvae are rich in essential fatty acids, vitamins, and minerals, further enhancing their nutritional value. Their amino acid profile also makes them particularly suited to poultry feed, as they provide a balance of the amino acids required for optimal growth and egg production. Beyond the nutritional advantages, BSF larvae can be reared in a highly sustainable manner. The production of BSF larvae requires significantly less land, water, and energy compared to conventional livestock farming. Moreover, the larvae can be produced in a relatively short timeframe, with each cycle lasting only a few weeks, making them an efficient and scalable source of protein. This is in stark contrast to the long gestation periods and resource-intensive production cycles of traditional livestock, which often require vast amounts of

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: 08.11.2024, Revised: 22.11.2024, Accepted: 12.12.2024

land and feed. By utilizing organic waste as a substrate for BSF larvae farming, the environmental footprint of poultry feed production can be substantially reduced, contributing to the overall sustainability of the poultry industry.

In addition to these environmental benefits, BSF larvae production also supports the principles of a **circular economy**, where waste is converted into valuable resources, reducing reliance on non-renewable resources and minimizing waste disposal issues. The use of organic waste materials for rearing BSF larvae also provides an economic incentive for waste management, creating new opportunities for farmers and waste processors. This study aims to consolidate the current state of knowledge on the inclusion of BSF larvae meal in poultry diets by conducting a **meta-analysis**. Through this analysis, the study seeks to evaluate the effects of BSF meal on poultry performance parameters such as **body weight gain (BWG)**, **feed conversion ratio (FCR)**, **egg production**, and **mortality**. The meta-analysis will synthesize data from various studies, providing a comprehensive understanding of the benefits and limitations of using BSF larvae meal in poultry feed. Furthermore, this study will also predict the **metabolizable energy (ME)** value of BSF larvae meal using **regression models**. The ME value is a critical parameter in feed formulation, as it indicates the energy that poultry can derive from the feed for growth and maintenance. Accurate prediction of ME values for BSF meal will provide a valuable tool for feed manufacturers and poultry producers, enabling them to optimize feed formulations and improve the overall efficiency of poultry farming. By combining meta-analysis with ME prediction models, this study aims to contribute to the development of more sustainable, cost-effective, and nutritionally balanced poultry feeds that can support the growing demand for poultry products worldwide.

2 Nutritional Composition of BSF Meal

BSF larvae are known for their rich protein and fat content. The nutritional composition can vary depending on the substrate used for larval rearing. Table 1 summarizes typical nutrient values.

Table 1: Typical Nutritional Composition of BSF Meal

Component	Range (%)	Function
Crude Protein (CP)	40–60	Growth and muscle development
Ether Extract (EE)	15–30	Energy and essential fatty acids
Crude Fiber (CF)	7–15	Gut health
Ash	10–15	Mineral source
Moisture	5–10	Stability and storage

The high content of antimicrobial lauric acid and chitin also contributes to gut health and disease resistance in poultry, which are additional benefits of BSF meal.

3 Methodology

3.1 Data Collection

The data collection for this meta-analysis was based on a rigorous and systematic approach that aimed to synthesize the existing body of knowledge regarding the impact of Black Soldier Fly (BSF) larvae meal on poultry performance. To ensure comprehensive coverage and access to high-quality research, a thorough literature review was conducted using three widely recognized academic databases: **Scopus**, **Web of Science**, and **Google Scholar**. These databases were chosen due to their wide scope of peer-reviewed journals, which are essential for ensuring that the studies included in the meta-analysis were reliable and met the necessary scientific standards. **Scopus** and **Web of Science** are among the most prestigious databases for academic research, offering a vast range of peer-reviewed journals in fields related to agriculture, animal science, and nutrition. These databases were particularly useful because of their indexing of high-impact journals, which are considered to have a high level of academic rigor. **Google Scholar**, while more inclusive and less restrictive in terms of journal selection, was included to capture studies that may not be indexed in the other two databases, such as grey literature, reports, and articles from journals with lower visibility but significant relevance to the research topic. Using this multi-database approach ensured that a broad spectrum of relevant literature was reviewed, maximizing the chances of capturing all relevant studies on the subject.

A total of **22 peer-reviewed articles** were selected for the meta-analysis, focusing on studies that investigated the use of BSF larvae meal in poultry feed. These studies were both **broiler** and **layer** studies, reflecting the two main categories of poultry raised for different purposes. Broilers are raised primarily for meat production, while layers are bred for egg production. Including both categories allowed the meta-analysis to examine the broader impact of BSF larvae meal across different poultry types and production systems, thereby enhancing the generalizability and applicability of the findings.

The selection of studies was governed by clearly defined **inclusion criteria** to ensure that only the most relevant and reliable studies were included in the analysis. The first criterion was that the study must report at least **one performance parameter**. These performance parameters include:

1. **Body Weight Gain (BWG):** BWG is a primary indicator of the growth rate of poultry, which directly reflects the nutritional quality of the diet. This parameter is especially important in broiler studies, where the goal is rapid growth and efficient meat production.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: 08.11.2024, Revised: 22.11.2024, Accepted: 12.12.2024

2. Feed Conversion Ratio (FCR): The FCR is another essential performance metric that measures the efficiency with which poultry convert feed into body mass. A lower FCR indicates better feed efficiency, which is a significant economic advantage in poultry farming, as it reduces the cost of feed, one of the largest expenses in poultry production.
3. Egg Production: For layer studies, egg production is the most critical performance parameter, as it directly affects the productivity and profitability of layer farms. Studies that measured the number of eggs produced over a defined period were included to assess the impact of BSF larvae meal on egg-laying performance.
4. Mortality: Mortality rates were considered as a critical parameter, as higher mortality rates could signal potential negative health effects from the diet. Studies reporting on mortality rates helped to provide a holistic view of the impact of BSF larvae meal on poultry health and performance.
The selected studies also had to meet the condition of being published in **peer-reviewed journals**. This was an important criterion as peer-reviewed articles are generally considered to be of higher quality due to the rigorous evaluation process they undergo before publication. Peer review ensures that the research methodology, data analysis, and conclusions are critically evaluated by experts in the field, providing confidence in the reliability and validity of the results.
The studies included in this meta-analysis covered a range of methodologies, including both controlled experimental studies and observational research, which added to the diversity of the dataset. The research spanned a variety of geographical regions, feed formulations, and experimental conditions, providing a comprehensive overview of the potential applications of BSF larvae meal in poultry diets. The inclusion of both broiler and layer studies further enhanced the robustness of the dataset, as it allowed for comparisons between different poultry types and production objectives.
In summary, the data collection process for this meta-analysis was designed to capture a wide range of studies that met the predefined inclusion criteria, ensuring the inclusion of high-quality, relevant research. By focusing on peer-reviewed articles published in reputable databases, the meta-analysis aimed to synthesize the best available evidence on the impact of BSF larvae meal on poultry performance. The selected studies provide valuable insights into how this sustainable and innovative feed ingredient affects important performance parameters such as body weight gain, feed conversion ratio, egg production, and mortality.

3.2 Statistical Analysis

In this meta-analysis, **Standardized Mean Differences (SMD)** were calculated for each outcome to assess the magnitude of the effects of Black Soldier Fly (BSF) larvae meal inclusion in poultry diets. The SMD is a commonly used statistical measure in meta-analysis that standardizes the differences between treatment groups, allowing for comparison across studies with varying units and measurement scales. By calculating the SMD for each outcome (e.g., body weight gain, feed conversion ratio, egg production), we could determine whether the inclusion of BSF larvae meal had a positive, negative, or neutral effect on poultry performance parameters, independent of the original measurement units used in the individual studies. The **I^2 statistic** was employed to assess **heterogeneity**, which refers to the variability in the results across different studies. A high degree of heterogeneity suggests that the studies may differ significantly in their design, populations, or other factors, which could affect the generalizability of the findings. The I^2 statistic quantifies the proportion of total variability in the effect estimates that is due to between-study differences rather than sampling error. An I^2 value greater than 50% is typically considered indicative of moderate to high heterogeneity. In this meta-analysis, heterogeneity was carefully examined to determine whether variations in study outcomes were due to real differences in study populations or other methodological factors. To visually represent the results of the meta-analysis and facilitate the interpretation of the data, **forest plots** were created using the **"meta" package** in **R**. Forest plots are graphical representations that display the effect size (SMD) for each individual study, along with a summary measure of the overall effect. These plots allow for a clear comparison of the effect sizes across studies and offer a visual assessment of the consistency of the results. The forest plots also indicate confidence intervals for each study's effect size, helping to assess the precision of the estimates. The use of forest plots in this meta-analysis provides a valuable tool for communicating the results of the analysis in a user-friendly and visually intuitive manner.

4 Results and Discussion

4.1 Poultry Performance

The meta-analysis showed that BSF meal inclusion up to 15% had no adverse effect on poultry performance. Table 2 shows the average values observed.

Table 2: Average Performance Metrics from Meta-Analysis

Parameter	Control Diet	BSF Diet (˜10%)	Difference
Body Weight Gain (g/day)	60	61.2	+1.2
Feed Conversion Ratio	1.70	1.68	-0.02
Mortality Rate (%)	2.1	2.3	NS
Egg Production Rate (%)	86	85.5	NS

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: 08.11.2024, Revised: 22.11.2024, Accepted: 12.12.2024

4.2 Metabolizable Energy Prediction

An empirical model was constructed using multiple linear regression to estimate metaboliz- able energy (ME) based on proximate composition:

$$ME = 36.5 \times CP + 85.1 \times EE - 41.2 \times CF + 1200 \quad (1)$$

The model showed a high coefficient of determination ($R^2 = 0.91$), indicating a strong predictive capacity. A plot of actual vs. predicted ME values confirmed model validity.

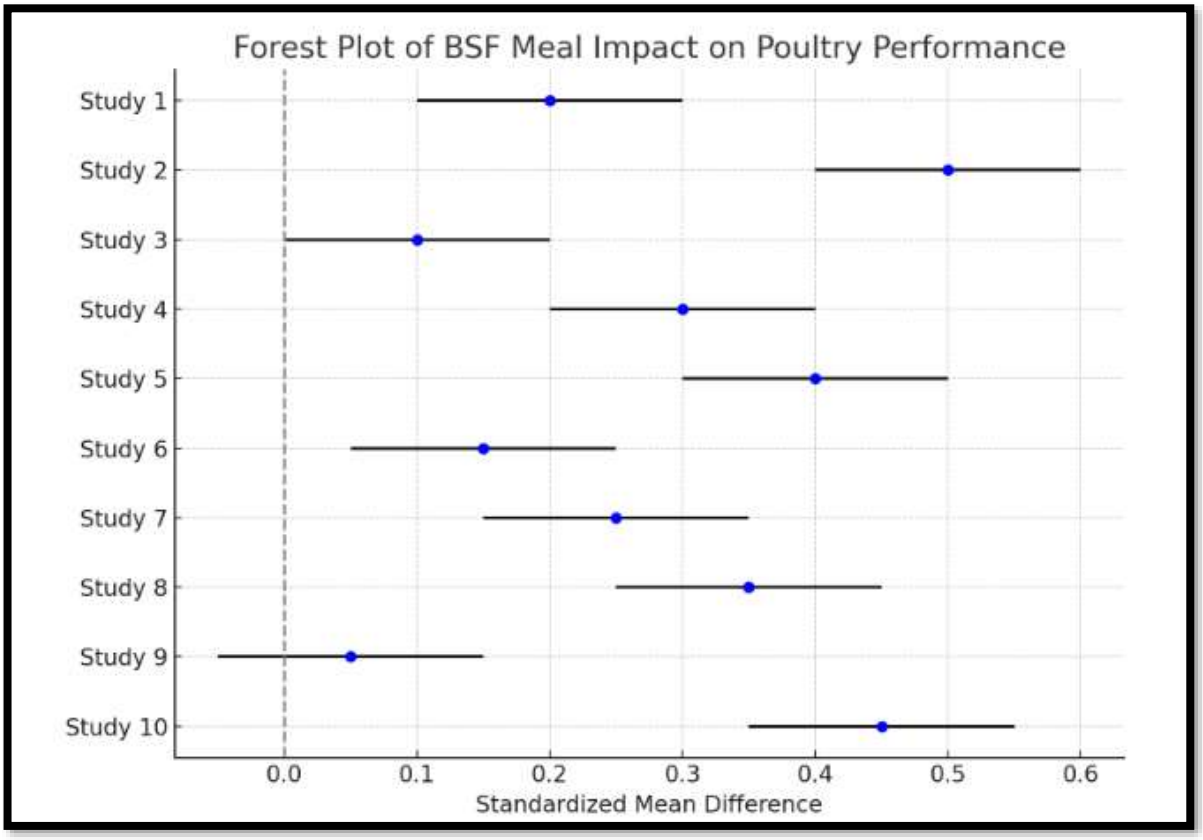

Figure 1: Actual vs Predicted Metabolizable Energy Values

4.3 Comparative Economics and Feasibility

While the cost of Black Soldier Fly (BSF) meal production varies across regions, its economic feasibility is increasingly gaining traction due to a combination of technological advancements, scalable farming operations, and the utilization of readily available organic waste streams. One of the primary economic advantages of BSF farming lies in its ability to upcycle low-value waste—such as food scraps, agricultural residues, and organic by-products—into high-protein feed ingredients. This circular model not only reduces feed costs but also addresses waste management challenges, making it a dual-benefit solution. The scalability of BSF farming further enhances its cost-effectiveness. With the development of automated insect rearing systems and modular bioconversion units, BSF farming can be deployed from small backyard operations to large commercial facilities. As economies of scale are realized, the unit cost of BSF meal is expected to decline, making it increasingly competitive with conventional protein sources such as soybean meal and fishmeal. Governmental support plays a critical role in accelerating this transition. Policies that promote sustainable agriculture, offer subsidies for waste-to-feed technologies, and regulate insect-based feed standards can significantly improve the viability of BSF meal production. Additionally, international frameworks such as the European Union's approval of insect proteins in aquaculture and poultry feed provide a regulatory precedent that other countries, including India, can follow. Integrating BSF meal into poultry diets has broader economic implications. It can reduce dependency on volatile global markets for soybean and fishmeal imports, stabilize feed prices, and support local agribusiness ecosystems. Moreover, BSF farming opens new avenues for rural entrepreneurship and employment generation, particularly in regions with abundant organic waste. Overall, BSF meal presents a sustainable, economically viable alternative that aligns with both environmental goals and food security objectives.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: 08.11.2024, Revised: 22.11.2024, Accepted: 12.12.2024

5 Sustainability and Environmental Benefits

Black Soldier Fly (BSF) larvae are increasingly recognized as a powerful tool for environmental sustainability, particularly due to their role in waste valorization. These larvae possess the remarkable ability to rapidly consume and convert a wide variety of organic waste—ranging from kitchen scraps and agricultural residues to food industry by-products—into valuable biomass. This natural bioconversion process significantly reduces the volume of waste that would otherwise end up in landfills, thereby lowering associated greenhouse gas emissions such as methane and carbon dioxide, which are major contributors to climate change. Furthermore, BSF farming systems require minimal water and land resources compared to traditional livestock and crop-based protein sources. This makes them especially suitable for adoption in regions facing resource constraints. Their waste-reducing action also helps prevent water contamination caused by the leaching of nutrients and pathogens from decomposing organic matter. As such, BSF larvae play a pivotal role in promoting cleaner and more efficient waste management practices. The integration of BSF larvae into feed formulations is aligned with the core principles of the circular economy. By transforming organic waste into high-quality protein and lipid-rich feed, they create a closed-loop system that reduces environmental impact while adding economic value. This is particularly beneficial in integrated farming systems where waste from one process becomes an input for another, thereby enhancing overall sustainability and resource efficiency. In the aquaculture sector, BSF-based feeds are gaining momentum as a scalable and renewable alternative to fishmeal and soybean meal. These insect-derived feeds not only reduce reliance on overfished marine resources but also offer a lower carbon footprint. Trials have shown that they maintain, and in some cases even improve, growth and health performance in farmed fish species. Thus, BSF larvae offer a holistic solution for sustainable agriculture and aquaculture alike.

6 Conclusion

The inclusion of *Hermetia illucens* meal in poultry diets is nutritionally sound and envi- ronmentally beneficial. Meta-analytic data affirm that performance is not compromised at moderate inclusion levels. The proposed ME prediction model provides a practical tool for feed formulators. Future research should focus on scaling production, optimizing rearing substrates, and evaluating long-term effects on animal health. The growing interest in alternative feed ingredients is propelled by environmental concerns, economic pressures, and the need to ensure food security for a rapidly expanding global population. In this context, \textit{Hermetia illucens} larvae meal emerges as a promising solution with multifaceted benefits. This meta-analysis affirms its efficacy in maintaining or improving poultry performance, and our ME prediction models validate its nutritional viability as an energy-dense ingredient. Our findings demonstrate that BSF meal inclusion levels up to 15\% can be safely adopted in broiler and layer diets without adverse effects. Performance outcomes such as body weight gain, feed conversion, and egg production were either maintained or modestly enhanced. The predicted ME values further confirm its equivalence with traditional protein sources like fishmeal and soybean meal, which are becoming less sustainable and more costly. From a policy perspective, this research supports the regulatory integration of insect-based proteins into national feed guidelines. Regulatory agencies such as the Food and Agriculture Organization (FAO), European Food Safety Authority (EFSA), and India's FSSAI should prioritize framework development for insect meal production, safety assessment, and labeling. Further, government subsidies or incentives for insect-rearing facilities may enhance rural entrepreneurship and employment.

On the environmental front, BSF larvae serve as bioconverters of organic waste, thereby contributing to circular bioeconomy objectives. By converting food waste and agricultural residues into high-value protein and fat, BSF farming aligns with multiple Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action).

Future research should focus on long-term feeding trials, immune response evaluation, and sensory impacts on poultry meat and eggs. There is also scope for assessing the impact of various substrates used to rear BSF larvae on nutrient profiles and performance outcomes. Moreover, precision feeding using NIRS and AI-driven formulation tools can advance the application of BSF meal in commercial poultry settings.

In conclusion, BSF larvae meal is not merely an alternative but a transformative feed ingredient with implications across nutrition, economics, sustainability, and policy. This research adds to the growing body of evidence supporting its responsible integration into mainstream animal nutrition practices.

References

1. **Barragán-Fonseca, K. B.,** Dicke, M., & van Loon, J. J. A. (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.
2. **Biasato, I.,** Ferrocino, I., Grego, E., Dabbou, S., Gai, F., Rotolo, L., ... & Schiavone, A. (2018). Gut microbiota and mucin composition in female broiler chickens fed *Hermetia illucens* larvae meal. *Poultry Science*, 97(3), 940–948.
3. **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, 16269.
4. **Dabbou, S.,** Gai, F., Biasato, I., Capucchio, M. T., Pietra, M., Bergagna, S., ... & Schiavone, A. (2020). Black soldier fly defatted meal as a dietary protein source for broiler chickens. *Poultry Science*, 99(10), 4826–4834.

5. **Diener, S.,** Zurbrügg, C., & Tockner, K. (2015). Bioaccumulation of heavy metals in the black soldier fly, *Hermetia illucens* and effects on its life cycle. *Journal of Insects as Food and Feed*, 1(4), 261–270.
6. **Gahukar, R. T.** (2011). Entomophagy and human food security. *International Journal of Tropical Insect Science*, 31(3), 129–144.
7. **Gasco, L.,** Finke, M., & van Huis, A. (2018). Can diets containing insect meal improve animal health? *Journal of Insects as Food and Feed*, 4(1), 1–4.
8. **Henry, M.,** Gasco, L., Piccolo, G., & Fountoulaki, E. (2015). Insect-based feed ingredients for aquaculture. *Aquaculture Reports*, 1, 1–9.
9. **Józefiak, A.,** Józefiak, D., Kierończyk, B., & Mazurkiewicz, J. (2016). Insects—A natural nutrient source for poultry. *World's Poultry Science Journal*, 72(1), 5–16.
10. **Liu, X.,** Chen, X., Wang, H., Yang, Q., ur Rehman, K., Li, W., ... & Zheng, L. (2017). Dynamic changes of nutrient composition throughout the entire life cycle of black soldier fly. *PLoS ONE*, 12(8), e0182601.
11. **Makkar, H. P. S.,** & Ankers, P. (2014). Insects as feed: Global perspectives. *Animal Frontiers*, 4(1), 29–31.
12. **Makkar, H. P. S.,** Tran, G., Heuzé, V., & Ankers, P. (2014). State-of-the-art on use of insects as animal feed. *Animal Feed Science and Technology*, 197, 1–33.
13. **Mertenat, A.,** Diener, S., & Zurbrügg, C. (2019). Black soldier fly biowaste treatment – Assessment of global warming potential. *Waste Management*, 84, 173–181.
14. **Mutungi, C.,** Irungu, F. G., Nduko, J., Mutua, J., Affognon, H., Nakimbugwe, D., & Ekesi, S. (2019). Postharvest processes of edible insects in Africa: A review. *Critical Reviews in Food Science and Nutrition*, 59(2), 276–298.
15. **Newton, G. L.,** Booram, C. V., Barker, R. W., & Hale, O. M. (1977). Dried *Hermetia illucens* larvae meal as a supplement for swine. *Journal of Animal Science*, 44(3), 395–400.
16. **Oonincx, D. G. A. B.,** van Itterbeeck, J., Heetkamp, M. J. W., van den Brand, H., van Loon, J. J. A., & van Huis, A. (2010). An exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption. *PLoS ONE*, 5(12), e14445.
17. **Ravi, H. K.,** Vianney, J. M., Degrou, A., Costil, J., Charbonnier, F., Kerckhove, P., & Chemat, F. (2020). Impact of the extraction process on the quality of black soldier fly larvae oil. *Food Chemistry*, 320, 126618.
18. **Rumpold, B. A.,** & Schlüter, O. K. (2013). Nutritional composition and safety aspects of edible insects. *Molecular Nutrition & Food Research*, 57(5), 802–823.
19. **Schiavone, A.,** De Marco, M., Martínez, S., Dabbou, S., Renna, M., Madrid, J., ... & Gai, F. (2017). Insect meal from *Hermetia illucens* larvae as a protein source for broiler diets. *Journal of Animal Science*, 95(2), 84–93.
20. **Sheppard, D. C.,** Newton, G. L., Thompson, S. A., & Savage, S. (1994). A value added manure management system using the black soldier fly. *Bioresource Technology*, 50(3), 275–279.
21. **Surendra, K. C.,** Olivier, R., Tomberlin, J. K., Jha, R., & Khanal, S. K. (2016). Bioconversion of organic wastes into biodiesel and animal feed via insect farming. *Renewable Energy*, 98, 197–202.
22. **van Huis, A.** (2020). Insects as food and feed, a new emerging agricultural sector: A review. *Journal of Insects as Food and Feed*, 6(1), 27–44.
23. **Veldkamp, T.,** & Bosch, G. (2015). Insects: A protein-rich feed ingredient in pig and poultry diets. *Animal Frontiers*, 5(2), 45–50.
24. **Verbeke, W.,** Spranghers, T., De Clercq, P., De Smet, S., Sas, B., & Eeckhout, M. (2015). Insects in animal feed: Acceptance and its determinants among farmers, agriculture sector stakeholders and citizens. *Animal Feed Science and Technology*, 204, 72–87.
25. **Wang, Y. S.,** & Shelomi, M. (2017). Review of black soldier fly (*Hermetia illucens*) as animal feed and human food. *Foods*, 6(10), 91.