Research Article

# Effect of Processing Methods on Nutrient Composition of Black Soldier Fly Larvae Reared on Slaughterhouse Waste and Rice Bran

**Nurul Isnaini and Faizal Andri**

*Faculty of Animal Science, Universitas Brawijaya, Malang, Indonesia*

*Article history*
Received: 03-02-2025
Revised: 26-04-2025
Accepted: 15-05-2025

Corresponding Author:
Nurul Isnaini
Faculty of Animal Science, Universitas Brawijaya, Malang, Indonesia
Email: nurulisna@ub.ac.id

**Abstract:** Black Soldier Fly (BSF) larvae have emerged as a sustainable and nutrient-dense resource for livestock feed, primarily due to their high protein and lipid contents. However, the nutritional composition of BSF larvae is substantially influenced by the processing methods. This study aimed to evaluate the effect of five processing methods (room dried, sun dried, oven dried, microwave dried, and roasted) on the nutrient content of BSF larvae reared on slaughterhouse waste and rice bran composite substrate. The treatments in this study were different processing methods namely room dried: conducted at ambient temperatures of 25–26°C for 31 days, sun dried: performed daily under sunlight exposure from 07:00 to 17:00 for 24 days, oven dried: executed at a controlled temperature of 60°C for 36 hours, microwave dried: completed in 20 minutes using a microwave, and roasted: conducted on a stainless-steel pan over a moderate flame for a duration of 4 minutes. Results showed that the processing methods significantly affect ($P < 0.05$) dry matter, ash, crude protein, crude fiber, and ether extract contents across the treatments. Room dried and sun dried were better suited for preserving ether extract. On the other hand, heat-based methods such as oven dried, microwave dried, and roasted were effective in enhancing protein content while reducing lipid levels. These findings highlight the critical role of processing methods in determining the nutritional profile of BSF larvae.

**Keywords:** Black Soldier Fly, Lipid, Protein, Proximate Composition, Sustainability

## Introduction

Black Soldier Fly (BSF) larvae represent a promising feed ingredient due to their high protein and lipid contents and their ability to efficiently convert organic waste into valuable biomass (Siva Raman *et al.*, 2022; Wiyoso *et al.*, 2023). By utilizing low-value materials such as agricultural by-products and slaughterhouse waste, BSF larvae contribute to sustainable feed resource development and the reduction of environmental burden (Beyers *et al.*, 2023; Kamugisha, 2025). However, the nutritional composition of BSF larvae is influenced by several factors, particularly the rearing substrates and post-harvest processing methods. A better understanding of these interactions is essential to optimize the nutritional value of BSF larvae for livestock feed applications.

The rearing media used for BSF larvae play a pivotal role in determining their growth potential and nutrient composition. Research has shown that BSF larvae can thrive on a wide variety of substrates, including food production side-streams and animal waste, enabling the transformation of low-value materials into high-quality biomass (Adebayo *et al.*, 2021; Hopkins *et al.*, 2021; Isnaini *et al.*, 2023). Slaughterhouse waste is a nutrient-dense substrate primarily composed of rumen contents, which may provide essential nutrients to promote larval growth and development (Froonickx *et al.*, 2023; Fasha *et al.*, 2024). Rice bran, on the other hand, is a rich source of macronutrients, including proteins, lipids, and carbohydrates, making it an excellent substrate for BSF larvae (Angeles *et al.*, 2024; Laksanawimol *et al.*, 2024). Combining these two substrates into a composite medium offers the potential to enhance larval productivity and optimize their nutrient profile, further maximizing their value as a sustainable feed ingredient.

Various processing methods play a critical role in shaping the nutrient profile of feed ingredients. Room dried and sun dried are cost-effective and widely accessible methods, making them suitable for low-

DOI: 10.3844/ajavsp.2025.374.379

resource settings (Hernández *et al.*, 2024). Oven dried offers a more controlled environment with consistent heat application to preserve nutrient contents (Hernández-Álvarez *et al.*, 2021). Microwave dried is highly efficient to reduce drying time while retaining more nutrients through rapid and uniform heating, however, the high cost of equipment and energy consumption may limit its widespread use (Khodifad and Dhamsaniya, 2020). Roasted is known for its ability to enhance crude protein content but with reduce ether extract (Muthee *et al.*, 2024). Other potential drying techniques are freeze-drying and vacuum-drying, which are recognized for their effectiveness in preserving nutritional quality. Freeze drying minimizes nutrient degradation by removing moisture through sublimation at low temperatures; however, it requires high operational costs, specialized equipment, and substantial energy consumption, which limit its feasibility for large-scale or low-resource BSF production systems (Parniakov *et al.*, 2022). Similarly, vacuum drying offers advantages in reducing oxidation and thermal degradation of nutrients, but it also demands sophisticated infrastructure and significant investment, making it less practical for broader application (Parniakov *et al.*, 2022). Therefore, the processing methods selected in this study prioritized techniques that are more economically viable, energy-efficient, and scalable to real-world production environments. Efficient processing methods to obtain optimum nutrient profile is crucial for maximizing the potential of BSF larvae as a sustainable feed source. Accordingly, this study evaluated the effects of five processing methods (room dried, sun dried, oven dried, microwave dried, and roasted) on the nutrient content of BSF larvae reared on slaughterhouse waste and rice bran composite substrate.

## Materials and Methods

This research was conducted in accordance with the ethical standards and guidelines approved by the institutional ethics committee under approval number 247/EC/KEPK/08/2023. One gram of BSF eggs was hatched at room temperature (26-27°C) for 7 days. The hatching substrate consisted of 400 grams of commercial catfish feed mixed with 400 ml of milk waste. After that, the larvae were reared on a composite substrate made of 1 kg of fermented slaughterhouse waste and 3 kg of rice bran. To enrich the substrate, 3 liters of milk waste were thoroughly mixed with the composite material before feeding it to the larvae. The larvae were reared on this substrate for 7 days, after which they were separated from the residual substrate. To prepare the larvae for further processing, larvae were rinsed with hot water, drained, and used in subsequent processing steps.

The treatments in this study consisted of five different processing methods:

- Room dried: conducted at room temperature of 26-27°C for 31 days
- Sun dried: performed daily under sunlight exposure from 07:00 to 17:00 with temperature of 27-31$^{o}$C for 24 days
- Oven dried: executed at a controlled temperature of 60°C for 36 hours
- Microwave dried: completed in 20 minutes using a microwave
- Roasted: conducted on a stainless-steel pan over a moderate flame for 4 minutes.

The durations for each method were chosen based on the time required to achieve a constant weight after processing. Each processing method was conducted in triplicate. The dried larvae were ground into powder using a laboratory blender and subjected to nutrient analysis. The evaluation of dry matter, ash, crude protein, crude fiber, and ether extract was conducted following the methods described by the Association of Official Analytical Chemists (Helrich, 1990). Data analysis involved a one-way analysis of variance with a significance threshold of $P < 0.05$. Significant differences among treatments were further analyzed using Duncan's post hoc test. All statistical analyses were performed using IBM SPSS Statistics version 25.

## Results and Discussion

Effects of different processing methods on the proximate composition of Black Soldier Fly larvae are summarized in Table 1. Significant differences ($P < 0.05$) were observed in the contents of dry matter, ash, crude protein, crude fiber, and ether extract across the treatments. Sun dried produced the highest dry matter content, followed by oven dried, room dried, and microwave dried, while roasted had the lowest content. The significant differences in dry matter content across treatments can be attributed to the varying drying conditions, including exposure duration and heat intensity which influence the efficiency of moisture removal (Babu *et al.*, 2018). Sun dried resulted in the highest dry matter content due to the prolonged exposure to sunlight and natural airflow over an extended period, facilitating substantial water evaporation. The consistent heat from sunlight for long duration ensured thorough moisture removal from the larvae. Oven dried produced the second-highest dry matter content. The stable temperature and prolonged duration in an enclosed environment likely contributed to effective moisture removal, despite limited airflow compared to sun drying. Room dried conducted at ambient temperatures yielded a slightly lower dry matter content. The slower moisture removal process under ambient conditions may lead to residual moisture in the samples. Microwave dried, while efficient for rapid moisture removal, resulted in even lower dry matter content. The shorter drying duration may have left some bound water within the larvae. Roasted produced the lowest dry matter content among the treatments. The short processing time may not have allowed sufficient time for complete moisture removal (Babu *et al.*, 2018).

DOI: 10.3844/ajavsp.2025.374.379

**Table 1:** Effect of Different Processing Methods on Nutrient Content of Black Soldier Fly Larvae

| Variable | Room Dried | Sun Dried | Oven Dried | Microwave Dried | Roasted |
|---|---|---|---|---|---|
| Dry Matter (%) | $86.88 \pm 0.41^c$ | $93.73 \pm 0.09^e$ | $87.81 \pm 0.25^d$ | $84.42 \pm 0.06^b$ | $74.37 \pm 0.13^a$ |
| Ash (%)* | $11.17 \pm 0.24^b$ | $10.66 \pm 0.07^a$ | $17.08 \pm 0.33^e$ | $15.87 \pm 0.13^d$ | $15.42 \pm 0.16^c$ |
| Crude Protein (%)* | $34.67 \pm 1.29^a$ | $34.94 \pm 0.17^a$ | $47.53 \pm 0.53^b$ | $47.01 \pm 0.30^b$ | $51.66 \pm 0.17^c$ |
| Ether Extract (%)* | $42.32 \pm 0.39^e$ | $40.48 \pm 1.16^d$ | $20.13 \pm 0.39^c$ | $16.46 \pm 0.26^b$ | $14.97 \pm 0.75^a$ |
| Crude Fiber (%)* | $9.30 \pm 0.02^a$ | $10.30 \pm 0.55^a$ | $12.13 \pm 0.51^b$ | $12.96 \pm 1.60^b$ | $16.87 \pm 0.24^c$ |

**As 100% dry matter*
*[a-e]Different superscript within a row indicate a significant difference (P<0.05)*

The different processing methods significantly (P<0.05) affect ash content of Black Soldier Fly larvae (Table 1). Oven dried yielded the highest ash content, followed by microwave dried and roasted. In contrast, room dried produced a lower ash content, while sun dried recorded the lowest levels. Low-temperature methods such as room dried and sun dried probably conducive to microbial activity (Mutungi *et al.*, 2019). These processes can degrade ash resulting in a reduction in ash content. In heat-based methods, the high temperatures effectively inactivate enzymes and inhibit microbial activity, preserving the ash content (Hernández-Álvarez *et al.*, 2021). Oven dried, in particular, not only prevents biological degradation but may also break down organic-inorganic complex compounds, enhancing the availability of ash. It was also previously reported that oven dried could increase ash content of *Sternocera orissa* (Shadung *et al.*, 2012). Microwave dried and roasted applying intense heat, but performed over shorter durations. This shorter exposure may limit the extent of organic-inorganic complex compounds breakdown compared to oven drying, resulting in slightly lower ash content.

Table 1 indicates that the crude protein content varied significantly (P<0.05) across the processing methods. Room dried and sun dried produced lower crude protein content compared to the heat-based treatments. In contrast, roasted resulted in the highest protein levels, followed by microwave dried and oven dried. The variations in crude protein content across the processing methods can be primarily attributed to enzymatic and microbial activity during the drying process (Hernández-Álvarez *et al.*, 2021). Prolonged processing duration with lower temperature in room dried and sun dried creates an environment conducive to enzymatic activity and microbial growth. Proteolytic enzymes naturally present in the larvae or introduced by microbial contamination can break down the protein resulting in an apparent reduction in crude protein levels. On the other hand, heat-based methods such as oven dried, microwave dried, and roasted effectively inactivate proteolytic enzymes and inhibit microbial activity due to the high temperatures involved (Liang *et al.*, 2024). This procedure prevents protein degradation and preserves the protein content of the larvae. Microwave dried and oven dried apply sufficient thermal energy to halt enzymatic and microbial activity, maintaining protein integrity and resulting in higher crude protein levels compared to room dried and sun dried. In a previous study by Aniebo and Owen (2010), it was also reported that *Musca domestica* Linnaeus larvae processed with oven dried had a higher crude protein content as compared to sun dried. Furthermore, the exposure of intense heat for a short duration in roasted treatment helps ensuring minimal protein loss. In line with this finding, Muthee *et al.* (2024) reported that roasted beneficially improve crude protein content of *Oryctes* sp. In another study, Manditsera *et al.* (2019) also observed that roasted was effective to increase crude protein content of *Eulepida mashona* and *Henicus whellani*.

The ether extract content varied significantly (P<0.05) across the processing methods (Table 1). Room dried retained the highest ether extract levels, followed by sun dried, which was slightly lower. Oven dried and microwave dried resulted in reduced ether extract levels compared to room dried and sun dried, while roasted produced the lowest ether extract content among all treatments. The variations in ether extract content observed in this study highlight the sensitivity of lipids to heat and oxidative processes during different processing methods (Caligiani *et al.*, 2019). Room dried and sun dried retained higher ether extract levels due to their reliance on lower temperatures and slower drying rates, which minimizes the thermal degradation and oxidation of lipids. The absence of direct high heat exposure in these methods helps preserve the structural integrity of fatty acids, preventing lipid oxidation and volatilization. In line with this study, Nyangena *et al.* (2020) also found that processing of BSF using sun dried retained a higher ether extract content as compared to the oven dried. In the current study, higher processing temperatures using oven dried and microwave dried caused a significant reduction in ether extract content. These methods accelerate the breakdown of lipids through thermal oxidation, hydrolysis, and volatilization of short-chain fatty acids (Melgar-Lalanne *et al.*, 2019). Microwave dried subjects the sample to rapid heating, which increases the likelihood of oxidative reactions in unsaturated fats. In line with this finding, Aniebo and Owen (2010) reported that oven dried results in the lower ether extract of *Musca domestica* Linnaeus larvae as compared to sun dried processing. Roasted likely caused the most pronounced thermal degradation and oxidation of lipids due to the high temperatures in a short time. The intense heat can cause lipid peroxidation and the volatilization of free fatty acids, which reduces the ether extract content. In a previous study, Ssepuuya *et al.* (2020) also observed that the roasted process could reduce the ether extract of long-horned grasshopper *Ruspolia differens* Serville.

Table 1 shows the crude fiber content was significantly ($P<0.05$) affected by the processing methods. Roasted resulted in the highest crude fiber content, followed by microwave dried and oven dried. In contrast, room dried and sun dried produced the lowest crude fiber content among the treatments. The lower crude fiber content observed in room dried and sun dried can be attributed to enzymatic and microbial degradation during the prolonged drying periods under ambient conditions. These methods provide conducive environment for microbial activity and enzymatic breakdown (Parniakov *et al.*, 2022). In contrast, heat-based methods such as roasted, microwave dried, and oven dried effectively inhibit microbial growth (Meyer-Rochow *et al.*, 2021), thus preventing fiber degradation. Roasted treatment results in the highest crude fiber content because of the rapid and intense heat applied for a short duration. This high-temperature exposure effectively halts any enzymatic or microbial activity, thereby prevent crude fiber reduction. Previously, it was also reported that roasted could increase the fiber components in mopane caterpillars (Madibela *et al.*, 2007). Microwave dried and oven dried also preserve fiber content by preventing degradation but may result in slightly lower levels compared to roasted due to differences in heat intensity and duration. In a study by Nyangena *et al.* (2020), it was also observed that BSF and grasshoppers processed with the toasted method had a higher crude fiber content as compared to sun dried and oven dried.

The findings of this study have important practical implications for the application of BSF larvae as a feed ingredient in livestock production systems. Processing methods were shown to significantly influence the proximate composition, particularly affecting protein and lipid contents, which are critical nutritional components in livestock diets. Heat-based processing methods such as roasting, oven drying, and microwave drying, which enhanced crude protein levels, are particularly advantageous for poultry diets that require high-quality protein to support rapid growth, efficient feed conversion, and carcass quality (Ahmed *et al.*, 2023). In beef cattle production, nutritional strategies emphasize protein supplementation, especially when consume low-quality forage. BSF larvae have demonstrated potential as an effective protein supplement under these conditions (Fukuda *et al.*, 2022; Carrasco and Drewery, 2024). In contrast, for lactating dairy cows, the nutritional focus is on increasing dietary energy density to support high milk yields and maintain energy balance. Room drying and sun drying, which preserved higher ether extract levels, may be advantageous for producing energy-dense BSF larvae-based feed ingredients suitable for dairy cow rations (Nekrasov *et al.*, 2022). Thus, selecting appropriate processing methods tailored to the nutritional and production needs of different livestock species is essential to optimize the value of BSF larvae as a sustainable and versatile feed resource.

## Conclusion

These findings highlight the critical role of processing methods in determining the nutritional profile of Black Soldier Fly larvae. Room dried and sun dried, which rely on longer processing durations, are better suited for preserving ether extract. On the other hand, heat-based methods such as roasted, microwave dried, and oven dried are effective in enhancing protein content while reducing lipid levels with shorter processing times. The choice of processing method should be tailored to the desired nutritional and functional properties for specific applications, taking into account the time dependency and its impact on nutrient retention. Although this study focused on the proximate composition of BSF larvae, addressing microbial safety and toxicological risks associated with different processing methods remains essential. Future research is recommended to include microbial load and shelf-life evaluation to ensure the safety and stability of BSF larvae as a sustainable feed ingredient.

## Acknowledgment

The authors acknowledge the research grant from the Directorate of Research and Community Services, Universitas Brawijaya through the “Hibah Penguatan Ekosistem Riset Guru Besar” program.

## Authors’ Contributions

**Nurul Isnaini:** Contributed to conceptualization, methodology, investigation, data curation, and writing – review and editing.

**Faizal Andri:** Contributed to conceptualization, methodology, investigation, data curation, and writing – original draft.

All authors read and approved the final version of the manuscript.

## Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this study.

## Ethics

The article presents original content that has not been previously published. All authors have reviewed and approved the version to be submitted and any revised version, and no ethical concerns are involved.

## References

Adebayo, H. A., Kemabonta, K. A., Ogbogu, S. S., Elechi, M. C., & Obe, M. T. (2021). Comparative assessment of developmental parameters, proximate analysis and mineral compositions of black soldier fly (Hermetia illucens) prepupae reared on organic waste substrates. *International Journal of Tropical Insect Science*, *41*(3), 1953–1959. https://doi.org/10.1007/s42690-020-00404-4

Ahmed, I., İnal, F., Riaz, R., Ahsan, U., Kuter, E., & Ali, U. (2023). A Review of Black Soldier Fly (*Hermetia illucens*) as a Potential Alternative Protein Source in Broiler Diets. *Annals of Animal Science*, *23*(4), 939–949. https://doi.org/10.2478/aoas-2022-0094

Angeles, G. T., Tuaño, A. P. P., Angeles, A. A., Lagrada, V. J. G., Merca, F. E., & Navasero, J. M. P. (2024). Evaluation of cellulolytic activity of black soldier fly [Hermetia illucens (Linnaeus)] larvae fed different combinations of rice bran and market vegetable waste from Los Baños, Laguna, Philippines. *Philippine Journal of Veterinary and Animal Sciences*, *50*(1), 45–56.

Aniebo, A. O., & Owen, O. J. (2010). Effects of Age and Method of Drying on the Proximate Composition of Housefly Larvae (Musca domestica Linnaeus) Meal (HFLM). *Pakistan Journal of Nutrition*, *9*(5), 485–487. https://doi.org/10.3923/pjn.2010.485.487

Babu, A. K., Kumaresan, G., Raj, V. A. A., & Velraj, R. (2018). Review of leaf drying: Mechanism and influencing parameters, drying methods, nutrient preservation, and mathematical models. *Renewable and Sustainable Energy Reviews*, *90*, 536–556. https://doi.org/10.1016/j.rser.2018.04.002

Beyers, M., Coudron, C., Ravi, R., Meers, E., & Bruun, S. (2023). Black soldier fly larvae as an alternative feed source and agro-waste disposal route – A life cycle perspective. *Resources, Conservation and Recycling*, *192*, 106917. https://doi.org/10.1016/j.resconrec.2023.106917

Caligiani, A., Marseglia, A., Sorci, A., Bonzanini, F., Lolli, V., Maistrello, L., & Sforza, S. (2019). Influence of the killing method of the black soldier fly on its lipid composition. *Food Research International*, *116*, 276–282. https://doi.org/10.1016/j.foodres.2018.08.033

Carrasco, M. N., & Drewery, M. L. (2024). Mealworm larvae and black soldier fly larvae as novel protein supplements for cattle consuming low-quality forage. *Translational Animal Science*, *8*, txae122. https://doi.org/10.1093/tas/txae122

Fasha, F. R., Andri, F., & Isnaini, N. (2024). Morphometric traits of Black Soldier Fly larvae in slaughterhouse waste and rice bran growing medium. *BIO Web of Conferences*, *88*, 00035. https://doi.org/10.1051/bioconf/20248800035

Froonickx, L., Berrens, S., Broeckx, L., & Miert, S. (2023). The potential of black soldier fly to recycle nitrogen from biowaste. *Current Opinion in Green and Sustainable Chemistry*, *44*, 100864. https://doi.org/10.1016/j.cogsc.2023.100864

Fukuda, E. P., Cox, J. R., Wickersham, T. A., & Drewery, M. L. (2022). Evaluation of Black Soldier Fly larvae (Hermetia illucens) as a protein supplement for beef steers consuming low-quality forage. *Translational Animal Science*, *6*(1), txac018. https://doi.org/10.1093/tas/txac018

Helrich, K. (1990). *Official methods of analysis of the Association of Official Analytical Chemists*.

Hernández, A., González-Moya, M., Márquez, A., & Acevedo, L. (2024). Review microalgae drying: A comprehensive exploration from conventional air drying to microwave drying methods. *Future Foods*, *10*, 100420. https://doi.org/10.1016/j.fufo.2024.100420

Hernández-Álvarez, A.-J., Mondor, M., Piña-Domínguez, I.-A., Sánchez-Velázquez, O.-A., & Melgar Lalanne, G. (2021). Drying technologies for edible insects and their derived ingredients. *Drying Technology*, *39*(13), 1991–2009. https://doi.org/10.1080/07373937.2021.1915796

Hopkins, I., Newman, L. P., Gill, H., & Danaher, J. (2021). The Influence of Food Waste Rearing Substrates on Black Soldier Fly Larvae Protein Composition: A Systematic Review. *Insects*, *12*(7), 608. https://doi.org/10.3390/insects12070608

Isnaini, N., Amertaningtyas, D., Sulistyo, H. E., Yekti, A. P. A., & Andri, F. (2023). Reproduction and Production Traits of Eggiest of Black Soldier Fly Reared in Different Enriched Media and its Potential as Poultry Feed. *Advances in Animal and Veterinary Sciences*, *11*(11). https://doi.org/10.17582/journal.aavs/2023/11.11.1905.1910

Kamugisha, P. P. (2025). Economic Potentials of Using Black Soldier Flies in Transforming Solid Bio-Waste Into Animal Feeds to Mitigate Greenhouse Gases Emission in Tanzania. *Environmental Quality Management*, *34*(3), e70026. https://doi.org/10.1002/tqem.70026

Khodifad, B. C., & Dhamsaniya, N. K. (2020). Drying of Food Materials by Microwave Energy - A Review. *International Journal of Current Microbiology and Applied Sciences*, *9*(5), 1950–1973. https://doi.org/10.20546/ijcmas.2020.905.223

Laksanawimol, P., Anukun, P., & Thancharoen, A. (2024). Use of different dry materials to control the moisture in a black soldier fly (*Hermetia illucens*) rearing substrate. *PeerJ*, *12*, e17129. https://doi.org/10.7717/peerj.17129

Liang, Z., Zhu, Y., Leonard, W., & Fang, Z. (2024). Recent advances in edible insect processing technologies. *Food Research International*, *182*, 114137. https://doi.org/10.1016/j.foodres.2024.114137

Madibela, O. R., Seitiso, T. K., Thema, T. F., & Letso, M. (2007). Effect of traditional processing methods on chemical composition and in vitro true dry matter digestibility of the Mophane worm (Imbrasia belina). *Journal of Arid Environments*, *68*(3), 492–500. https://doi.org/10.1016/j.jaridenv.2006.06.002

Manditsera, F. A., Luning, P. A., Fogliano, V., & Lakemond, C. M. M. (2019). Effect of domestic cooking methods on protein digestibility and mineral bioaccessibility of wild harvested adult edible insects. *Food Research International*, *121*, 404–411. https://doi.org/10.1016/j.foodres.2019.03.052

Melgar-Lalanne, G., Hernández-álvarez, A., & Salinas-Castro, A. (2019). Edible Insects Processing: Traditional and Innovative Technologies. *Comprehensive Reviews in Food Science and Food Safety*, *18*(4), 1166–1191. https://doi.org/10.1111/1541-4337.12463

Meyer-Rochow, V. B., Gahukar, R. T., Ghosh, S., & Jung, C. (2021). Chemical Composition, Nutrient Quality and Acceptability of Edible Insects Are Affected by Species, Developmental Stage, Gender, Diet, and Processing Method. *Foods*, *10*(5), 1036. https://doi.org/10.3390/foods10051036

Muthee, M. W., Khamis, F. M., Cheseto, X., Tanga, C. M., Subramanian, S., & Egonyu, J. P. (2024). Effect of cooking methods on nutritional value and microbial safety of edible rhinoceros beetle grubs (Oryctes sp.). *Heliyon*, *10*(3), e25331. https://doi.org/10.1016/j.heliyon.2024.e25331

Mutungi, C., Irungu, F. G., Nduko, J., Mutua, F., Affognon, H., Nakimbugwe, D., Ekesi, S., & Fiaboe, K. K. M. (2019). Postharvest processes of edible insects in Africa: A review of processing methods, and the implications for nutrition, safety and new products development. *Critical Reviews in Food Science and Nutrition*, *59*(2), 276–298. https://doi.org/10.1080/10408398.2017.1365330

Nekrasov, R. V., Ivanov, G. A., Chabaev, M. G., Zelenchenkova, A. A., Bogolyubova, N. V., Nikanova, D. A., Sermyagin, A. A., Bibikov, S. O., & Shapovalov, S. O. (2022). Effect of Black Soldier Fly (Hermetia illucens L.) Fat on Health and Productivity Performance of Dairy Cows. *Animals*, *12*(16), 2118. https://doi.org/10.3390/ani12162118

Nyangena, D. N., Mutungi, C., Imathiu, S., Kinyuru, J., Affognon, H., Ekesi, S., Nakimbugwe, D., & Fiaboe, K. K. M. (2020). Effects of Traditional Processing Techniques on the Nutritional and Microbiological Quality of Four Edible Insect Species Used for Food and Feed in East Africa. *Foods*, *9*(5), 574. https://doi.org/10.3390/foods9050574

Parniakov, O., Mikhrovska, M., Wiktor, A., Alles, M., Ristic, D., Bogusz, R., Nowacka, M., Devahastin, S., Mujumdar, A., Heinz, V., & Smetana, S. (2022). Insect processing for food and feed: A review of drying methods. *Drying Technology*, *40*(8), 1500–1513. https://doi.org/10.1080/07373937.2021.1962905

Shadung, K. G., Mphosi, M. S., & Mashela, P. W. (2012). Influence of drying method and location on proximate chemical composition of African metallic wood boring beetle, Sternocera orissa (Coleoptera: Buprestidae) in Republic of South Africa. *African Journal of Food Science*, *6*(6), 155–158. https://doi.org/10.5897/ajfs11.146

Siva Raman, S., Stringer, L. C., Bruce, N. C., & Chong, C. S. (2022). Opportunities, challenges and solutions for black soldier fly larvae-based animal feed production. *Journal of Cleaner Production*, *373*, 133802. https://doi.org/10.1016/j.jclepro.2022.133802

Ssepuuya, G., Nakimbugwe, D., De Winne, A., Smets, R., Claes, J., & Van Der Borght, M. (2020). Effect of heat processing on the nutrient composition, colour, and volatile odour compounds of the long-horned grasshopper Ruspolia differens serville. *Food Research International*, *129*, 108831. https://doi.org/10.1016/j.foodres.2019.108831

Wiyoso, S. A., Sulistyo, H. E., Andri, F., & Isnaini, N. (2023). Effect of fermented laying hen manure and starter feed as growing media on black soldier fly larvae development. *BIO Web of Conferences*, *81*, 00021. https://doi.org/10.1051/bioconf/20238100021