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Editorial

Sustainability and Perspectives of Edible Insect Rearing and Utilization of Their Products and Byproducts

Simona Errico

Laboratory "Circular Regenerative Bioeconomy", Division "Sustainable Agri-Food Systems", Department "Sustainability", ENEA—Trisaia Research Centre, SS Jonica 106, Km 419+500, I-75026 Rotondella, Matera, Italy; simona.errico@enea.it

This Special Issue, titled "Sustainability and Perspectives of Edible Insect Rearing and Utilization of Their Products and Byproducts", aimed to gather high-quality scientific contributions suggesting innovative solutions for rearing edible insects and new perspectives on the use of rearing products and by-products. The prediction that the world's population will increase to 9 billion by 2050, but probably even earlier, resulting in an ever-increasing demand for protein, makes it necessary to find alternative protein sources [1].

Edible insect rearing can be useful in this context. However, it must be sustainable to avoid further burdening the environment and climate. This can be achieved by valorising waste and by-products for insect feed. Europe has only recently started using insects as human food, though insects have been bred for food purposes in other countries for a long time [2].

This Special Issue comprises five scientific studies and three reviews.

The first of those published reviews evaluates the sustainability and economic opportunity represented in one European country, Romania, by the rearing of the silkworm (*Bombyx mori*), which has been proposed for human consumption but is not yet approved by the European Commission. The authors analyse possible improvements in rearing, the crucial importance of preserving the mulberry tree habitat and the need to also use the by-products of rearing to make it sustainable. However, they suggest that further studies are needed on the nutritional qualities and possible health effects of silkworm larvae with a view of their potential use for human nutrition [3].

The second review analyses *Hermetia illucens* rearing, mainly by assessing its demand regarding nutrition, potential and performance measures. This contribution emphasises the difficulty of translating gained knowledge to industrial applications mainly due to the considerable differences in by-products used and the biotic and abiotic variables considered by previous studies, but it also helps define the range of variables to be tested in the future [4].

The last of the three reviews describes the valorisation of spent coffee grounds to rear black soldier fly (*Hermetia illucens*) larvae and illustrates the results of a bibliometric study, i.e., the statistical analysis of books, articles or other publications. This contribution explains how an adequate diet composition is indispensable since coffee contains caffeine as an alkaloid that hampers the growth of certain plants and *Hermetia illucens* larvae themselves. Furthermore, it analyses the possibility and limitations of using *Hermetia illucens* larvae fed in this way in aquaculture and fisheries [5].

Among the studies, Suraporn et al. propose using waste from Thai silkworm rears with the perspectives of both sustainability and economic benefit. Specifically, the group isolated lactic acid bacteria from the faeces of a local strain of *Bombyx mori* and obtained five extracts, all of which showed bile salt hydrolase activity, the ability to adhere to epithelial cells and remarkable probiotic properties, making them potential candidates for use as probiotics in feed [6].

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Of the other four studies, two focus on *Hermetia illucens* rearing and two on mealworm (*Tenebrio molitor*).

The two studies focusing on *Hermetia illucens* larvae, one from Canada and one from Italy, explore their uses in areas other than human food because Canada has yet to implement specific regulations on entomophagy and Europe has not yet approved *Hermetia illucens* larvae for human consumption.

Bejaei and Cheng studied the effects of including dried *Hermetia illucens* larvae in the diets of free-range laying hens on production efficiency, food safety, blood metabolites and health. In general, their use had no negative effects on hen health and welfare; however, the authors emphasised the need for further studies to determine more efficient proportions of dried *Hermetia illucens* larvae in the diets of laying hens [7].

De Santis et al., on the other hand, proposed a multidisciplinary approach for developing a supply chain in the conversion of agro-food waste biomass mediated by *Hermetia illucens* larvae. The approach covers the entire process, from rearing to the exploitation of by-products. In their study, the heterogeneity of fruit and vegetable waste from large-scale distribution did not appear to be a limiting factor in standardising production in an insect rear and in organising the bioconversion process on an industrial scale. Furthermore, the researchers noted the possibility of using compost obtained from *Hermetia illucens* rear residues as a soil conditioner and as a partial replacement for synthetic fertiliser [8].

The other two studies address issues related to rearing *Tenebrio molitor*, the only insect discussed in this Special Issue that is presently approved by the European Commission.

The study by Errico et al. shows the advantages of using prickly pear (*Opuntia ficus indica*) cladodes as a source of water and nutrients for the small- and medium-scale rearing of *Tenebrio molitor* larvae, especially in the Mediterranean area, where this cactus is widespread, but its cladodes are rarely consumed. *Opuntia ficus indica* maintains its overall qualities longer than apple and potato while remaining palatable to mealworms, which allows for less frequent feeding. The possibility to utilise residual cladodes from pruning and the fact that it does not need to be stored at low temperatures makes Opuntia *ficus indica* an advantageous alternative water source that could further reduce the ecological footprint of rearing *Tenebrio molitor* at the small-to-medium production level [9].

Vrontaki et al. investigated the effects of using agricultural by-products in the large-scale rearing of *Tenebrio molitor* larvae on larval growth and body composition. In particular, the authors emphasise the benefit of incorporating locally abundant oat by-products, spent brewer's grains and rice bran into *Tenebrio molitor* diets. The work shows, on the one hand, the great advantage of this large-scale utilisation of *Tenebrio molitor* rears, and on the other hand, how it is not possible to directly apply the protocol and the results obtained to any by-product due to the unique characteristics of each matrix and the possible need for transforming the by-product before it is included in the *Tenebrio molitor* diet [10].

It is clear from these scientific contributions that the issue of sustainability in protein production is very much on the minds of researchers globally. Although dealing with very different specific topics, all of the studies aim to achieve the valorisation of by-products and agrifood waste (oat by-products, spent brewer's grains, rice bran, and prickly pear) and the use of rearing by-products in different sectors (using isolates of lactic acid bacteria from faeces as probiotics in animal nutrition, frass as a soil conditioner for vegetable crops, etc.).

Overall, these contributions provide valuable insights for new research, demonstrating the current relevance of this topic and its significance to researchers. They invite further studies to provide a comprehensive answer to the questions posed by society, politics, and consumers.

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References

1. United Nations Department of Economic and Social Affairs, Population Division (2024). World Population Prospects 2024: Summary of Results (UN DESA/POP/2024/TR/NO. 9). United Nations—Department of Economic and Social Affairs Population Division. World Population Prospects 2024. Available online: https://desapublications.un.org/publications/world-population-prospects-2024-summary-results (accessed on 30 October 2024).
2. Omuse, E.R.; Tonnang, H.E.Z.; Yusuf, A.A.; Machekano, H.; Egonyu, J.P.; Kimathi, E.; Mohamed, S.F.; Kassie, M.; Subramanian, S.; Onditi, J.; et al. The global atlas of edible insects: Analysis of diversity and commonality contributing to food systems and sustainability. *Sci. Rep.* **2024**, *14*, 5045. [CrossRef] [PubMed] [PubMed Central]
3. Hăbeanu, M.; Gheorghe, A.; Mihalcea, T. Silkworm *Bombyx mori*—Sustainability and Economic Opportunity, Particularly for Romania. *Agriculture* **2023**, *13*, 1209. [CrossRef]
4. Nayak, A.; Rühl, M.; Klüber, P. *Hermetia illucens* (Diptera: Stratiomyidae): Need, Potentiality, and Performance Measures. *Agriculture* **2024**, *14*, 8. [CrossRef]
5. Hutabarat, D.J.C.; Mangindaan, D. Cultivation of Black Soldier Fly (*Hermetia illucens*) Larvae for the Valorization of Spent Coffee Ground: A Systematic Review and Bibliometric Study. *Agriculture* **2024**, *14*, 205. [CrossRef]
6. Suraporn, S.; Cansee, S.; Hupfauf, S.; Klammsteiner, T. Lactic Acid Bacteria from *Bombyx mori* Frass: Probiotic Properties and Antagonistic Activities. *Agriculture* **2024**, *14*, 924. [CrossRef]
7. Bejaei, M.; Cheng, K.M. Inclusion of Dried Black Soldier Fly Larvae in Free-Range Laying Hen Diets: Effects on Production Efficiency, Feed Safety, Blood Metabolites, and Hen Health. *Agriculture* **2024**, *14*, 31. [CrossRef]
8. De Santis, E.; de Iudicibus, A.; Lecce, F.; De Mei, M.; Petrazzuolo, F.; Del Giudice, A.; Carnevale, M.; Gallucci, F.; Beni, C.; Assirelli, A.; et al. A Multidisciplinary Approach for the Development of a Supply Chain in Biomass Conversion of Agrifood Waste Mediated by Larvae of *Hermetia illucens* L.: From Rearing to By-Product Exploitation. *Agriculture* **2024**, *14*, 1010. [CrossRef]
9. Errico, S.; Sangiorgio, P.; Moliterni, S.; Verardi, A.; Spagnoletta, A.; Dimatteo, S.; Baldacchino, F. Prickly Pear Cladodes as an Alternative Source of Water in Small and Medium-Scale Yellow Mealworm Rearing. *Agriculture* **2023**, *13*, 1435. [CrossRef]
10. Vrontaki, M.; Adamaki-Sotiraki, C.; Rumbos, C.I.; Anastasiadis, A.; Athanassiou, C.G. Bridging the Gap: Scaling Up the Sustainable Production of the Yellow Mealworm with Agricultural By-Products—Insights into Larval Growth and Body Composition. *Agriculture* **2024**, *14*, 520. [CrossRef]